SCIENCE

(Theory & Practical)

Class-10

2019-20

State Council of Educational Research and Training Chhattisgarh, Raipur

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Preface

Science is a means of understanding natural phenomenon and it provides an alternative dimension to our thinking. Children are naturally curious. We need to encourage their curiosity and provide opportunities to them to deepen their understanding. They also need avenues to try out this knowledge in their day to day life. Such experiences will increase their capacity to ask questions and develop their logical ability as well.

For some students science taught in class X is an opportunity to build the foundation for future studies and for other students it is the last chance to formally study the subject. Therefore, it is necessary to make the students aware of historical developments in scientific thinking and the continuous changes in different theories over the centuries. This will help them understand that is science is a process and not a finished product. This class gives them the basic ideas about their natural environment which helps them adapt and take part in today's rapidly changing technological society.

These are the points that have been kept in mind while first designing the syllabus and then developing the subject-content accordingly. It is our endeavor to develop such traits in students that may learn to thoughtfully collect information, feel excited about conducting experiments and are eager to test theories. Therefore, several opportunities have been provided in the textbook to collect numerical data, compare observations, carry out data analysis and draw conclusions from it. By this age, children have developed the capability to reflectively judge abstract scientific facts therefore those scientific theories are also introduced which the child may not have experienced directly. Teachers are requested to not only actively participate in these chapters but themselves think of such examples so that the textbook becomes even more useful for the children as well the society.

The current textbook of Chhattisgarh retains relations and linkages between basic science components. We have tried to ensure that children are not unduly mentally burdened and they get sufficient time to carry out activities, discuss, explore and test.

The process of textbook writing was a joint collaboration between teachers, teacher educators and members of partner organizations. The Council thanks all those who were either directly or indirectly part of the textbook development process. The process received the support of Vidya Bhawan Society (Udaipur), Eklavya (Bhopal) and Azim Premji Foundation. The Council thanks them. Your suggestions will make this better. We welcome them.

Director

State Council of Educational Research and Training

Chhattisgarh, Raipur

Content

CHAPTER 1

EVOLUTION

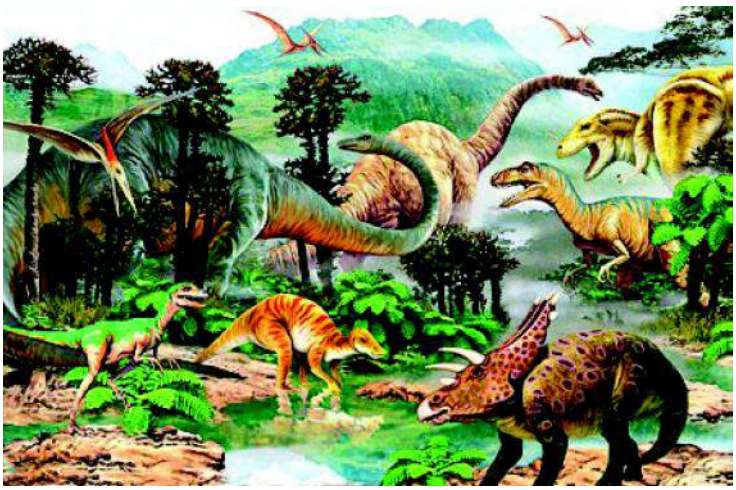


Figure-1: Different types of Dinosaurs

There are hundreds of lakhs of species present on this earth. We have observed some of them while we have heard of some others. There are several others that exist no more now that is, they have become extinct. Today fossil remains are evidences of their existence long ago. "Dinosaurs" are some of the groups of extinct species. You all may have heard about dinosaurs. Their fossils have been found at different places on earth. Even in India their fossils have been found from time to time at several places in the Narmada valley like "Lametaghat" near Jabalpur. Now we know that these regions in the Narmada valley were habitat of dinosaurs'. Fossils have helped us to know that dinosaurs were of different types and present on earth in large numbers from around 2000 to 600 lakh years ago. The size of dinosaurs ranged from a minimum of nearly 50 cm to a maximum of around 40 metres. They were of several types; some carnivores, some herbivores, some bipeds (walking on two legs), some quadrupeds (walking on four legs) while some could even fly. Diverse forms of flora and fauna were present during the time of dinosaurs. Several plants similar to those that are found nowadays like algae, fern, moss, cycads, gingko and animals like mammals resembling rats, insects such as cockroaches etc. were present during the time of dinosaurs. The birds that we see now are considered as small forms of dinosaurs. This list may extend even further. By the time of extinction of dinosaurs a number of giant mammals like elephants were observed to inhabit areas where the dinosaurs lived.

Do You Know?

This is a species of gingko tree similar to that found during the period of dinosaurs. This was the only form of life that could withstand the atomic-bomb blast in Hiroshima.

Dinosaurs are no longer seen today but certain species of plants and animals similar to those of the age of dinosaurs are still observed today.

- Think how this may have happened?

1.1 Habitat and its effect

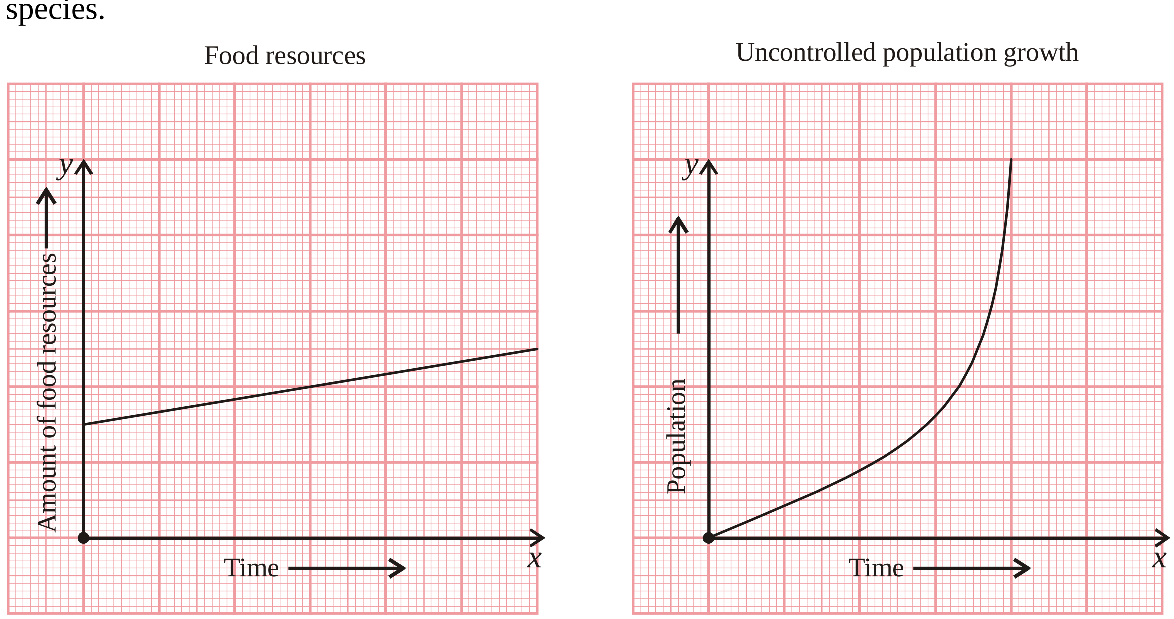
You have studied in the chapter on habitat in class 9 that, habitat is a place where the basic needs (food, reproduction and safety) of any living organism is fulfilled.

- When dinosaurs were abundant on earth, do you think there were enough resources in the habitat for their survival?
- Would their population increase if resources were adequate?

We observe presently, that the population of some species is increasing at a fast rate while that of some others is declining rapidly. As for example, the number of tigers in our country are reducing at such a fast pace that they are at the edge of extinction. The same thing is happening with vultures, sparrow and certain other animals. On the other hand human population is increasing at such a fast pace that there is a rapid fall in the availability of resources in human habitats.

- You have read about the food chain. What will happen if any organism of a food chain vanishes?
- What do you think may be the cause for the rapid decline in the number of tigers? Does the increase in human population have any role?
- What will happen if the population of a certain species of organism increases unusually?
- Is the rate of population growth of a species similar to the rate of the growth of food and other abiotic resources?

We find that indeed there are certain factors that may control increasing number of organisms. We shall take the help of the graphs to study one of them. A study conducted way back in around 1780 claimed a situation as showed in the following graphs. Here one graph shows the uncontrolled increase in population size while the other shows amount of available food resources for organisms of a species.



2 (a) 2 (b)

Figure-2: Graph showing increase in food resources and uncontrolled population growth

Study the graphs and answer the following-

- Is the rate of population growth and that of food resource same?
- Which graph shows growth at a faster rate?

- Would the amount of food resources have any effect on the rate of growth of population?

The graph shows that if population of a species grows uncontrollably then the food resources will not be able to fulfil the requirement of the population. In this situation, control in number due to natural disasters or deaths due to conflicts related to competition for resources may occur.

- Do organisms that survive have some special abilities?
- Does nature have any influence on the number of organisms?
- Could declining amount of resources in habitat be a cause for extinction of dinosaurs?

Scientists have been wondering about such questions on extinction, origin of species their diversification etc. Questions like; what is the process of origin of organisms? Were all organisms in their present form placed on earth from somewhere as such? Or do organisms that survive on earth change over time? Do organisms become extinct as new forms take their place?

You have studied previously that new cells originate from pre-existing cells. The pre-existing cells originally being formed from certain compounds. Also that, cells organise to tissues, tissues to organ, organs to organ systems to multicellular forms of organisms. Are organisms formed from pre-existing organisms just as cells?

A little over 200 years back eminent naturalists(scientists studying nature) Charles Darwin and Alfred Russell Wallace were looking for answers to such questions, there were of course many before them as well who tried to answer such questions in their own way. But these two made an extensive study of organisms, their remains, natural conditions and proposed the most profound theory in science that brought about a remarkable change in the views of the society till then. Let us study mainly about Darwin and his findings to see how an important theory was arrived at.

1.2 Voyage of the Beagle and Darwin's Experience

Since childhood Darwin was interested in studying and gathering information about natural phenomenon, habitats of different organisms and their behavior. He studied about diversity of living organisms and the influence of nature on the diversity. His observations completely changed the social and scientific thought of his time.

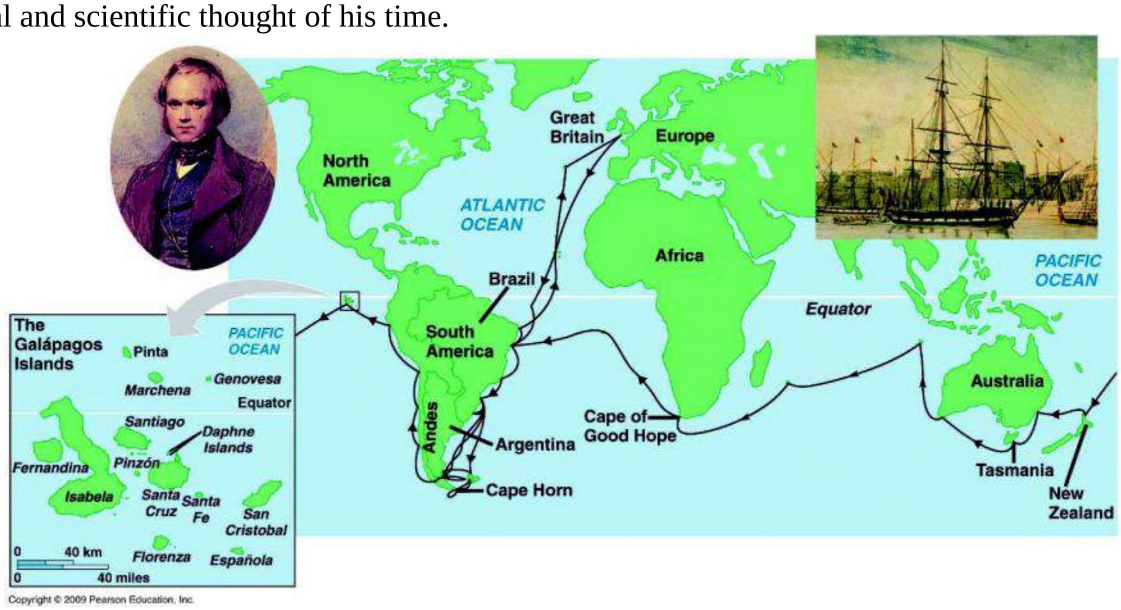


Figure-3: Map showing the areas surveyed during the voyage by HMS Beagle

In the year 1831, Darwin got an opportunity to travel around the world on a survey expedition by the ship, HMS Beagle. He was to give company to the captain of the ship. The Beagle expedition was undertaken to map different regions of the world, explore mineral resources, study biodiversity etc. During the voyage, that started from England and went via South America, Darwin found a chance to roam around different islands of the world. It was the first time that he studied organisms of tropical rain-forests. He collected and observed different organisms as well as remains of organisms of the distant past. Apart from the accommodation and study room there was a good library in the ship. The voyage started on 27th December 1831 and ended on 2nd October 1836.

1.3 Darwin's Observations

Some of the major observations during the voyage, which helped Darwin to propose the theory of evolution, are as follows-

- Darwin studied samples of sea water and was surprised to see various types of organisms in those samples. Here he observed a beautiful chain of food and feeding among even the microscopic forms of life! The forests and mountains of South America had several such examples too. Everywhere he found food chains and food webs where an organism (predator) fed on the other(prey). These predator prey relationships made him wonder- "There is struggle for life everywhere, either kill or die. Those able to survive, live on. Perhaps those that get accustomed to geographical conditions survived!"

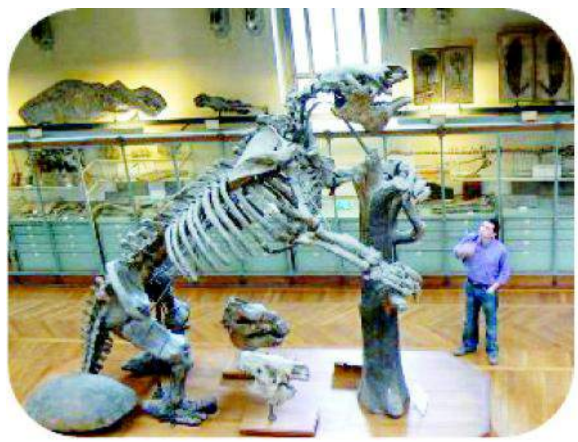


Figure-4: Fossil collected by Darwin

- He found fossils of aquatic organisms and that may have lived in the sea earlier on the mountains of South America. During his studies there, he experienced an earthquake as well. The ocean level rose to nearly 3 meters due to the earthquake. These types of observations were indicating that sudden severe changes may occur on islands or in the oceans over time.
- Darwin found that slow and continuous changes on earth could also bring about changes in land forms on earth. Beaches surrounded by cliffs rather than plain sandy stretches indicated this.
- The fossils of giant mammals, reptiles etc. showed similarities as well as differences as compared with the existing organisms. Thus, as the surface of the earth changed over time, so might have the organisms.

Do you know?

Fishermen caught a peculiar fish along the sea coast of South Africa in 1938 that caused a stir among the scientific community. An organism that was thought to have become extinct along with the dinosaurs was found! It was believed to have undergone no changes in features which were similar to those of the period of dinosaurs and even before that. It was thus called as a living fossil. It had certain features like reptiles and certain others like fishes. This was a promising missing link between reptiles and fishes. We now know that its population has evolved over time and is still undergoing evolution so it may not be right to still call it as a living fossil.

1.4 Some important observations of Darwin on Galapagos islands

Darwin collected fossils and several specimens of organisms that he found on Galapagos.

- What do you think fossils help us to study about?

The speeimens and fossils helped him to study and compare forms of present organisms with those of the past. As for example, he observed that armadillo of the past were larger in size than those of the present (see Figure- 6). "Armadillos had changed over time", thought Darwin.

Figure-5: Different organisms observed by Darwin in Galapagos Islands - Monitor lizards(60-100 cm) duck like Boobie birds(70-90cm) Cactus(600-700cm) Finch(10-20cm) Tortoise (120-150cm)

Darwin had collected fossils of molluscs (like snails), reptiles, mammals etc. as well as specimens of the existing forms. Fossils are important as they often provide evidences of mutual relationships between organisms of the past and the present as well as between organisms present now.

While studying about the finches of the Galapagos Islands, Darwin was simply amazed to see the variations among them. Finches are birds similar to sparrows of our country. Darwin had studied nearly 15 finch species. As he observed finches of different islands as well as the mainland, he found certain variations in spite of basic similarities among them. The variations were most prominent in the type of their beaks and coat colour. He measured the dimension of the beaks and found them to differ a lot. Birds with different beaks, he observed, had different food habits as well. While some birds ate seeds, some others ate fruits. Some of the finches ate insects and worms while others survived on the nectar of flowers growing on the island. Variation in beaks appeared to correspond to the variation in the types of available food resources. So, Darwin remarked that structural variations in beak were related to their functional variations.

He was of the opinion that finches had originally flown from Ecuador(on the mainland, refer to figure-3) to the different islands of Galapagos. Groups of finches started thriving in different environments of these islands. A group most suited to the environment evolved most and could be seen to have characters conducive for their survival on these islands. This could only have been possible due to variations in the group of finches.

The development of different communities of finches surviving on different islands of Galapagos from a community that had originally come from Ecuador showed that varied finches originated from an apparently similar group. Finches with prominently visible variations in type of beak were related and had the same origin. Such characters as the type of beak in finches,which had diversified structurally and functionally from the same original type, are called as,'homologous characters'. Darwin had considered these as very strong evidences for evolution.

Let us observe some characters first in plants and then in animals to find out more about homologous characters.

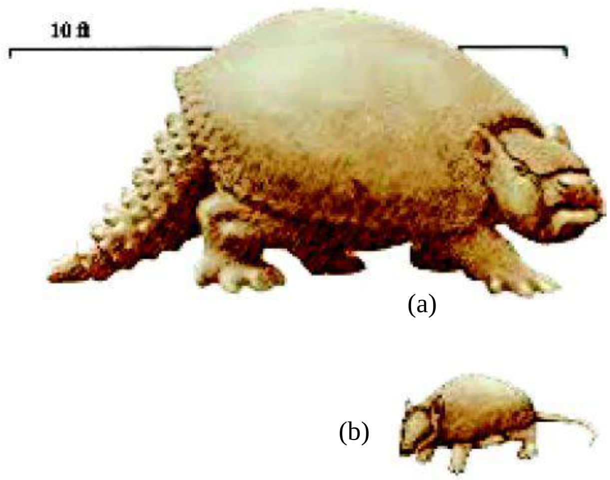


Figure-6: Ancient and present Armadillo

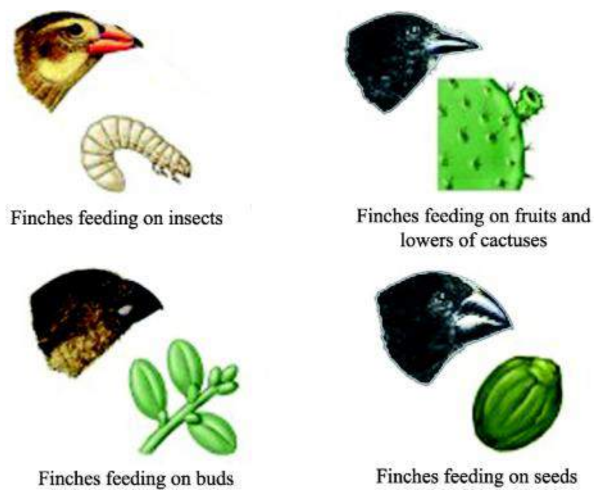


Figure-7: Different types of beaks of finches

Activity-1: Observation of homologous characters

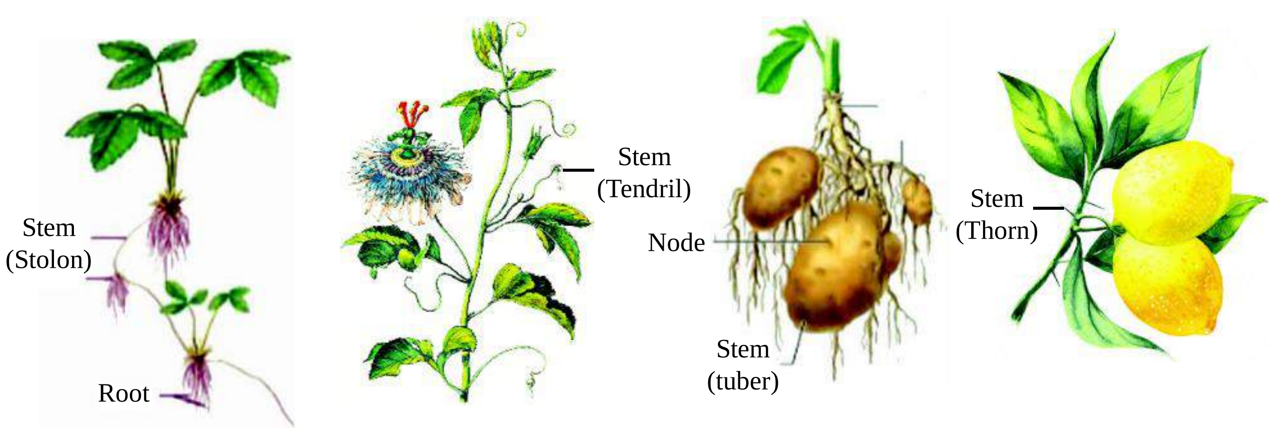


Figure-8(a): Some homologous characters in plants

You may have observed different types of stems in plants. Some types are shown in figure 8a. With the help of the figure, your own prior observation and discussion with your friends enlist all the different plants in which you can see stems that appear to perform different functions. Write the functions that you believe the stems must be having. Take the help of your teacher or other books to check your answer. Figure 8a shows stems of strawberry that have role in reproduction(called as stolon here), stems of passion flower that have role in climbing (stem tendrils), potato stems (tuber) that have mainly the function of storage of food and reproduction and stem of lemon developed into thorns (mainly protective in function. All these stems have diversified both structurally and functionally but indicate the same origin as all these are stems.

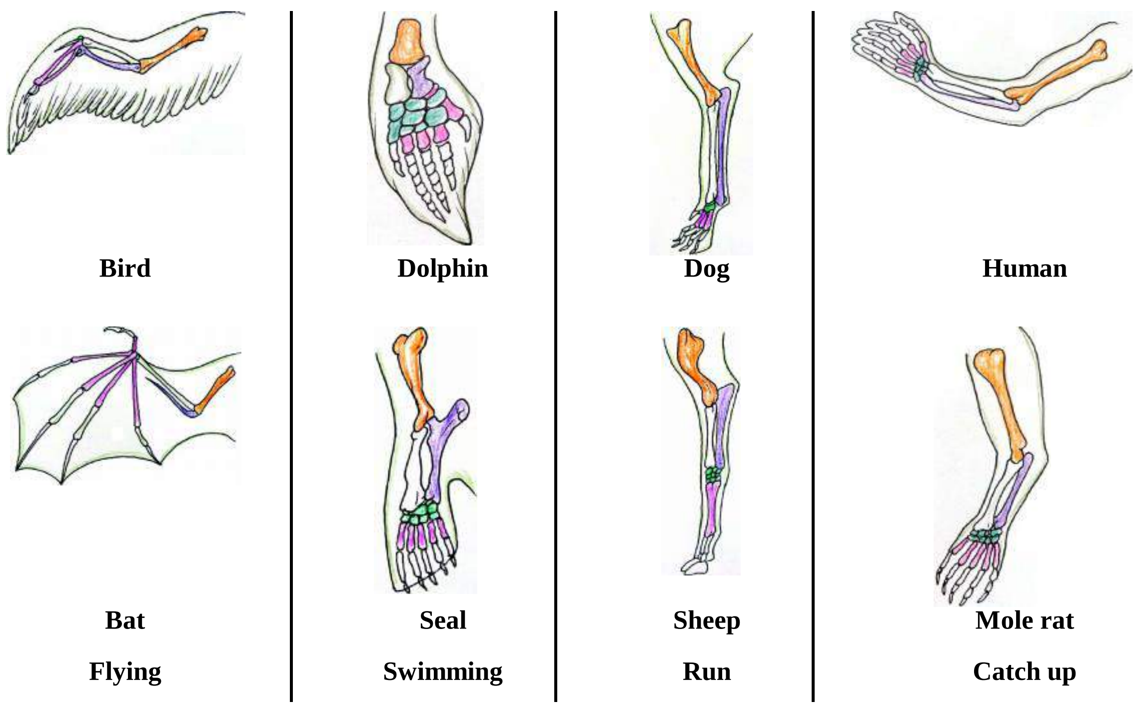


Figure-8(b): Some homologous characters in animals

You can observe the wings of bat, the flippers of dolphins and seal, the forelimb of sheep and dogs as well as humans and mice (in figure 8b) all apparently have the similar set of bones in them. As for example the humerus, radius and ulna are prominently visible in all these organisms. This suggests a common ancestry of these organisms though the appendages are used differently in dolphins, bats, sheep and humans. Characters that indicate similar origin but diverse functions are called as homologous organs. Contrary to this, if we find functional similarity in organs of different origin like the wings of birds and butterflies, we call such organs as 'analogous organs'. While the wings in birds have developed from their forelimbs those of butterflies are mainly from their skin. How could apparently similar organs take up different roles overtime was the question that Darwin and scientists even before Darwin thought about?

1.4.2 Selection and Evolution

As the journey of the Beagle came to an end and the crew returned to England, Darwin started putting together pieces of information that he had collected all through the voyage from the different continents. He started writing an account on his observations. He was aware of the fact that humans could bring about changes in characters in domesticated animals or in crop plants by selecting organisms with preferable characters and breeding them. Selective breeding among a species of organisms with preferable characters by humans, is called as, 'artificial selection'. Darwin started thinking that if humans could select and bring about changes in characters of organisms, could the presence of diverse organisms in nature be a result of some process of selection occurring there?

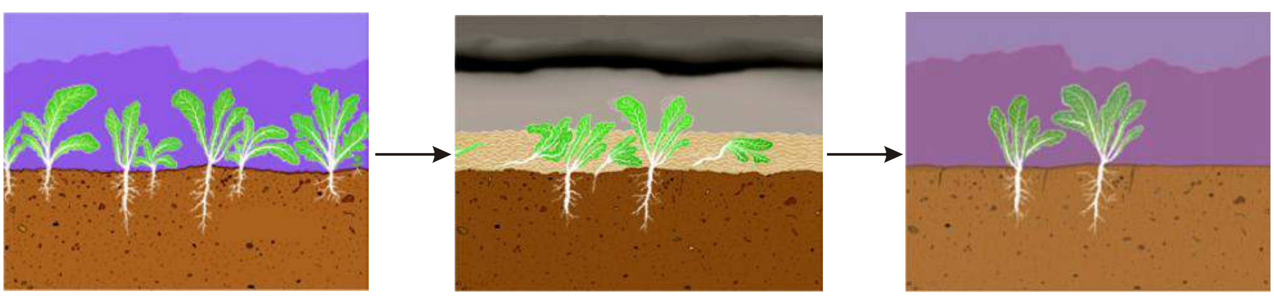
- What type of selection is selective breeding by humans called?

Darwin suggested that a process of natural selection was instrumental in the evolution of one form to the other, resulting in the diverse forms of species found in nature. To understand the process of natural selection you would need to do the project work on it as given in page number........

- What do we understand about natural selection by doing the project work?
- Is natural selection an intentional process of selection by nature as in artificial selection?

Activity-2

A few figures have been given here. Observe them and suggest the type of selection process shown here. Justify your answer.



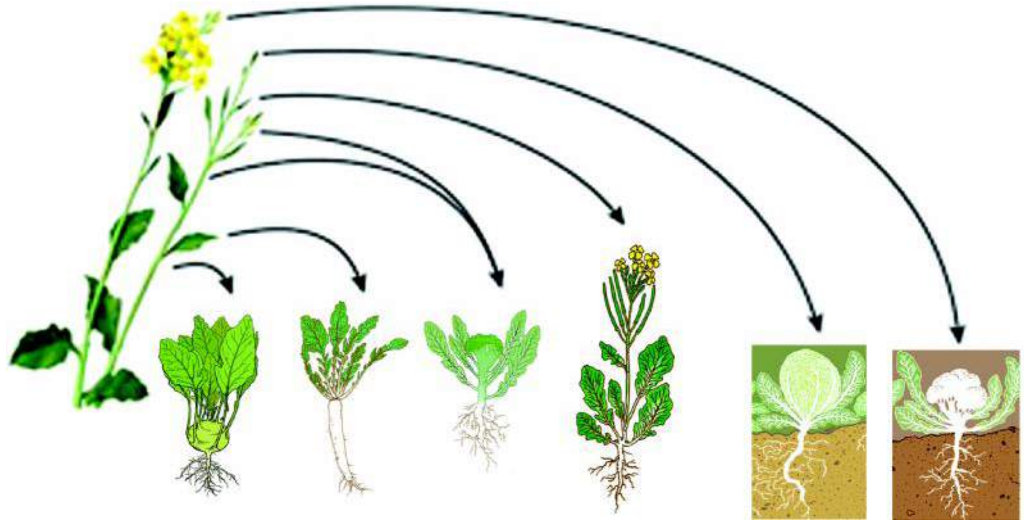
Radish plants growing on a field — radish plants swept away by floods — radish plnts left on the field.

Figure-9: Effect of flood on a radish field (visit site http://www.khaydock.com/books.php for details.)

Nearly two decades after the voyage of the Beagle, another scientist named Alfred Russell Wallace set out on similar voyages from England mainly to islands in the American and Asian subcontinents. He had mainly done an extensive study on the butterflies and mammals of these regions and come to similar conclusions as Darwin. Wallace also suggested that, organisms evolved from preexisting organisms and selective processes in nature occurred spontaneously and non-intentionally giving rise to the diverse forms of species present on earth.

Do you know?

Artificial selection has led to the evolution of different varieties of rice, wheat, etc. that we see today. Different types of vegetables and fruits have also been developed in this way.



Different varieties of mustard Parts preferably consumed by humans

Kholrabi stem | Radish root | Broccoli flower bud | Mustard seeds leaf | Cabbage leaf bud | Cauliflower flower bud

1.4.3 Theory of Evolution

Darwin and Wallace together suggested the following based on evidence and rigorous study-

1. Variations found in organisms led to the diversity in the ability of them to survive in nature. Some live long while others for a short period of time. Some produce more off springs while others produce less off springs. Populations of those that have greater ability to survive, have more chances of evolving over the others. Thus, over time we have new composition of the population of organisms with those apparently suited better to certain sets of environmental conditions.

2. New varieties of organisms may emerge suddenly from preexisting one due to natural calamities.

3. Various organisms have had similar ancestors and thus the evolutionary relationship may be represented by a diagram showing a branched tree(see figure 10).

4. Variations are found in populations of organisms. Only some variations or variable characters pass on from one generation to the next.

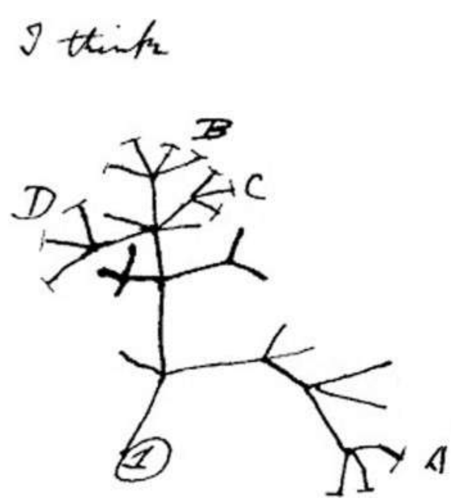
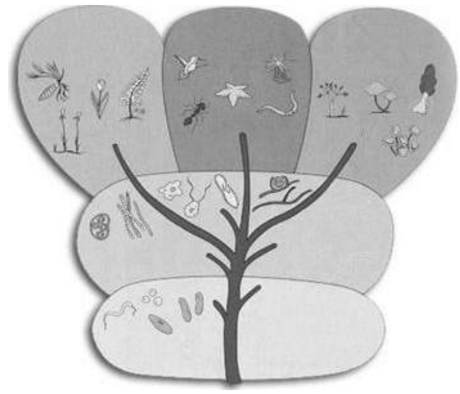


Figure-10: Diagram showing evolutionary relationship as drawn by Darwin

Such variations over generations lead to formation of populations of organisms that may show remarkable changes from their ancestral types. These variations often prove to be advantageous for the organisms that have them over others that do not have them.

6. Populations of organisms that have advantageous variations usually start growing more profusely in an area, affecting the population composition there. Those with less advantageous variations are nearly replaced by those that bear more advantageous variations leading to evolution.

Do you know?



Branched tree representation of Darwin in the context of 5 kingdom classification

- Could the extinction of dinosaurs be due to the evolution of population of organisms having more advantageous variations? What is your opinion about this?

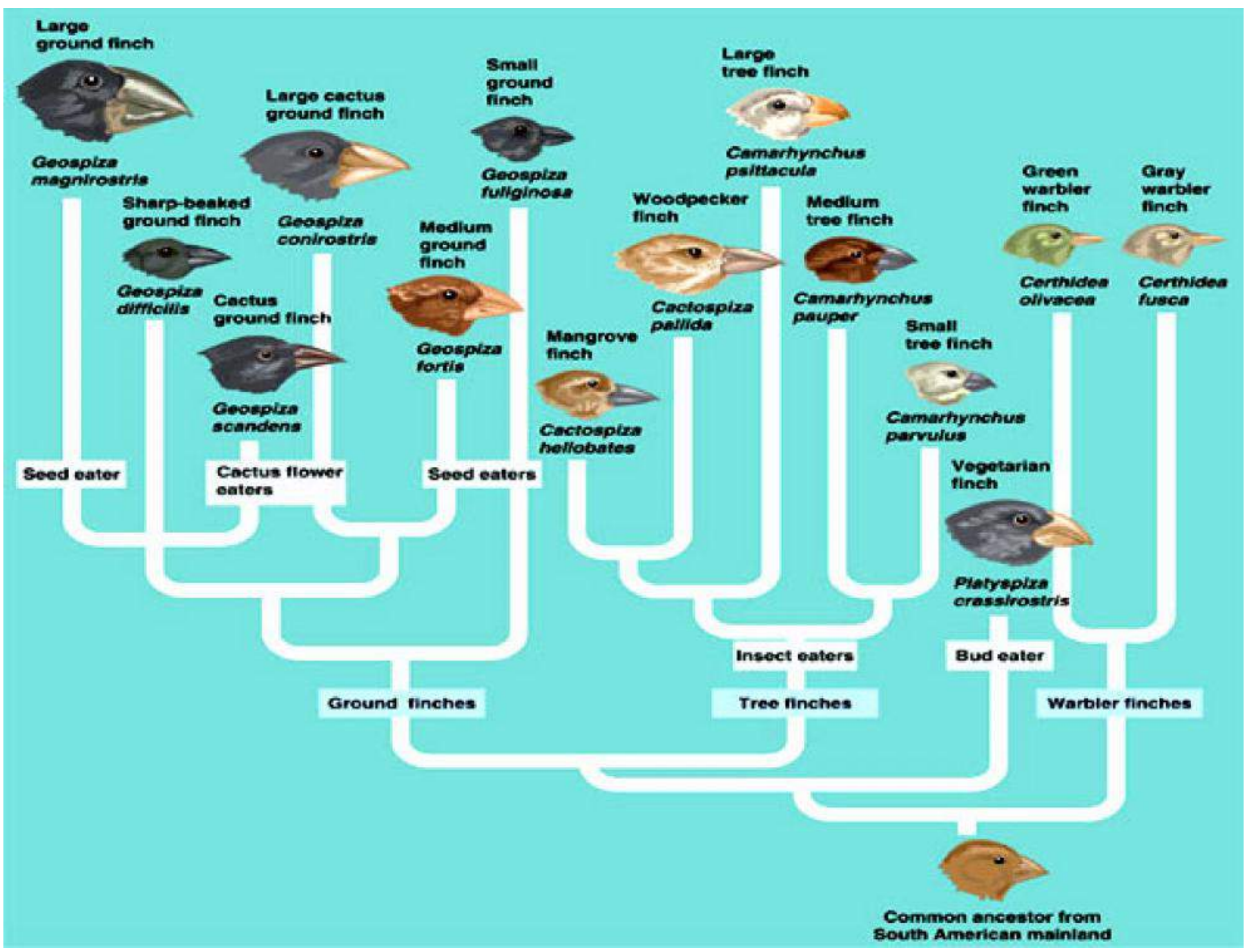


Figure-11: Branched tree of evolution of finches showing common ancestry

Do you know?

Darwin had written the book "On the origin of species by natural selection" while Wallace the book "Darwinism" in which they proposed the evolutionary theory and provided evidences for the same. These books were published in the year 1859 and 1889 respectively

1.5 Process of speciation on the basis of Theory of Evolution

1.5.1 Adaptation and speciation

We have studied that the beaks of finches showed variations according to the availability of food resources. Populations of finches had flown from Ecuador and according to availability of resources different population of finches became suited to environment of different islands. The process of change by which organisms or species become better suited to their environment is called as adaptation.

Were dinosaurs not well adapted to the changing conditions of environment that they could not survive and became extinct?

- How do you think the fishes of Kotumsar caves adapt to the environment of the cave?

Darwin had observed that the finches of Galapagos were so varied that finches of one island could not be bred with finches of other islands. The evolution of organisms such that they vary so much as not being able to interbreed has been considered as the process of speciation. The process may fast due to natural calamities or slow otherwise.

1.5.2 What are species?

Species were considered to be those groups of organisms even during Darwin's time that could sexually interbreed and produce offsprings that were viable(meaning here is -having the ability to reproduce). The definition of species on the basis of their ability to interbreed sexually is considered as 'biological species concept'.

Darwin was concerned regarding this definition as he had observed several species of tortoise, reptiles etc. that could interbreed but were so varied that it would have been better to consider them as a new species. Though the definition of biological species has helped us to organize them under the schema of the systems of classification from two kingdom to five kingdom etc. it has not helped us in organizing groups of organisms like bacteria, certain plants etc. that reproduce asexually.

Darwin had been conducting experiments to find out how variations came to occur among organisms and how they were inherited. He had conducted extensive experiments on plants like Mirabilis(the nine o clock plant) and animals like pigeons. Quite unknown to him a contemporary of Darwin, Gregor Johann Mendel had actually described the process by extensive experiments that we shall study about in chapter 15 (Heredity).

Key words

Evolution of organisms, speciation, adaptation, natural selection, artificial selection, fossils, homologous characters, analogous characters.

What we have learnt?

1. According to the theory of evolution, variations in populations of organisms in nature lead to changes in composition of populations over time. Thus a new population of species emerges from an old one by the process of natural selection.
2. A lot of effort is put into collecting facts and evidences and test them before proposing a theory.
3. Artificial selection is the process of selection of desirable characters of organisms by humans.
4. The process of selection occurring in nature without human intervention, by changes in mainly environmental conditions is called as natural selection.
5. Adaptation is the process of change by which organisms or species become better suited to their environment.
6. Groups of organisms that can interbreed sexually producing viable (capable of further reproduction) off-springs are called as species.This definition of species on the basis of their ability to interbreed sexually is considered as 'biological species concept'.

Exercise

1. Choose the correct answer-

   (i) Name the process through which modern breed of pet dog was acquired-

   (a) Natural selection (c) Juvenile selection

   (b) Artificial selection (d) Work selection

   (ii) Forelimbs of dog and sheep are for walking, whale for swimming and that of bat for flying. All these are examples of-

   (a) Analogous (c) Undeveloped organ

   (b) Homologous (d) all above

(ii) Which of the following are analogous structures-

(a) Wings of bat and butterfly (b) Gills of prawn and fish

(c) Thorns of bougainvillea and tendrils of bottle gourd

(d) Wings of bat and legs of horse

(iii) While proposing his theory, Darwin was influenced by-

(a) The observations of his voyage (b) Cell theory

(c) Law of genetics of Mendel (d) None of the above

2. Fill in the blanks

(i) A group of organisms which can interbreed sexually producing viable off-springs is known as ....

(ii) Difference among beaks of finches show the .... among them.

(iii) Some bacteria can grow in the medium containing streptomycin (antibiotic). The reason behind this is ....

3. There are different types of bacteria growing in our intestines. They are capable of reproducing mainly asexually(without involvement of sex cells) very fast about once every 20 minute. During reproduction variations emerge and some of these variations are heritable, that is, they pass from one generation to the next. Due to this, we find variations in populations of bacteria growing in our intestines. This is how they evolve very fast. We often consume antibiotics that kill most of these bacteria but some always remain on which the antibiotics may have no effect. This is simply because of the variations present among the bacteria. Bacterial types on which antibiotics have no effect are said to be antibiotic resistant.

Answer the following on the basis of this information.

(a) Justify that natural selection is responsible for evolution among bacterial population.

(b) During which process does variation arise in bacteria?

(c) What is the role of variation in the process of evolution? Use the example of reproduction of bacterial population to elaborate your answer.

(d) "Evolution can be slow or very fast" .Give an example each of slow and fast process of evolution.

(e) Does a better adapted population of bacteria become antibiotic resistant? Give reasons for your answer.

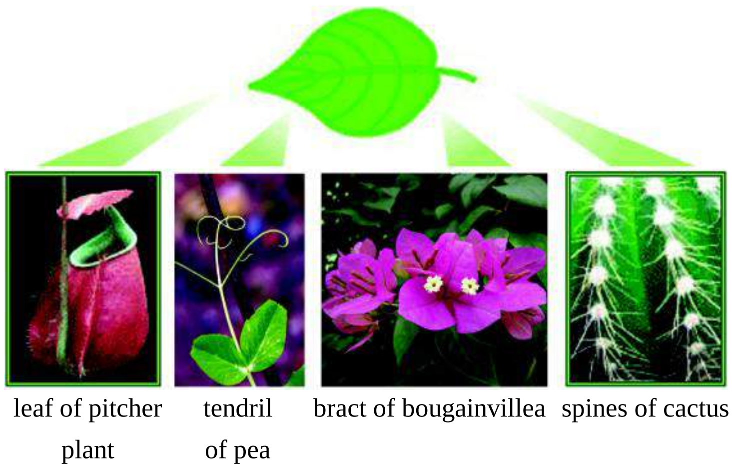
4. Write two difference between natural and artificial selection.

5. What do we come to know from the theory of evolution as proposed by Darwin and Wallace?

6. What are the main points of the theory of evolution of organisms?

7. What is the role of selection and adaptation in the process of evolution?

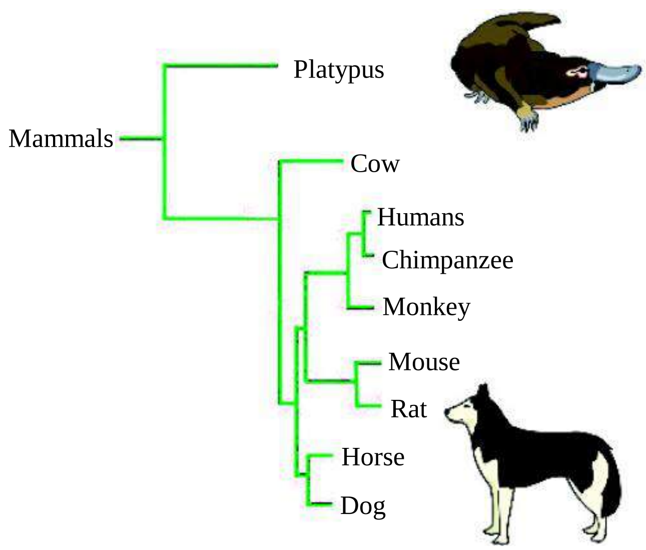
8. Observe the figure and say whether it represents homologous or analogous structures? Justify your answer.



9. (i) Observe the branched tree of evolution given in the figure and find out the closest relative of humans.

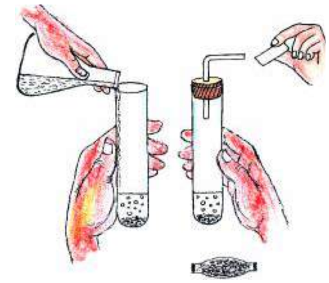
(ii) Write the names of two organisms, by observing the figure,that show maximum similarity. Also write the names of two organisms that show maximum differences.

(iii) What do you understand from the figure about evolution of organisms shown there? Write a brief description to elaborate your answer.



CHAPTER 2

ACIDS, BASES AND SALTS



You have learnt about acids, bases and salts as well as some of their properties in previous classes. Have you ever wondered why when a red ant or a wasp stings us, we are advised to rub soap over the sting? You must have observed that of *haldi* (turmeric) stains on our clothes changes in colour when we rub soap over it.A person suffering from acidity eats baking soda for relief. Lemon juice or tamarind is used to clean tarnished copper vessels. Think: Where can we see the effects of acids and bases in our daily lives?

Do you recall reading about indicators? Indicators help us classify substances into acidic, basic or neutral groups. For example, litmus is an indicator that changes colour in the presence of acids and alkalis. You also know that the reaction between an acid and a base produces a salt and water.

2.1 Acids and Bases are everywhere around us

Let us try to find out which acids and bases are present in the many substances we use in our daily life.

Table-1: Acids and Bases from Natural Sources

S.No.	Natural Source	Acid	S.No.	Natural Source	Base
1.	Tamarind	Tartaric acid	5.	Lime	Calcium hydroxide
2.	Apple	Maleic acid	6.	Baking Soda	Sodium hydrogencarbonate
3.	Vinegar	Acetic acid	7.	Antacid	Magnesium hydroxide
4.	Tomato	Oxalic acid	8.	Washing soda	Sodium carbonate

In addition to the acids given in Table-1, we also have mineral/non-carbonic acids such as nitric acid (HNO_3), sulphuric acid (H_2SO_4) and hydrochloric acid (HCl). Similarly, there are many other alkalis such as ammonium hydroxide (NH_4OH), sodium hydroxide (NaOH), potassium hydroxide (KOH) etc.

Alkalis and Bases

Not all bases are soluble in water. Those bases that can be dissolved in water are called alkalis.

2.2 How to identify acids and bases?

You know that acids turn blue litmus red and alkalis turn red litmus blue. Similarly, any substance which can be used to test the nature of a solution is called an indicator. Indicators change their colour (or there is a change in some other property such as odour) in acidic or basic media and in this way they help us identify acids and bases. Hibiscus flower petals, purple cabbage leaves, turmeric can also be used to identify acids and bases; they all are natural indicators. Can you find more indicators which will help us distinguish between acids and bases?

We can also use synthetic indicators such as methyl red, methyl orange, phenolphthalein to test for acids and bases. Let us do an activity to understand how.

Activity-1

- Take three glass slides.
- With the help of a dropper place three drops of phenolphthalein on three different spots on the first slide (Figure-1).
- In the same manner, add three drops of methyl orange and three drops of juice of hibiscus or rose flowers to slide 2 and slide 3, respectively. Make sure that the drops are in three different spots and don't mix with each other.

  (If the indicators mentioned in the activity are not available, use any other indicator which is available)
- With the help of a dropper add one drop of dilute hydrochloric acid to the first drop on each slide. Use a second dropper to add dilute sodium hydroxide solution to second drop on each slide. Note the change in colour of drops in Table-2.

  (**Note:-** for accurate results, use distilled water for making the solutions)
- The third drop on each slide shows the actual colour of the indicator. This drop is used as a reference to identify changes in colour on addition of acid or base.

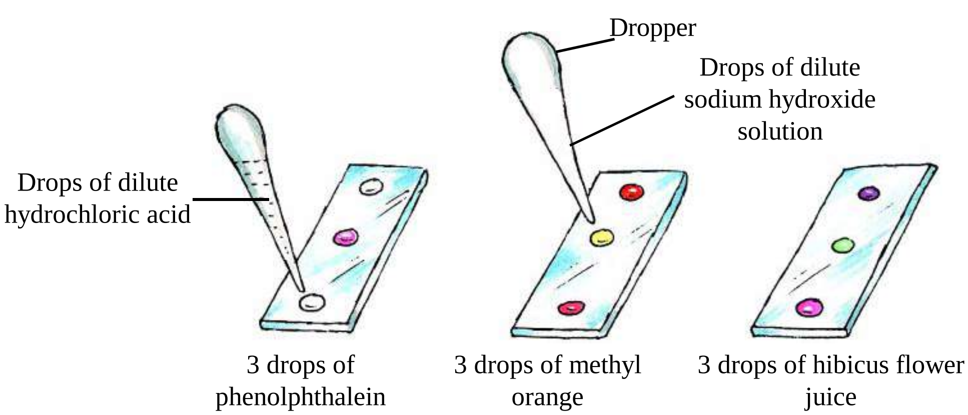


Figure-1: Changes of colour of different indicators in acidic or basic medium

Table-2: Change of colour of indicator in the presence of acids and bases

Indicator	Original colour of indicator	Colour in dilute hydrochloric acid	Colour in dilute sodium hydroxide
Phenolphthalein	______________	______________	______________
Methyl orange	______________	______________	______________
Juice of red rose/ hibiscus flower	______________	______________	______________

- Can you tell what will be the colour of methyl organe in dilute sulphuric acid?

Indicators react with acids and bases to form new substances and this causes change in colour. Do you know that there are some substances that change their odour in acidic or basic media? These substances are called olfactory indicators. Let us carry out an activity with an olfactory indicator.

Activity-2

- Cut an onion and rub it on a piece of white paper. Cut this paper into three smaller pieces.
- On the first piece, put a drop of dilute hydrochloric acid. On the second piece of paper put a drop of dilute sodium hydroxide solution.
- Compare the odour of the first and second paper with the third paper.
- Did you notice any change in the odour of the first and second pieces of paper?

Onion is one example of an olfactory indicator. Vanilla and clove oil are also olfactory indicators. Only dilute solutions of vanilla or clove oil should be used to test for acids and bases. Vanilla does not change its odour in the presence of dilute hydrochloric acid but its odour disappears in the presence of dilute sodium hydroxide. Carry out activity-2 using clove oil and note your observations.

Make your own indicator

Rub any one of the following - Jamuns, oleander (Kaner) flowers, turmeric, kachnaar flowers etc.- on a piece of white paper and use this paper as an indicator to distinguish between acids and bases.

Questions

1. Why are copper and aluminium containers not used to store pickles?
2. While eating midday meal, some sabzi fell on Kusum's clothes. She went home and rubbed some soap on the spot which turned red. Can you give the reason for the change in colour?
3. Suresh is a visually disabled student. Which indicators can he use to identify acids and bases? Give two examples.

2.3 Chemical Properties of acids and bases

We looked at the how acids and bases behave with different indicators. Let us now study some of the chemical properties of acids and bases.

2.3.1 How do acids and bases react with metals?

We know that generally metals react with acids to form a salt with the displacement of hydrogen gas. We can depict the reaction between an acid and a metal as follows:

$$\text{Acid} + \text{Metal} \longrightarrow \text{Salt} + \text{Hydrogen}$$

When hydrochloric acid reacts with zinc metal, the salt zinc chloride is formed along with the evolution of hydrogen gas.

$$2HCl(aq) + Zn(s) \longrightarrow ZnCl_2(aq) + H_2\uparrow$$

Hydrochloric acid   *Zinc*   *zinc chloride*   *hydrogen*

Write down the chemical equations of reactions between hydrochloric acid and some metals that you already know.

Let us do an activity to understand how alkalis react with metals.

Activity-3

- Place a few pieces of granulated zinc in a test tube.
- Add 2 mL of dilute sodium hydroxide solution to the test tube (Figure-2).
- Do you observe any changes on the surface of granulated zinc? What are the changes?
- How will you test the gas which evolves during the reaction?

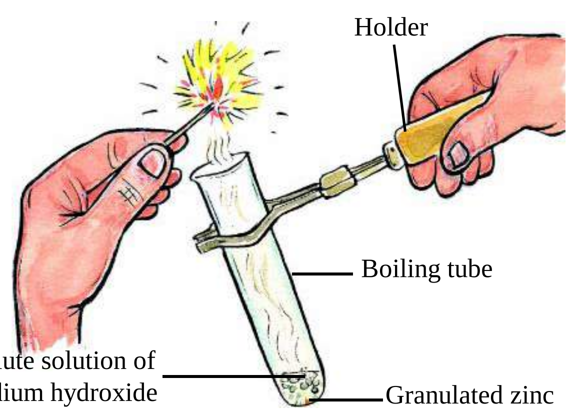


Figure-2 : Reaction of granulated zinc with dilute sodium hydroxide and test of H_2 gas

The reaction that takes place can be written as follows:

$$2NaOH(aq) + Zn(s) \xrightarrow{\text{warm}} Na_2ZnO_2(aq) + H_2\uparrow$$

Sodium hydroxide   *zinc*   *sodium zincate*   *hydrogen*

Some metals react with alkalis to form a salt with the evolution of hydrogen gas.

2.3.2 How do acids react with metal carbonates and metal hydrogencarbonates?

Let us first do an activity.

Activity-4

- Take about 0.5 g sodium carbonate in a test tube.
- Using a thistle funnel, add 2 mL dilute hydrochloric acid to the test tube (Figure-3).
- Do you notice any change?
- How will you test that the gas being produced is carbon dioxide?
- Repeat the activity by replacing sodium carbonate with sodium hydrogencarbonate.

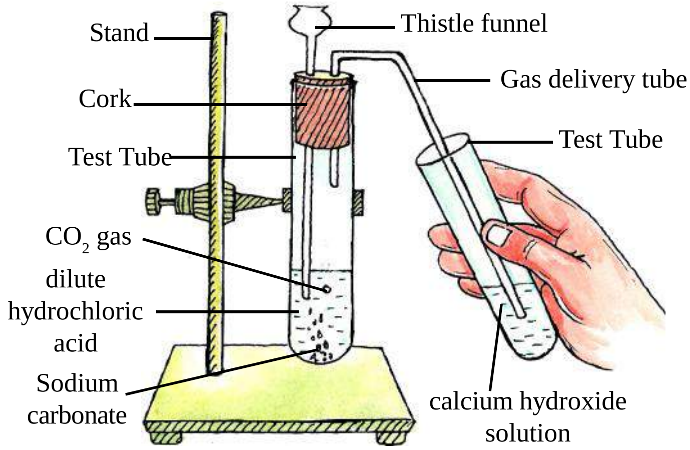


Figure-3 : Reaction of acid with metal carbonate and metal hydrogencarbonate

The chemical equations of the reactions taking place in activity-4 are as follows:

$$Na_2CO_3(s) + 2HCl(aq) \longrightarrow 2NaCl(aq) + H_2O(l) + CO_2\uparrow$$

$$NaHCO_3(s) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(l) + CO_2\uparrow$$

Sodium hydrogencarbonate

All metal carbonates and hydrogencarbonates react with acids to form the corresponding salt, carbon dioxide and water. We can summarize the reaction as follows:

Metal carbonate/ metal hydrogencarbonate + acid $\longrightarrow$ salt + carbon dioxide + water

2.3.3 How do bases react with non-metal oxides?

Non-metals such as carbon and sulphur react with oxygen to form carbon dioxide and sulphur dioxide respectively. Bases react with these non-metal oxides to form corresponding salts and water.

Non-metal oxide + base $\longrightarrow$ salt + water

Sulphur dioxide reacts with sodium hydroxide to form sodium sulphite and water.

$$SO_2(g) + 2NaOH(aq) \longrightarrow Na_2SO_3(aq) + H_2O(l)$$

Sodium sulphite

2.3.4 How do acids and bases react with each other?

We know that an acids and a base react to form a salt and water.

Acid + bases $\longrightarrow$ salt + water

Let us understand this more through an activity:

Activity-5

- Take 20 drops of dilute hydrochloric in a test tube and add 1-2 drops of phenolphthalein to it.
- With the help of a dropper, add dilute sodium hydroxide solution, drop by drop, to the above solution while continuously shaking the test tube. Keep adding sodium hydroxide till the colour of solution in the test tube become light pink.
- What is the reason for the change in colour of the solution?

We can write the equation for the above reaction as follows:

$$HCl(aq) + NaOH(aq) \longrightarrow NaCl(aq) + H_2O(l)$$

When a drop of alkali is added to acid, it reacts with some acid molecules to form salt and water. This is called neutralization. As we keep adding the alkali, it keeps on reacting with acid molecules. When all the acid molecules have reacted with the alkali molecules then the solution is neutral. As soon as we add another drop of alkali to the solution it becomes pink. Can you tell what will be the nature of this solution?

Questions

1. Explain the reaction between metals and dilute hydrochloric acids with the help of an example.
2. Write the balanced chemical equation of the reaction between calcium hydrogencarbonate and hydrochloric acid.
3. Give an example to show that non-metal oxides are acidic in nature.

2.3.5 Do acids and alkalis conduct electricity?

Let us do an activity to answer this question.

Activity-6

- Take 50 mL dilute hydrochloric acid in a 100 mL beaker.
- Fix 2 awl pins on a cork and place it in the beaker (Figure-4).
- Connect the awl pins to the two terminals of a 9 volt battery through a bulb and a switch as shown in the figure.
- Did the bulb light up and glow?
- Do the same activity using sodium hydroxide solution instead of hydrochloric solution.
- Did the bulb glow when you used sodium hydroxide solution?

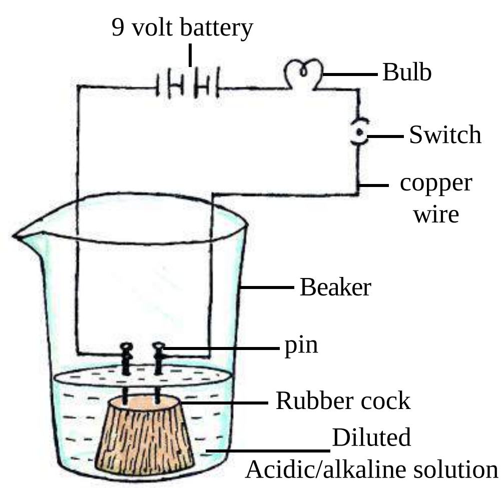


Figure-4: Electrical conductivity in acidic/alkaline solution

In class 9th we had performed a similar activity and seen that when electric current is passed through aqueous solution of an ionic compound, the bulb glows. We can conclude that ionic compounds dissociate into their ions in water which conduct electricity. Similarly, we can conclude from activity 6 that since solutions of acids and bases conduct electricity it shows that acids and bases also undergo ionization in water.

2.4 Ionization

From time to time, many scientists attempted to understand the behaviour of acids and alkalis in water. In 1884, the Swedish scientist Arrhenius used his observations to explain the special characteristics of acids and alkalis. According to Arrhenius, in aqueous solutions an acid molecule will dissociate into a positively charged hydrogen ion (H^+) and a negative ion. Similarly, in aqueous solutions an alkali molecule will dissociate into a negatively charged hydroxide ion (OH^-) and a positive ion. These ions are responsible for the flow of electric current.

Svante August Arrhenius (1859-1927)

He was a Swedish scientist who worked on the electrical conductivity of aqueous solutions of ionic compounds. He suggested that ionic compounds when dissolved in water dissociate into their ions which conduct electricity.

He explained the properties of acids and alkalis on the basis of formation of H^+ and OH^- ions respectively. He was awarded the Nobel Prize in 1903.

$$H_2SO_4 \longrightarrow 2H^+ + SO_4^{2-}$$

$$Ca(OH)_2 \longrightarrow Ca^{2+} + 2OH^-$$

Ionization mostly depends on the amount of a substance in solution (concentration) and its ability to dissociate into ions.

2.4.1 Are all hydrogen containing compounds acidic?

Activity-7

- Take 50 mL of glucose solution in a 100 mL beaker. Set up the apparatus in the same way as done in activity-6.
- Did the bulb glow?

In activity 6, when hydrochloric acid solution was taken, the glowing of bulb indicated that HCl molecules form H^+ ions on ionization. But glucose does not give H^+ ions. Therefore, not all hydrogen containing compounds are acidic.

2.4.2 Do acids produce ions only in aqueous solutions?

Activity-8

- Take about 1 g of sodium chloride in a clean and dry test tube.
- Add 1-2 mL of concentrated sulphuric acid to the salt along the sides of the test tube.

- Did you notice any gas coming out of the test tube?
- Place a dry blue litmus paper near the mouth of the test tube to test the gas.
- Did the blue litmus paper change its colour?
- Now, take a moist blue litmus paper near the mouth of the test tube.
- Did the moist blue litmus paper change its colour?

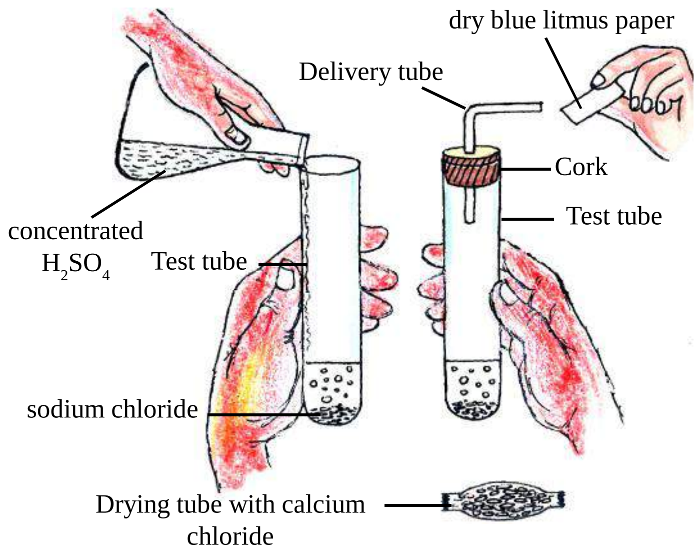


Figure- 5 : Test for HCl

Note for teachers:- If the climate is very humid, pass the gas produced through a drying tube containing calcium chloride to dry the gas.

Our observations show that HCl behaves like an acid only when it is in the presence of water because it can ionize to give H^+ ions when it comes in contact with water. Some compounds generate OH^- in water, they are called alkalis. For example, NH_4OH, NaOH are alkalis.

The extent of ionization of any base or acid decides whether it is strong or weak. The molecules of strong acids and bases ionize completely in water. On the other hand, the molecules of weak acids or bases ionize partially, that is, only a few of the molecules dissociate in water and most remain unionized.

Questions

1. Identify acids from the given compounds - HNO_3, Na_2CO_3, $Ca(OH)_2$, HCl
2. Sulphric acid is a strong acid while ammonium hydroxide is a weak base. Explain.
3. When some pellets of sodium hydroxide are place on red litmus paper then initially nothing happens but after some time the red litmus starts turning blue. Explain why.
4. The aqueous solutions of glucose and starch do not show acidic properties but that of sulphuric acid and acetic acid do. Why?

2.5 The strength of solutions of acids and alkalis

We know that presence of H^+ and OH^- ions decides whether a solution is an acid or an alkali. Can we count the number of ions present in a given solution? Can we judge how strong an acid or an alkali is?

What is pH scale?

In 1909, Danish scientist Sorensen developed pH scale to distinguish between the strength of acids and bases. Here, ´p´ stands for potenz (the German word for power). pH tells us the concentration of H^+ ions in a given solution. On the pH scale we can measure pH from 0 (very acidic) to 14 (very alkaline). We can think of pH as a number which indicates the acidic or basic nature of a dilute solution.

We use universal indicator, which is a mixture of several indicators, to find and compare the pH of different solutions. It tells us the strength of an acidic or basic solution. Universal indicator shows different colours at different concentrations of hydrogen ions in a solution.

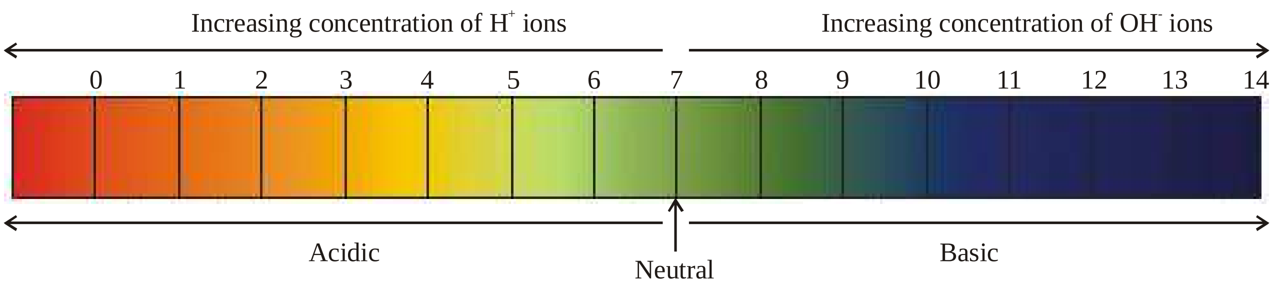


Figure-6: pH scale (colours are only a rough guide)

Activity-9

Test the solutions given in table-3 using red and blue litmus paper and universal indicator. Observe the colour changes and on this basis note down the pH and nature of solution in the table.

Table-3: Nature of solutions and pH value

S.No.	Solutions	Nature of solution as determined by litmus paper	pH value as determined by universal indicator
1.	Lemon juice		
2.	Milk		
3.	Tomato juice		
4.	Baking soda		
5.	Dilute hydrochloric acid		
6.	Dilute sodium hydroxide		
7.	water		
8.	solution of soap in water		
9.	copper sulphate		
10.	bleaching powder		
11.	ammonium acetate		
12.	common salt		

You know that pH is a measure of hydrogen ion concentration. In activity-9 we observed that even basic substances have a pH value. What does the hydrogen ion concentration in a basic solution imply? Let us understand.

Pure water ionizes partially, producing H^+ and OH^- ions:-

$$H_2O \rightleftharpoons H^+ + OH^-$$

Due to this partial ionization, all aqueous solutions have some H^+ and OH^- ions and therefore even acidic solutions have some OH^- ions and basic solutions have some H^+ ions.The number of H^+ and OH^- ions is inversely related. This means that if the number of H^+ ions in a solution is more, the number of OH^- ions will be less. Conversely, if the concentration of OH^- ions is more, that of H^+ ions will be less.

As shown in table-4, pH depicts the relative values of H^+ and OH^- ions.

At 25°C, equal amounts of H^+ and OH^- ions are present in pure water. In table-4, we can see that at pH 7, the concentration of H^+ and OH^- ions is equal (10^{-7}mol/L).In this way, pH 7 stands for neutral solutions. A pH value of less than 7 shows acidic nature and more than 7 shows that the solution is basic.

Table-4: Concentration of H^+ and OH^- ions and pH value

Increasing acidic nature ← → **Increasing basic nature**

pH value	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
H^+ mol/L	10°	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}	10^{-8}	10^{-9}	10^{-10}	10^{-11}	10^{-12}	10^{-13}	10^{-14}
OH^- mol/L	10^{-14}	10^{-13}	10^{-12}	10^{-11}	10^{-10}	10^{-9}	10^{-8}	10^{-7}	10^{-6}	10^{-5}	10^{-4}	10^{-3}	10^{-2}	10^{-1}	10°

2.6 Importance of pH in our daily lives

pH value of a substance helps us in understanding its acidity or basicity. There are many fluids in our body with a very specific, fixed pH and the bio-chemical processes in our body are also pH dependent. pH of soil and water also play an important role in our life. Let us understand through some examples:

1. pH and the process of digestion: Our stomach secretes dilute hydrochloric acid but the acid does not harm the stomach. In fact, it helps in digestion of food. When too much acid is produced in the stomach it causes indigestion and the sufferer feels acidity and pain. Antacids such as weak bases are used to neutralize excess acid in the stomach.

2. pH of blood and life-processes: The pH of our blood is in the range 6.8 to 7.8. This pH is optimum for life processes because proper equilibrium of chemicals present in blood plasma and serum is maintained within this range. For example, in acidic pH the shape of hemoglobin molecules changes and they are not able to take in oxygen properly; so the pH of blood should not fall below this limit, that is, it should not become acidic.

3. pH of saliva: Our teeth enamel is made of calcium phosphate, a hard substance that does not dissolve in water. But when the pH of the saliva in our mouth falls below 5.5, then our teeth start decaying. To prevent this, we should brush our teeth daily with a basic toothpaste.

4. Self defense of animals and plants and pH: Some plants such as the nettle plant have thin, stinging hair or fur. When humans or other animals come in contact with these stings, the stinging hair inject formic acid that causes pain and a burning sensation. So, animals leave the plants alone and they are not eaten. Bees and wasps also secrete an acid when they sting us, causing pain and burning. This is how animals and plants protect themselves.

5. pH of soil and crop production: Ideal soil for cultivation of paddy should have pH between 5 and 8. When the pH is above or below this level farmers add fertilizers or lime or ash to it so that crop production is not affected.

The colour of the flower of the hydrangea plant depends on the pH of the soil in which it is cultivated. When the soil is acidic, the flowers are blue and when it is slightly alkaline they are pink.

Questions

1. Are H^+ ions present in basic solutions? If yes, then why is the solution basic?
2. You have two solution "A" and "B" in water. The pH value of solution "A" is 6 and that of "B" is 8. Which solution will have a higher concentration of hydrogen ions? Which one of the solutions is acidic and which is basic?
3. When Julie tested solutions "A", "B", "C", "D" and "E" using a universal indicator, she got pH values of 9,7,1,13, and 6 respectively. On this basis can you tell which solution-

   (a) Is a weak acid (b) Is a weak base (c) Is a strong acid

   (d) Is a strong base (e) Is neutral
4. On the basis of the numbers given in question 3, arrange the solutions in increasing order of hydrogen ion concentration.

2.7 Salts

We know that acids produce H^+ ions and alkalis produce OH^- in the presence of water. When acids and bases react with each other, these H^+ and OH^- ions together give water molecules along with the production of a salt. Salts are ionic compounds in which one part is positively charged and the second part is negatively charged. The number of positive ions is equal to the number of negative ions and as a result salts are electrically neutral. Salts can be prepared by many methods. Neutralization reaction between an acid and a base is one of the most popular ways of preparing salts.

$$HNO_3(aq) + KOH(aq) \longrightarrow KNO_3(aq) + H_2O(l)$$
Nitric acid + *potassium hydroxide* → *potassium nitrate* + *water*

$$H_2SO_4(aq) + Cu(OH)_2(aq) \longrightarrow CuSO_4(aq) + 2H_2O(l)$$
Sulphuric acid + *copper hydroxide* → *copper sulphate* + *water*

$$CH_3COOH(aq) + NaOH(aq) \longrightarrow CH_3COONa(aq) + H_2O(l)$$
Acetic acid + *sodium hydroxide* → *sodium acetate* + *water*

$$CH_3COOH(aq) + NH_4OH(aq) \longrightarrow CH_3COONH_4(aq) + H_2O(l)$$
Acetic acid + *ammonium hydroxide* → *ammonium acetate* + *water*

In the reactions given above, we can see that the positively charged part of the salt, comes from the base and is called basic radical and the negatively charged part comes from the acid and is known as acidic radical. For example, in potassium nitrate (KNO_3), K^+ is the basic radical and NO_3^- is the acidic radical.

2.7.1 Are all salts neutral?

In activity-9, we found pH values of salts such as common salt, ammonium acetate, baking soda and copper sulphate. How many of them had pH value equal to 7?

If all salts are formed by neutralization reaction between acids and bases, then why do different salts have different pH values? To answer this, we will need to understand the nature of the acidic radical and basic radical in each salt. In common salt, the basic radical (Na^+) is from strong base sodium hydroxide (NaOH) and the acidic radical (Cl^-) is from strong acid hydrochloric acid (HCl). The salts formed by the neutralization reaction between a strong acid and a strong base are neutral in nature. See table-5 to understand the nature of other salts.

Table-5: Nature of salts

Formula of salt	Source of basic radical		Source of acidic radical		Nature of salt
	Formula of source	Nature of source	Formula of source	Nature of source	
$CuSO_4$	$Cu(OH)_2$	weak	H_2SO_4	strong	acidic
$NaHCO_3$	NaOH	strong	H_2CO_3	weak	basic
CH_3COONH_4	NH_4OH	weak	CH_3COOH	weak	neutral
NH_4Cl	?	?	?	?	?
KNO_3	KOH	strong	HNO_3	strong	?

We find that the nature of salt formed between a strong base and a weak acid is basic and that formed by reaction between strong acid and weak base is acidic. The nature of salt formed by neutralization reaction of weak acid and weak base is also neutral.

2.8 Acid Rain

Usually, the pH of rain water is 7. But when different gases present in the atmosphere dissolve in it, the pH of rain water becomes less than 7. When pH of rain water is less than 5.6, it is called acid rain. Carbon dioxide, sulphur dioxide (SO_2) and the oxides of nitrogen produced during fuel combustion are the main cause of acid rain. The gases produced during decomposition of vegetation and volcanic explosions are another factor. These gases dissolve in water to produce carbonic acid, sulphuric acid and nitric acid.

$$CO_2 + H_2O \longrightarrow H_2CO_3$$
$$2SO_2 + O_2 \longrightarrow 2SO_3$$
$$SO_3 + H_2O \longrightarrow H_2SO_4$$
$$3NO_2 + H_2O \longrightarrow 2HNO_3 + NO$$

Acid rainfall damages plants, animals and buildings.

Questions

1. Identify the acidic and basic radicals in each of the given salts:

   NH_4Cl, KNO_3, $(NH_4)_2CO_3$, $CuSO_4$

2. What will be the nature of an aqueous solution of potassium chloride? Explain.
3. How does excess of carbon dioxide, sulphur dioxide and oxides of nitrogen in the atmosphere effect life?

What we have learnt

- Indicators react with acids and bases to form new substances which are responsible for change in colour of indicator.
- Blue litmus becomes red in the presence of acid and red litmus becomes blue in the presence of a base.
- We can use different flowers and leaves - such as hibiscus flower, rose, red cabbage, turmeric, kachnaar flower - found in nature as indicators.
- There are some substances that change their odour in the presence of an acid or a base. These are known as olfactory indicators, for example, clove oil, onion juice, vanilla etc.

- Acid and bases reacts with a metal to give corresponding salt with evolution of hydrogen gas.
- When an acid reacts with a metal carbonate or metal hydrogencarbonate, it gives the corresponding salt, carbon dioxide gas and water.
- Bases react with non-metal oxides to give a salt and water.
- Acids and bases react with each other to form corresponding salts and water, this reaction is known as neutralization.
- Acid and alkali solution in water conduct electricity because they ionize into their ions. An acid dissociates into H^+ and a negative ion and an alkali dissociates into OH^- and a positive ion.
- pH value is used to show the amount of hydrogen ions (H^+) in dilute solutions on a scale of 0 to 14.
- A neutral solution has a pH of 7, while an acidic solution has a pH less than 7 and a basic solution has a pH of more than 7.
- The negative part of a salt comes from a base and is known as a basic radical and the positive part comes from acid and is known as acidic radical.
- Salts can be acidic, basic or neutral in nature.

Keywords

Antacid, base, alkali, indicator, olfactory indicator, neutralization reaction, acid rain, acidic radical, basic radical.

Exercises

1. Choose the correct option

    (i) In lemon juice

    (a) H^+ ions are more, OH^- ions are less

    (b) H^+ ions are less, OH^- ions are more

    (c) H^+ ions and OH^- ions are equal

    (d) Only H^+ ions are present

    (ii) When an acid reacts with a metal carbonate then we get-

    (a) Salt and water

    (b) Salt and water and carbon dioxide

    (c) Salt and sulphur dioxide

    (d) Salt and hydrochloric acid are

(iii) Which among the following is not a strong acid

(a) HCl (b) HNO_3

(c) CH_3COOH (d) H_2SO_4

(iv) The pH of a neutral solution is

(a) 1 (b) 0

(c) 14 (d) 7

(v) Sakina has a burning sensation in her stomach due to acidity; she needs

(a) A strong acid (b) A strong base

(c) A weak base (d) A weak acid

(vi) The cause of tooth decay is pH of saliva

(a) Being less than 6.5 (b) Becoming 7

(c) Being less than 5.5 (d) Being more than 6.5

(vii) Which of the following salts is acidic in nature

(a) NaCl (b) Na_2SO_4

(c) NH_4Cl (d) KNO_3

2. Write the names of any two acids found in the food that we eat.
3. How do we distinguish between acids and bases using an olfactory indicator?
4. The pH of fresh milk is 6. What will be the pH when it sets into curd/yogurt?
5. You have been given three test tubes. One of them has distilled water and of the remaining two, one has an acid and the second has a basic solution. If you only have red litmus paper then how will how identify the nature of solutions in each of the test tubes?
6. During an experiment, Neelam and Manish added concentrated sulphuric acid to dry (anhydrous) sodium chloride. A gas evolved during the reaction. When Manish placed a dry blue litmus paper near the mouth of the test tube nothing happened but when he placed a moist blue litmus paper, it became red. Explain why.
7. Some substances and their pH values are given in the table. Analyse the data in the table and answer the following questions:

(a) Which of the substances are basic in nature?

(b) Which of the substances are acidic in nature?

(c) Which of the substances are neutral?

Substance	pH value
Solution of baking soda	8.2
Lemon juice	2.2
Vinegar	5.5
Sodium hydroxide solution	13
Water	7

8. Acids "A" and "B" were taken in two beakers. Acid "A" ionizes partially in water while acid "B" ionizes completely. On this basis, tell:
   (a) Which among "A" and "B" is strong acid and which is weak?
   (b) What is a weak acid?
   (c) What is a strong acid?
   (d) Give examples of both strong and weak acids.
9. Which gas is usually displaced during reaction between acids and a metal? How will you test this gas? Take the example of magnesium metal to explain.
10. When an egg shell is reacted with dilute hydrochloric acid, foaming is observed and an effervescent gas is produced. Once foaming subsides, a lighted *agarbatti* is extinguished on placing it inside test tube. Explain the following in the given activity:
    (a) Procedure or steps followed in the activity
    (b) Draw the picture of the experimental set-up
    (c) Write the balanced chemical equation of the reaction taking place
11. The pH of soil in Tikeshweri's field is 4.2. How can she control the pH of her soil so that she gets a good paddy crop?
12. What is neutralization reaction? Explain and give two examples.
13. Samaru added baking soda to raw milk so that its pH changed from 6 to 8. This milk will take longer to change into curd; why?
14. What is a salt? How is the nature of a salt determined? Take NH_4NO_3 and Na_2CO_3 as examples and explain.

CHAPTER 3

HEAT AND TEMPERATURE

Words like hot and cold are of great importance in our daily life. The temperature of our environment should be such that it allows us to perform our daily work with ease. To keep food fresh the temperature should be low, while to cook it the temperature needs to be high. During hot summer days we need to switch on the fans, while during winters we need blankets. We always like our tea hot, while we enjoy juices as cold. Hence regulating temperature and heat is of much importance for several necessities of our life.

3.1 Hot or cold?

Hot and cold- are these two words sufficient to tell about the temperature of an object? What would you say after touching warm water? It is colder than hot water but warmer than cold water. On keeping hot milk at room temperature you see that it becomes cold after same time. Is it as cold as the milk taken out of a refrigerator?

Just by touching, sensing or seeing we cannot say how much hot or cold an object really is. Our sensitivity towards temperature is not only unreliable but also very limited. Especially for industrial and scientific purpose nobody would like to touch and try to tell the exact temperature of boiling water.

Ordinarily we express temperature comparatively but due to above reasons we had to develop such techniques and instruments by which we could make correct precise and objective measurements for temperature.

3.1.1. Temperature

We know that hot objects can be cooled down while cold objects can be heated too. Can you tell some such examples from your daily life? Discuss amongst yourself.

Analyze the following diagram and state whether hot and cold are two different divisions.

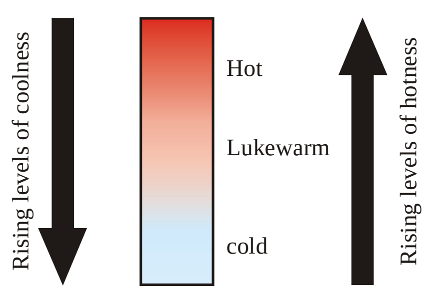


Figure-1: Cold, warm and hot shown on the same scale

As you can see, hot and cold are not two different categories. These two are values on the same measurement scale, one small and another big. We can also say that all objects are hot, some lesser hot while others hotter or it can also be said that all objects are cold, some lesser cold while other colder.

This degree of hotness or coldness is called temperature and its value keeps changing constantly. When we compare the temperature of two objects then the object having higher temperature is called hot and the object with lower temperature is called cold.

3.1.2 How to measure temperature?

To measure the temperature of an object we need following three things.

1. Some property of an object which depends on temperature and which clearly changes with temperature.
2. A material that clearly represents a change in this property and,
3. A universal and commonly used measurement that shows this corresponding change with specific increase or decrease.

If these three conditions are fulfilled then you can make your own thermometer. Thermometers are used in laboratories, hospitals, weather departments etc.

Activity-1: Make your own thermometer

Required material: A small injection bottle, a 10 cm long piece of empty refill, scissors, ink, tap water, candle.

Procedure: Make a small hole in the cap of the bottle using the tip of a scissor. The hole should be just big enough to let the refill pass. Now fill the bottle with tap water up to half and add few drops of ink. Now put the cap on and push the refill inside such that it does not touch the base of bottle. Now close the cap. Completely seal the cap by dropping molten wax from burning candle so that no air can escape from the bottle. Heat your hands by rubbing them together and cover the bottle with your hands (Figure-2). Does the level of water increase in the refill? Why did it happen?

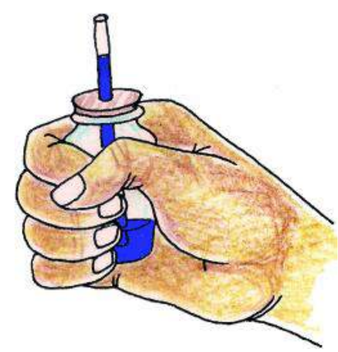
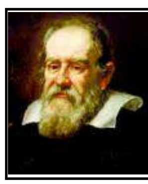


Figure-2: Homemade thermoscope



Galileo is called 'Father of Modern Physics', 'Father of Science' etc. In 1593 he created the first Thermoscope.

This type of temperature measuring device is called as 'Thermoscope' because it does not have a measuring scale as present in thermometer. The change in temperature is shown only through the increase and decrease in the level of liquid filled. It was invented by Galileo. By placing warm hands on the outer surface of a thermoscope, the air inside the bottle gets warmed up and expands. As the bottle is tightly sealed, the warm air exerts pressure on the liquid and forces it to rise up in the straw.

Measuring temperature through volumetric of a liquid expansion is the simplest method for us.

A doctor's thermometer is also based on the same principle. Note down the temperature of hot water, sand, ice etc. using a laboratory thermometer. To understand the structure and method of use of thermometer see instruments used in practical work section given at the end of the book.

3.1.3 Scales of temperature

There are three popular scales for measuring temperature are Fahrenheit,Celsius and Kelvin.

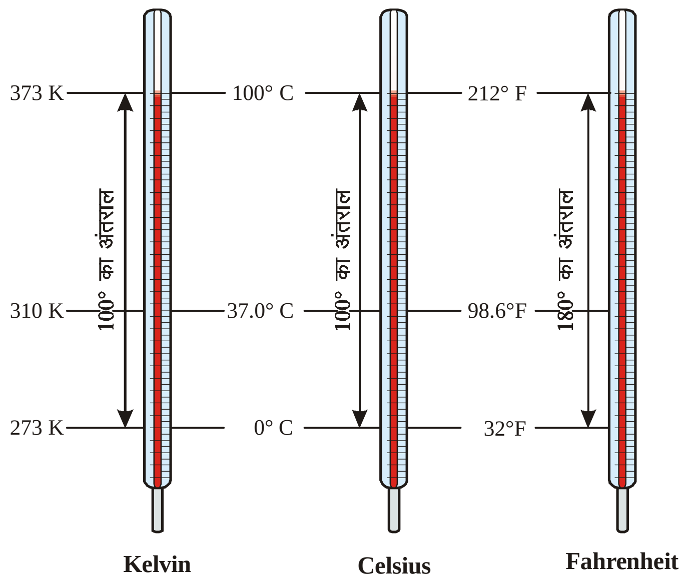
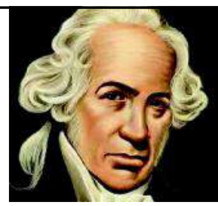


Figure-3: Celsius, Kelvin and Fahrenheit scales



Daniel Gabriel Fahreinheit (1714) is credited with the invention of mercury thermometer.

In Fahrenheit scale– boiling point of water (temperature at which water turns into steam) is 212°F and freezing point of water (temperature at which water turns into ice) is 32°F. This difference in maximum and minimum temperature is divided into 180 similar divisions.

Similarly in Celsius scale boiling point of water is marked at 100°C and freezing point of water is marked at 0°C. Here the difference between the minimum and maximum temperature is divided into 100 similar divisions.

Relation between scales of temperature can be established as following-

$$\left(\frac{\text{Temprature scale - freezing point}}{\text{Boilingpoint - freezingpoint}}\right)\text{of first thermometer} = \left(\frac{\text{Temprature scale - freezing point}}{\text{Boiling point - freezing point}}\right)$$

(eq. 1)

Let us understand this through a solved example-

Example: Our normal body temperature is said to be 98.6° F. What is its value in Celsius?

Solution: $\frac{F-32}{212-32} = \frac{C-0}{100-0} =$ from eq. (1)

$$\Rightarrow \quad \frac{F-32}{180} = \frac{C}{100}$$

$$\Rightarrow \quad \frac{F-32}{9} = \frac{C}{5}$$

$$\Rightarrow \quad \frac{5}{9}\left(F-32\right) = C$$

Therefore 98.6° F in Celsius is

$$C = \frac{5}{9}(98.6\text{–}32)^\circ$$

$$C = \frac{5}{9}(66.6)^\circ$$

$$C = 37^\circ$$

98.6°F = 37°C is the normal temperature of human body.

In the same way, freezing point of water in Kelvin scale is 273 K at normal pressure and boiling point of water is 373 K. In this scale the minimum and maximum temperature is divided into 100 equal divisions.

Example: If the temperature of a room is 0° K, what is its temperature in Celsius scale.

Solution: $$\frac{K-273}{373-273} = \frac{C-0}{100-0}$$

$$\frac{K-273}{100} = \frac{C}{100}$$

Therefore K–273 = C .... $\boxed{\text{or} \quad K = C + 273}$

Hence C = 0 – 273

= –273

0K or –273° C is also called as absolute zero because temperature below this cannot be attained. This is the least temperature that we can possibly achieve.

Think

The temperature of a substance is T. If we divide the substance in 2 equal parts, does the temperature get divided into two? Similarly if the temperature of two equal quantities of substance is T each does the temperature get double when we add both the quantities? Discuss this with your friends.

3.2 Heat

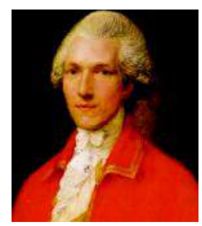
If a small utensil of hot water is kept inside a large utensil of cold water then we see that very soon the hot water gets colder and the cold water gets warmer. After some more time, the temperature of both becomes equal. You must have experienced this in your daily life. To save food from spoiling the utensil is kept inside another utensil containing cold water.

When two objects having two different temperatures are brought in contact then the temperature of each of them increases or decreases until it becomes equal. You must have noticed this. But have you ever thought that why and how this happens? What is the reason behind this increase or decrease in values of temperature?

Earlier it was believed that when two objects at different temperatures are brought together, exchange of an invisible fluid takes place. Quantity of this fluid was assumed to be greater in hotter objects as compared to colder objects. Therefore it was believed that a flow of this fluid takes place from hotter to colder object until both objects have the same amount of this fluid. This fluid was called 'caloric'. People thought that on increasing the quantity of caloric, temperature increases.

How was the theory of 'Caloric' falsified?

Benjamin Thomson (1753-1814) who was later known as Count Rumford was a renowned scientist and a military advisor.



Count Rumford

A special kind of a machine having metal cutters was used to make holes in military cannos. These special cutters were rotated using horse-power. While boring a hole, the machine used to get very hot due to friction. According to the Caloric theory, on boring the caloric inside the cannons would start seeping into the barrels making them hot. But Rumford did not agree with this explanation. He carried out several experiments to test the caloric theory and found that metals could produce heat due to friction without undergoing any change. Production of heat did not affect mass of the metal. He concluded that the movement of horses that provided the power to bore cannons was also the source of heat produced during boring. This means that it was horse power that was converted into heat by friction. In 1798 he proposed that heat could not any material but was a form of energy. Newton had also held a similar view. Joule's experiments in 1840-50 also proved this point. Joule demonstrated an equivalence between mechanical energy and heat energy and you will study more about this in higher classes.

Today we know that heat is not a substance. Rather, it is a form of energy that causes change in temperature. The type of energy which lets us feel the hotness of a object is called heat energy. Heat energy always flows from an object at high temperature to a object at low temperature. On increasing the heat, the temperature of an object increases while on decreasing the heat, its temperature decreases. Hence on adding heat, temperature increases while on removing heat, temperature decreases.

Discuss

Why does an object feel hot or cold upon touch? On touching with your hands what happens to the direction of flow of heat in both the situations?

Units of heat energy

1. In C.G.S. the unit of heat is calorie (Cal). 1 calorie heat is the amount of heat required to raise the temperature of 1 g of water from 14.5°C to 15.5°C. In place of calorie another unit called kilo calorie (kcal) can also be used. 1 kcal = 1000 cal.
2. As heat is a from of energy, therefore the S.I. unit of heat is Joule.

   1 calorie = 4.18 Joule

   1 kilo calorie = 4.18 × 1000 Joule

3.2.1 Transfer of heat

We saw that just as a liquid always flows from higher level to lower level, heat energy also flows from an object at higher temperature to an object at lower temperature. The transfer of heat from one place to another due to difference in temperature is called heat transfer.

In class-9 you have studied about sound and that the transfer of sound always requires a material medium.

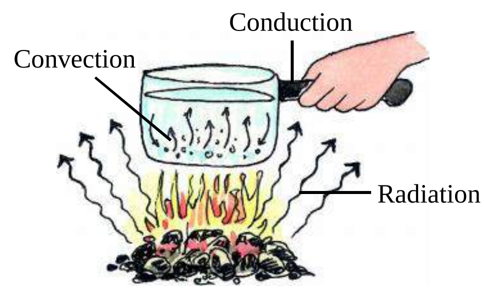


Figure-4: Three types of heat transfer

Does the transfer of heat always require a material medium?

Come, let us know about the three types of heat transfer (figure-4).

1. Conduction

Activity-2

Materials required: Candles, a rod of aluminum, glass & wood rods (each of same length and thickness), awl-pins.

On each rod, stick awl-pins at regular distances using wax work. Tie a piece of cloth at one end of the rod, so that it is easier to hold it on heating. Put the other end on the flame of a candle and heat it. What do you see (figure-5 (a))?

Note down the time at which the awl-pins fall. Do this for every rod. Can you tell from which rod did the awl-pin fall first and why?

Now stick awl-pins on a rod such that the space in middle is empty. Stick the pins at regular gaps on both sides (figure-5 (b)). Now, what happens when you heat the rod from the middle? From which direction do the awl-pins fall first? What can you say about the direction of heat transfer?

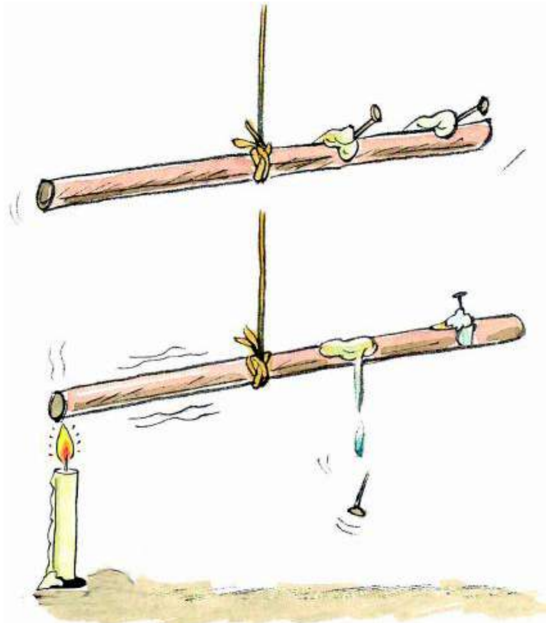


Figure-5(a)

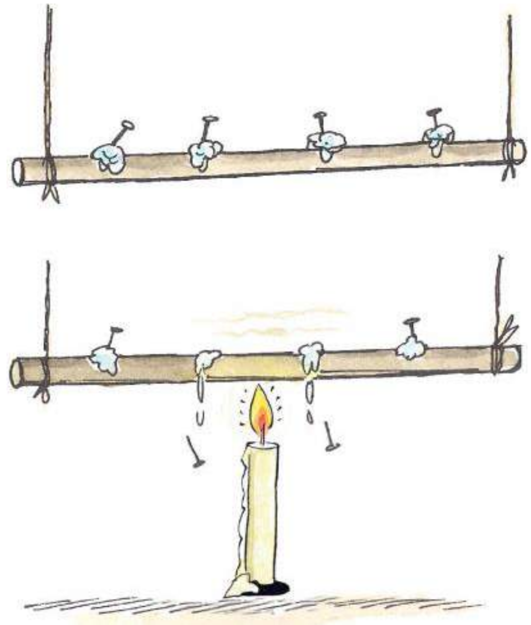


Figure-5(b)

In the process of conduction, heat transfer takes place from one molecule of the substance to another molecule without any actual movement of these molecules. You saw that on heating one end of a metal rod, the other end gets hot very quickly. On heating up, the molecules in that part of the rod start vibrating fast and their heat energy increases. These vibrating molecules pass on the energy to the next molecules. This is the only method by which heat transfer takes place in solids.

Heat transfer through conduction is called heat conductivity. It depends upon the nature of a substance. Based on heat conductivity, substances can be classified into three types-

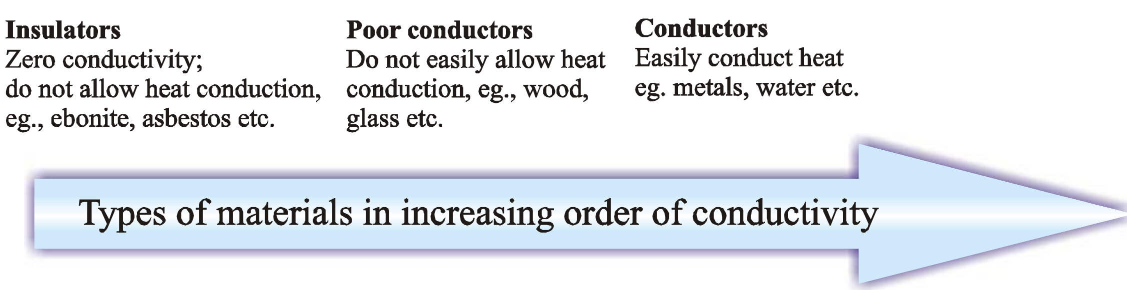


Figure-6: Materials can be insulators, poor conductors or good conductors

2. Convection

Activity-3

Procedure: Fill a flask with water and heat it on a spirit lamp. Add few drops of ink in the flask. Can you see convection currents?

On heating a liquid in a flask, the liquid near the base warms up quickly, becomes lighter and rises up. Its place is taken by the heavier, colder liquid. This process continues till the temperature of the whole liquid is same. This way, convection currents are produced. Heat transfer in gases and liquids take place in the same way.

Question: Can you explain why heat transfer cannot take place by the process of convection in solid substances?

You can observe convection process in several natural phenomena.

The sand on the river coast gets warm during day time.

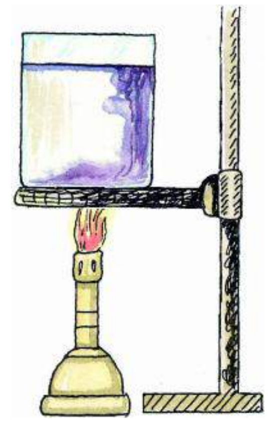


Figure-7: Convection lines will look like this

This results in warming up of the air above the warm sand. This warm air rises up and is replaced by cold breeze coming from the sea. In a similar way, the sand gets colder during night-time while the air above the sea water is warmer. This warm air above sea rises and is replaced by the colder air from the sand. This way, the cycle of land breeze and sea breeze continues.

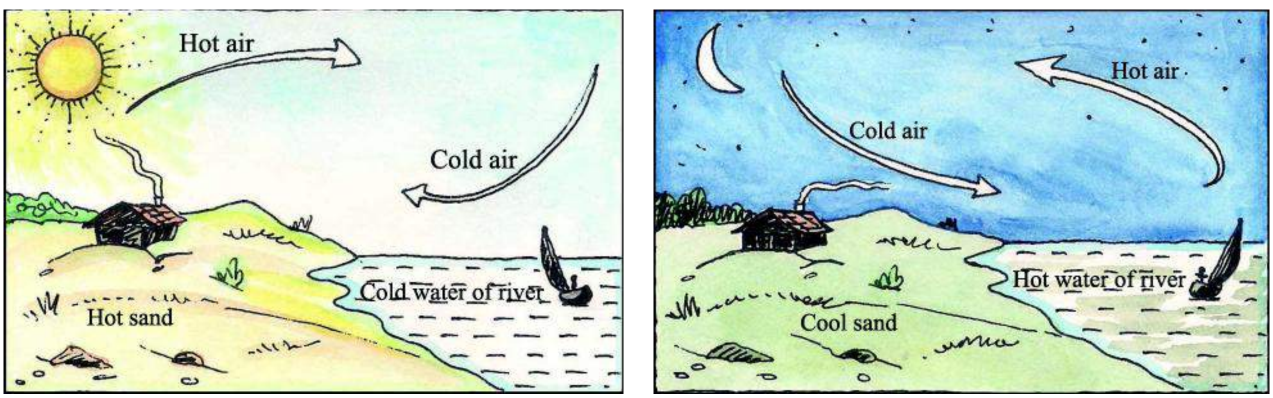


Figure-8: Wind cycle

3. Radiation

Does the transfer of heat energy always require a material medium? Think about the heat obtained through the sun. Air is absent in space, then how do we receive the heat from the sun?

Like light energy, transfer of heat energy can also take place in vacuum. Through radiations, heat travels in a straight line just like light.

Heat is transferred in all directions uniformly. To see this, put your hands around a bulb, lantern or a lamp. You will feel equal warmth in all directions.

When heat energy reaches an object through radiations, then same amount of heat is absorbed by the object and is called as a good absorber. A good absorber of heat is also a good emitter of heat.

Think

Why do we wear light colored cloths during summers and dark colored cloths during winters?

You will find the answer to this question through the following activity.

Activity-4

Materials required: A utensil painted with black color, a similar shiny utensil (of steel) and another earthen utensil.

Procedure: Fill the 3 utensils with water and put them in sunlight. After some time, note down the temperature of water in all three utensils using a thermometer. Which utensil has water with highest temperature and which one has lowest temperature water?

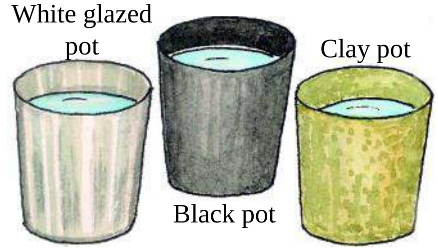


Figure-9: Heat emission and absorption of the object depends on its color and nature.

In the same way put all the three utensils in a cold place. The temperature of which utensil reduces the fastest? You may notice that the absorption and emission of heat depends on two factors (1) on the temperature of object and (2) on the color of the object or its surface (smooth or rough).

3.2.2 Effects of heat

We cannot see the transfer of heat energy is our daily life but we can at least experience its effects. On giving heat, the temperature of an object increases. The increase in temperature depends upon the amount of heat obtained and it leads to expansion of substances. This can also lead to change in the state of substances.

1. Increase in temperature

Have you ever thought that why an iron bench gets hotter than a wooden bench when both are kept under the sun? The sand near a river gets warmer than the river water.

On heating up an object, it absorbs heat and its temperature increases. On cooling down, the object releases heat and its temperature falls. To equally raise the temperature of different substances of same mass, we need to provide different amounts of heat. The quantity of heat (Q) absorbed and emitted by an object depends on the following-

1. On the mass of substance $Q \alpha m$ ....(1)
2. On the change of temperature $Q \alpha \Delta T$ ....(2)
3. On the nature of the material

Hence, $Q \alpha m. \Delta T$

$Q = m.S. \Delta T$ ....(3)

When S is proportionality constant and its value depends upon the nature of the substance. This is known as the specific heat or specific heat capacity of the material.

From equation (3)................ $S = Q/m \Delta T$

S.I. unit of specific heat is Joule/kg/°C.

Therefore, the specific heat capacity of any substance is the amount of heat required to raise the temperature of one unit substance by one degree. The substances with higher specific heat capacity take longer to heat up and to cool down.

Similarly, substances with low specific heat require less time to heat up and to cool down.

Think

What could have happened if all substances had same specific heat capacity? Discuss.

If $m = 1$, $\Delta T = 1$ Then $S = Q$

Question

- Can you tell why water is used to extinguish a fire? (Note:- Only when the fire is not caused because of electric short circuits).
- If 487.5 J of heat is supplied to raise the temperature of 25 g copper from 25° C to 75° C then what is the specific heat of copper expressed in J/g° C.

Solution: We know that-

$Q = mS.\Delta T$

So, $487.5\text{ J} = (25\text{g.}) \times S \times (75°C - 25°C)$

$487.5\text{ J} = 25\text{g} \times 50°C \times S$

$$S = \frac{487.5\text{J}}{25\text{g} \times 50°C} = 0.39\text{ J/g°C}$$

Heat Capacity

The quantity of heat required to raise the temperature of the entire mass of the substance by 1°C is called heat capacity.

If the mass of the substance is 'm' and its specific heat is 'S', then,

Heat capacity = mass × specific heat

$= m \times S$

Unit of heat capacity is J/° C

Equivalent temperature of a mixture

Suppose, you have taken water for bathing in two buckets. One of the buckets contains hot water and the other contains cold water. The temperature of water in one bucket water is 80°C and in the other is 20°C. Now in a third bucket add 1 *l* hot water and 1 *l* cold water. What will be the temperature of this mixture of water?

Here, the specific heat of water in both the cases is same.

Hence $S_1 = S_2 = S$

If the temperature of the mixture is t, then

The heat given out by hot object $= m_1 \times S_1 \times$ fall in temperature in temperature [Mass of hot water is m_1 and its initial temperature is t_1]

$= m_1 S_1 (t_1 - t)$

Heat absorbed by colder object $= m_2 \times S_2 \times$ rise in temperature $= m_2 S_2 (t - t_2)$ [Mass of cold water is m_2 and its initial temperature is t_2]

According to the law of energy conservation, heat taken by the mixture = heat emitted by the mixture

$$m_1 \times S_1 \times (t_1 - t) = m_2 \times S_2 \times (t - t_2)$$

$$m_1 \times \cancel{S} \times (t_1 - t) = m_2 \times \cancel{S} \times (t - t_2) \qquad [S_1 = S_2]$$

Hence, equivalent temperature $t = \dfrac{m_1 t_1 + m_2 t_2}{m_1 + m_2}$

$$\Rightarrow \quad \frac{1\times 80 + 1\times 20}{1+1}$$

$$\Rightarrow \quad \frac{80+20}{2}$$

$$\Rightarrow \quad \frac{100}{2}$$

$$\Rightarrow \quad 50°C$$

Therefore, the temperature of this mixture of water will be 50° C.

2. Thermal expansion

You must have noticed that when we pour boiling water in glassware, there is a possibility that the glassware might break. This happens because the internal surface of the glassware expands on receiving heat but outer layer does not.

Discuss

Why are telephone and electrical wires tied loosely? Why is a small gap left between each concrete block when placing them while the making a road? Discuss more such examples.

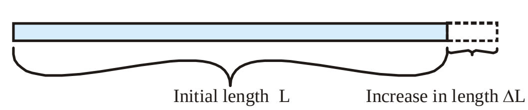
Generally, on providing heat to a substance, its volume increases and on obtaining heat from a substance, the volume decreases.

Heat expansion in a solid substance

1. Coefficient of linear expansion

The expansion in the unit length of an object, which occurs on raising the temperature by 1°C is called, coefficient of linear expansion. This is denoted by 'α'.

$$\alpha\uparrow= \frac{\text{Increase in length}}{(\text{initial length} \times \text{increase in temperature})}$$



$$\alpha\uparrow= \frac{\Delta L}{L \times \Delta T}$$

Figure-10(a): Coefficient of linear expansion $\alpha = \dfrac{\Delta L}{L\times\Delta T}$

Hence, $\Delta L = \alpha\,(L \times \Delta T)$

Increase in length = coefficient of linear expansion × (initial length × increase in temperature)

The unit of thermal expansion is per degree Celcius. Coefficient of linear expansion for iron is 0.00012/° C. Therefore, on raising the temperature by 1°C the length of a 1 m long iron rod increases by 0.00012 m.

2. Coefficient of superficial expansion

The expansion in the area of an object which occurs on raising the temperature of a unit area by 1° C is called coefficient if superficial expansion. This is denoted by 'β'.

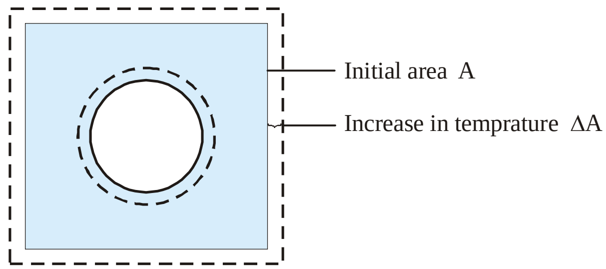


Figure-10(b): coefficient of superficial expansion b = $\frac{\Delta A}{A \times \Delta T}$

$$\beta = \frac{\text{Increase in area}}{\text{initial area} \times \text{increase in temperature}}$$

$$\beta = \frac{\Delta A}{A \times \Delta T}$$

Hence, $\Delta A = \beta (A \times \Delta T)$

Increase in area = coefficient of superficial expansion × (initial area × increase in temperature)

Unit of β is also /°C. Coefficient of superficial expansion (β) is twice that of the coefficient of linear expansion which means β = 2 α

3. Coefficient of volumetric expansion

The expansion in the volume of a substance, which occurs on increasing the temperature of a unit volume by 1°C, is called coefficient of volumetric expansion. This is denoted by 'γ'.

$$\text{Coefficient of volumetric expansion} = \frac{\text{Increase in volume}}{\text{initial volume} \times \text{increase in temperature}}$$

$$\gamma = \frac{\Delta V}{V \times \Delta T}$$

$$\Delta V = \gamma (V \times \Delta T)$$

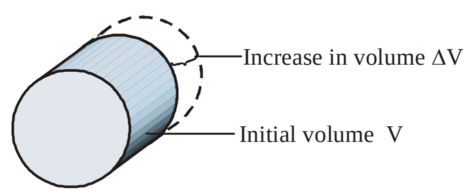


Figure-10(c): coefficient of volumetric expansion $\gamma = \frac{\Delta V}{V \times \Delta T}$

Increase in volume = coefficient of volumetric expansion (initial volume × increase in temperature)

Unit of γ is also /° C. Coefficient of volumetric expansion (γ) is thrice of the coefficient of linear expansion α

Therefore, α =2β = 3γ

Activity -5: Nail and a loop

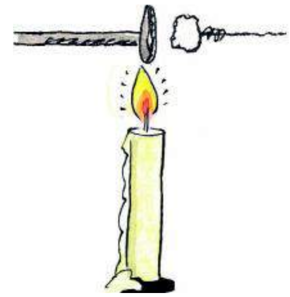


Figure-11: Expansion in volume of solids

Make a loop from a wire such that the head of your nail can easily pass through it. Now heat the head of the nail taken. Can you still easily pass the head through the same loop?

Discuss amongst yourself, why did this happen.

Heat Expansion in Liquids

You know that liquids do not have a definite shape. They take the shape of the utensil in which they are kept. When we heat any liquid in a utensil, first expansion of utensil takes place, followed by expansion of the liquid. Hence, volumetric expansion is of two types-

(1) Apparent expansion (2) Real expansion

Come, let us understand the expansion of liquids through the following activity.

Activity-6

Take a glass flask. Put a thin and transparent hollow rod in it. Fill the flask to the brim with water and seal its open mouth with a cork.

Suppose, the level of liquid in the rod is initially at A. On heating the flask, the level of liquid first decreases from A to B and then it increases from B to C, as shown in the figure.

Can you tell why this happens?

On heating, the heat energy first reaches the flask and thus it expands. The level of water decreases. After this, the heat is absorbed by the liquid and it starts to expand. Due to this, the level of water can be seen as rising.

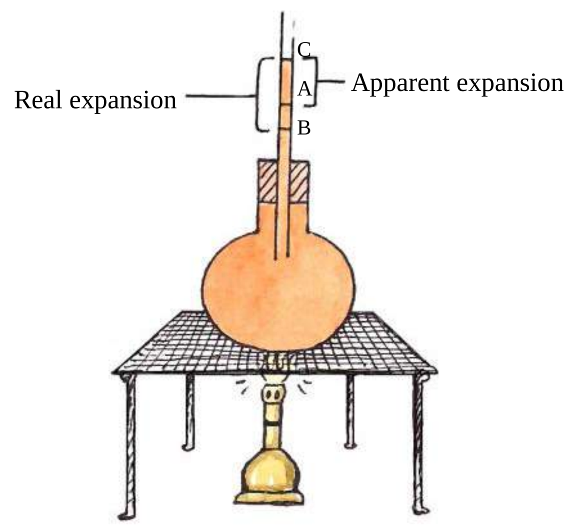


Figure-12: The volume of fluid during thermal expansion

Note down the level at A, B and C. We can see that the apparent expansion of liquid is from A to C, while the real expansion is from B to C. A to B is actually equivalent to the expansion of the flask. For apparent expansion, the expansion of utensil is not taken into consideration. However, in real expansion, the expansion of utensil is also considered.

BC=AC + AB

Therefore, the real expansion of liquid= apparent expansion of liquid + expansion of utensil

Know this: Like all other liquids water also expands on heating. But it is interesting to know that water does not expand between the temperatures of 0°C to 4°C.

This is the reason due to which aquatic life is possible in colder regions. Even if the temperature of uppermost layer of water is less than 0°C, the temperature of lower layers remains 4°C and hence the aquatic life remains safe.

Heat Expansion in gases

Upon heating, the expansion in gases is more than that in liquids and solids. Like liquids, only volumetric expansion is possible in gases. This expansion can be of two types-

1. At constant pressure – If the temperature of a gas is increased keeping pressure constant, then the volume of gas increases. This type of expansion coefficient is called as coefficient of volumetric expansion at constant pressure. On supplying heat to a balloon filled with air, the air inside starts to expand, which can be noticed through the increase in size of the balloon.

$$\text{Hence, coefficient of volume expansion of a gas} = \frac{\text{Increase in volume}}{\text{Initial volume} \times \text{Increase in temprature}}$$

$$\text{This means,} \quad \gamma_p = \frac{\Delta V}{V \Delta T}$$

2. At constant volume – if the temperature of gas is increased keeping volume constant, then the pressure of gas increases. This type of expansion coefficient is called as coefficient of volumetric expansion at constant volume. You must have seen a pressure cooker in use. On heating, the whistle of a cooker blows and steam escapes through it. This happens because at constant volume the pressure inside the cooker keeps building up.

$$\text{Hence, coefficient of pressure expansion of a gas} = \frac{\text{Increaseinpressure}}{\text{Initialpressure} \times \text{Increaseintemprature}}$$

$$\text{This means,} \quad \gamma_v = \frac{\Delta P}{P \Delta T}$$

Activity-7

Take a small empty bottle made of glass and put few drops of water on its mouth. Cover the mouth of this bottle with a coin. Now, rub your hands together and put your palms around the bottle for half a minute. You will notice the coin dancing. Think, why does the coin dance up and down? Which kind of expansion is this, is it an expansion at constant pressure or constant volume?

Question: Why is only volumetric expansion possible in liquids and gases?

3. Change in physical state

On receiving heat, the state of matter may change from one state to another. Study the following figure and understand it using examples.

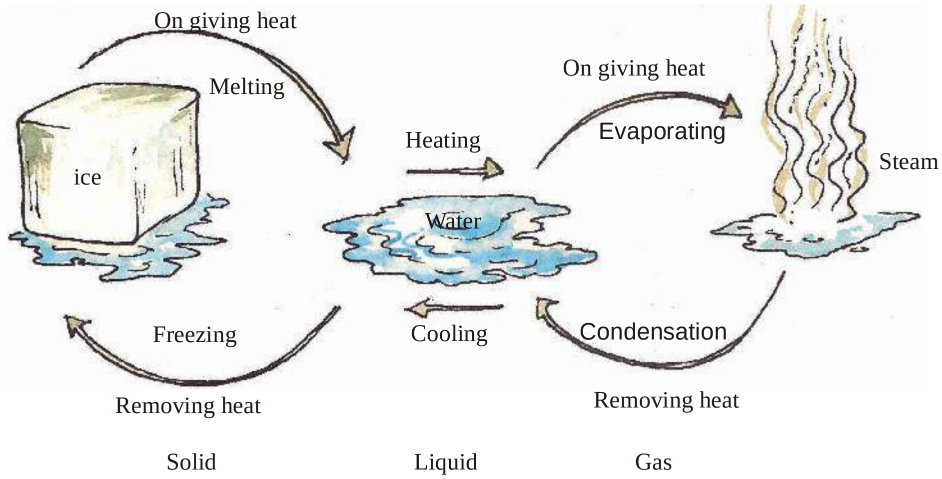


Figure-13: Change in state on providing to or taking heat from a substance.

Activity-8

Take a few ice cubes in a container and note its temperature using a thermometer. As you provide heat to the ice, it starts melting down. Keep noting its temperature until all the ice gets converted into water. Keep heating the water and note its temperature. When the water starts to boil and changes into vapor, note its temperature. Draw a graph of your observatios. This graph would look like the one given in figure-14.

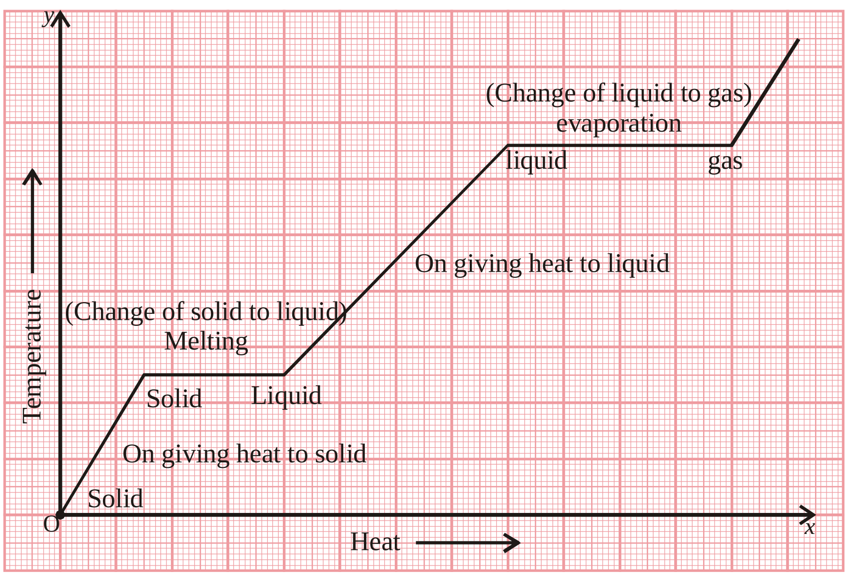


Figure-14: The heat absorbed or given out during state change does not cause increase in temperature.

We saw that on heating, the temperature of a substance keeps increasing. On reaching a certain point in the temperature, the state of the substance changes and temperature becomes constant. This happens because the temperature absorbed during heating process is utilized for state change. As this heat (absorbed or given out) is not evident through rise in temperature, therefore it is called as latent (hidden) heat. Latent heat is of two types.

1. Latent heat of fusion

On providing heat to unit mass of a substance it gets converted from solid state into liquid state. The amount of heat provided during this process is called latent heat of fusion. Latent heat is denoted by 'L'. The unit of latent heat is cal/g or kcal/kg. Latent heat of fusion of ice is 80 kcal/kg. This means that to convert 1 kg ice at 0°C into 1 kg water at the same temperature, requires 80 kcal of heat. If the mass of a substance is 'm' and latent heat is 'L', then the amount of heat given or taken by a substance at a constant temperature is Q=ML. To convert a solid into liquid, same amount of heat is taken away from the substance.

2. Latent heat of vaporization

The amount of heat required to convert a unit mass of water into vapor, at its boiling point, is called latent heat of vaporization. This latent heat is also denoted by 'L'. To change vapor into liquid state, same amount of heat is taken away from the vapor.

What we have learnt

- Hot and cold are measures on the same scale.
- We cannot state the exact temperature of a substance just by touching, seeing or sensing it.
- The degree of hotness or coldness is called temperature.
- It is easy to convert measured temperature from one unit to another.
- Temperature change occurs due to exchange of heat energy.
- S.I. unit of heat is Joule.
- Transfer of heat does not always require a material medium. Through radiation, heat can be transferred even through vacuum.
- In solids, heat transfer can take place only through the method of conduction. Convection can take place only in liquids and gases.
- Heat transfer takes place in each direction uniformly.
- To increase the temperature of equal amount of different substances equally, requires different amounts of heat. This is known as specific heat capacity of a substance.
- In solids, the ratio between linear expansion, superficial expansion and volumetric expansion is 1:2:3.
- In liquids, heat expansion is of two types – apparent expansion and real expansion.
- The heat energy required for change in state is known as latent heat energy.

Keywords

Thermal Energy, Fahrenheit, Kelvin, Calorie, Temperature difference, Heat transfer, conduction, convection, heat capacity, specific heat capacity, coefficient of linear expansion, coefficient of superficial expansion, coefficient of volume expansion, apparent expansion, real expansion, latent heat of fusion and vaporization.

Exercise

1. Choose the correct option-

   (i) Ratio of linear, area and volume expansion in solids is-

   (a) 1:1:1 (b) 1:2:3 (c) 1:2:1 (d) 3:2:1

   (ii) Amongst object A and B, if the specific heat of object A is less than of object B, then-

   (a) Object A will get warm sooner (b) Object B will get warm sooner

   (c) Both will get warm at a same rate (d) None of above

   (iii) Which one amongst the following is best conductor of heat-

   (a) Iron (b) Asbestos (c) Glass (d) Wood

   (iv) In which one of the following heat cannot flow due to convection-

   (a) Tea (b) Water (c) Wind (d) Vacuum

2. Fill in the blanks-

   (i) Heat is not matter instead it is ....

   (ii) .... results in heat transfer.

   (iii) Heat transfer is possible in .... due to conduction.

   (iv) .... is not required for heat transfer due to radiation.

   (v) Heat provided to change the physical state of matter results in change in temperature, this process is called ....

3. When two objects with different temperatures are put in contact with each other, they both achieve the same temperature after some time. Why is it so?

4. What is latent heat?

5. Balloon filled with gas bursts when we take it close to fire, why?

6. Convert the temperatures given below into given units-

   (i) 14° F into Celsius. (ii) 100° C into Fahrenheit. (iii) 12 K into Celsius.

7. Write three uses of specific heat of water in daily life.

8. Determine the final temperature if we mix one kg of water which is at 40°C with one kg of water which is at 60°C.

9. Mass of an aluminum object is 500 g, how much amount of heat needs to be supplied in order to increase its temperature by 40°C? Specific heat of aluminum is 0.09 J/k°C.

10. Length of an aluminum wire is 100 cm, what will be the increase in its length when its temperature is increased to 50°C from 30°C? Coefficient of linear expansion for aluminum is 26×10-6/°C.

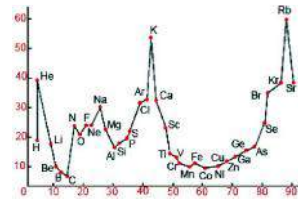
11. Define specific heat capacity.

12. What are the types of heat transfer? Write about them.

13. Give few examples of effects of heat seen in our daily life.

CHAPTER 4

PERIODIC CLASSIFICATION OF ELEMENTS



Matter is present all around us and it can be classified into elements, compounds or mixtures. Did we always classify substances in this way? Take the case of elements. The history of elements is very interesting and it took a very long time for scientists to understand which substances were elements and which were not.

4.1 Elements – then and now

According to the philosopher Aristotle (384-322 BC), the universe is made up of five elements namely fire, water, air, earth and ether. Many centuries later, a British scientist Robert Boyle (1627-1691) also did a number of experiments related to matter. On the basis of his experiments he concluded that the five elements described by Aristotle were not actually elements.

In 18^{th} century, a French scientist Lavoisier defined an element as a substance that could not be decomposed or broken down into simpler substances. For example, we know that water can be broken down into hydrogen and oxygen, therefore, it is not an element. Lavoisier prepared a list of 33 elements on the basis of his experiments but today 118 elements are known. It is very difficult to individually explore so many elements and their properties. Scientists have tried to solve this problem in many ways so that elements can be easily studied.

4.2 Why arrange elements?

We are always trying to arrange objects on the basis of their properties and use. For example, in our homes, we keep the clothes which we wear in one place. Other clothes such as bed-sheets, pillow covers are also kept together but separate from the clothes we wear. Even in the clothes that we wear, we keep winter clothes separate from summer clothing.

Think, when you go to a grocery shop and ask the shop-keeper for an item, how is he able to locate it easily among the different objects? Organizing objects saves us time and energy. That is why scientists too made many attempts to organize elements based on their properties.

In class 9^{th} we learnt about atomic number, atomic weight and electronic configuration of elements. Some elements are given in table-1 along with their atomic numbers and atomic weight.

(a) Arrange the elements in table-1 in increasing order of their atomic weights.

(b) Arrange the elements in table-1 in increasing order of their atomic numbers.

Table-1

Element	Atomic weight	Atomic number	Element	Atomic weight	Atomic number
S	32.1	16	B	10.8	5
Li	6.9	3	P	31	15
Al	27	13	Ca	40.1	20
O	16	8	Ne	22.2	10
Ar	39.9	18	C	12	6
Be	9	4	Cl	35.5	17
H	1	1	Na	23	11
Si	28.08	14	N	14	7
F	19	9	Mg	24.3	12
He	4	2	K	39.1	19

- Did you get the same order of elements in both the cases?
- Write the electronic configurations of the given elements.
- Can we group the elements based on their electronic configuration?

By now, you must have realized why we try to arrange and organize elements and that there can be more than arrangement. Let us try to understand the attempts made by some scientists in the past to classify elements.

4.3 Döbereiner's Law of Triads

The German scientist, Döbereiner, classified elements on the basis of their atomic weights. When he placed three elements having similar properties one below the other in increasing order of their atomic weights, he found that the atomic weight of the middle element was nearly the average of the atomic weights of the other two elements. The three elements formed a group known as a triad.

J.W. Döbereiner (1780-1849)

Johann Wolfgang Döbereiner trained as a pharmacist at Münchberg in Germany, and then studied chemistry at Strasbourg. Döbereiner was the first person to identify the catalytic properties of platinum. He also identified triads of similar elements which later led to the development of the Periodic Table of elements.

Li 6.9
Na 23
K 39.1

For example, he took the triad consisting of potassium, lithium and sodium and found that the atomic weight of sodium is almost equal to the average of the atomic weights of lithium and potassium. Its properties also lie somewhere between the properties of lithium and potassium. Döbereiner proposed a law based on this observation of relation between properties of elements and their atomic weights. According to Döbereiner's law of triads, when three elements having similar properties are written in the order of their increasing atomic weights the atomic mass of the middle element is the average of the atomic weights of the remaining two elements and its properties lie in the middle of the two. Döbereiner could form only three triads from the elements known at that time (Table-2).

The law proved true in the case of very few elements therefore this method of classifying elements into triads was not successful.

As soon as people saw the similarity between elements based on their atomic weights, other attempts were made to organize elements. Newlands also made one such attempt.

Table-2 : Döbereiner's triads

Triads of elements		
I	II	III
Li	Ca	C1
Na	Sr	Br
K	Ba	I

4.4 Newlands' Law of Octaves

Do you know?

In the Indian system of music, the seven musical are- *sa, re, ga, ma, pa,da, ni*.

Western music uses the notes- *do, re, mi, fa, so, la, ti*.

Every eighth note is similar to the first one and it is the first note of the next scale. The notes are used for composing music.

Through Döbereiner attempts, other chemists also noticed the correlation between the properties of elements and their atomic weights. In this series, the British scientist John Alexander Newlands (1837-1898) gave the law of octaves according to which when elements are arranged in increasing order of their atomic weights, then the properties of every eighth element were similar to those of the first. He compared this to the octaves (eight notes) seen in music and therefore the law is known as law of octaves. He put hydrogen, having the lowest atomic weight, at the first position and ended with the element thorium at the 56th position.

Table-3: Newlands' Octaves

Notes in Indian music system	*sa*	*re*	*ga*	*ma*	*pa*	*dh*	*ni*
Notes in Western music system	*do*	*re*	*mi*	*fa*	*so*	*la*	*ti*
Elements	H F Cl	Li Na K	Be Mg Ca	B A1 Cr	C Si Ti	N P Mn	O S Fe

In Newlands' Octaves, the properties of fluorine were similar to those of hydrogen and fluorine was the eighth element after hydrogen. Similarly, the properties of lithium and sodium were similar.

There were many limitations with Newlands' octaves, for example -

- It could accommodate only 56 elements and did not have any place for new elements.
- It was found that the Law of Octaves was applicable only upto calcium, as after calcium the eighth element did not possess properties similar to that of the first.
- Newlands put some unlike elements in the same group. Iron was placed with oxygen and sulphur although its properties were very different from them.

Thus, Newlands' law too was unsuccessful in classifying all elements.

Questions

1. Look at the given table and answer:

Group 'A'	Element	Li	?	K
	Atomic mass	6.9	23.0	39.1
Group 'B'	Element	Ca	Sr	Ba
	Atomic mass	40.1	?	137.3
Group 'C'	Element	C1	Br	I
	Atomic mass	35.5	?	126.9

(i) Which element will lie in the middle of group ´A´?

(ii) What will be the atomic weight of the middle element in group ´B´?

(iii) What will be the atomic weight of the middle element in group ´C´?

2. What are the limitations of Döbereiner's classification?

3. Look at table-3 and identify the elements that sodium will resemble.

4.5 Lothar Meyer's atomic volume curve

The German scientist Lothar Meyer plotted a graph of atomic volume of an element against its atomic weight. He observed that the elements sodium, potassium and rubidium were located on the peaks on the graph and fluorine, chlorine and bromine were situated in the rising portions of the curve. Metals such as magnesium, calcium etc. were located on descending portions of the curve and beryllium, boron, carbon, aluminium etc. were situated on the minima of the curve (figure-1).

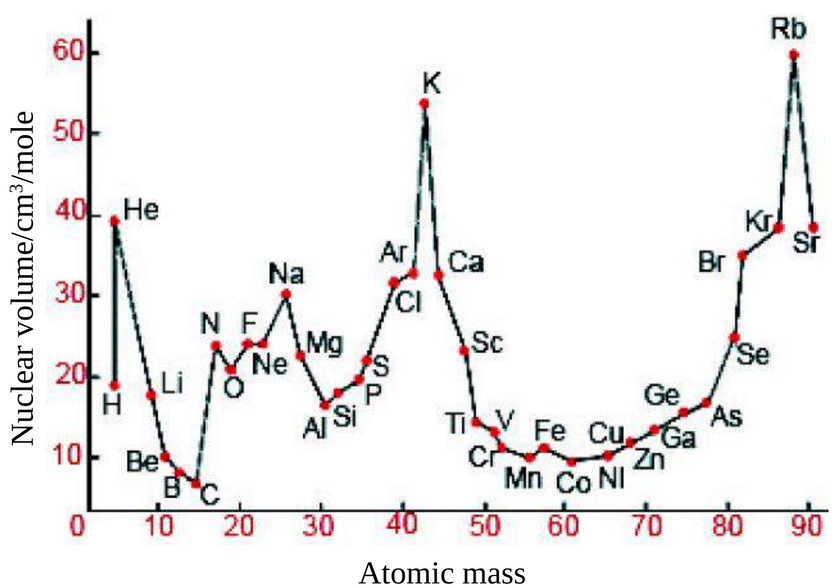


Figure-1 : Lothar Meyer's atomic volume curve

On this basis, he noticed that elements having similar properties were situated at similar locations on the curve, that is, the atomic volumes of the elements are periodic functions of their atomic weights.

While Lothar Meyer was working on classification of elements on the basis of atomic weights and atomic volumes, his contemporary Mendeleev presented a simpler classification based on the atomic weights and physical and chemical properties of elements. Meyer's use of the term periodic function gave direction to Mendeleev and helped him develop his version of the periodic table.

4.6 Mendeleev's classification

The major credit for classifying elements goes to a Russian chemist, Dmitri Ivanovich Mendeléev. He was an important contributor in the early development of a Periodic Table of elements. When Mendeléev started his work, 63 elements were known. He studied the relationship between the atomic weights of the elements and their physical and chemical properties. In chemical properties, Mendeléev focused on the compounds formed by elements with oxygen and hydrogen. He selected hydrogen and oxygen as they are very reactive and formed compounds with most elements.

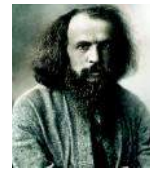
Mendeléev took 63 cards and on each card he wrote down the properties of one element. When he grouped together the elements with similar properties he found that most of the elements were arranged in the order of their increasing atomic weights. He arranged the elements in the form of a table where elements having similar properties were placed one below the other.

He also observed that the elements with similar properties occur after a fixed interval. On this basis, Mendeléev formulated a Periodic Law, which states that 'the properties of elements are the periodic function of their atomic masses'. In Mendeleev's periodic table, the vertical columns were called groups and the horizontal rows were called periods (figure-2).

Group	I	II	III	IV	V	VI	VII	VIII
Oxide **Hydride**	R_2O RH	RO RH_2	R_2O_3 RH_3	RO_2 RH_4	R_2O_5 RH_3	RO_3 RH_2	R_2O_7 RH	RO_4
Periods ↓	A B	A B	A B	A B	A B	A B	A B	**Transition series**
1	H 1.008							
2	Li 6.939	Be 9.012	B 10.81	C 12.011	N 14.007	O 15.999	F 18.998	
3	Na 22.99	Mg 24.31	Al 29.98	Si 28.09	P 30.974	S 32.06	Cl 35.453	
4 First series: Second series:	K 39.102 Cu 63.54	Ca 40.08 Zn 65.37	Sc 44.96 Ga 69.72	Ti 47.90 Ge 72.59	V 50.94 As 74.92	Cr 50.20 Se 78.96	Mn 54.94 Br 79.909	Fe Co Ni 55.85 58.93 58.71
5 First series: Second series:	Rb 85.47 Ag 107.87	Sr 87.62 Cd 112.40	Y 88.91 In 114.82	Zr 91.22 Sn 118.69	Nb 92.91 Sb 121.75	Mo 95.94 Te 127.60	Tc 99 I 126.90	Ru Rh Pd 101.07 102.91 106.4
6 First series: Second series:	Cs 132.90 Au 196.97	Ba 137.34 Hg 200.59	La 138.91 Tl 204.37	Hf 178.49 Pb 207.19	Ta 180.95 Bi 208.98	W 183.85		Os Ir Pt 190.2 192.2 195.09

Figure-2: Mendeléev's periodic table

Dmitri Ivanovich Mendeléev (1834-1907)



The Russian chemist Mendeléev is known as the father of periodic table. In addition, he contributed towards the modernization of Russian chemical and mining industries. He also proposed a theory regarding the formation of petroleum. His efforts to develop a new method of teaching chemistry resulted in an organized form of the periodic table.

Mendeléev's periodic table was first published in a German journal in 1872. At the top of each column, the general formula for oxides and hydrides were given where the letter 'R' was used to represent any of the elements in the group. For example, the hydride of carbon, CH_4, is written as RH_4 and the oxide CO_2, as RO_2. Mendeléev decided the location of an element in a group based on the chemical compounds formed by it. He used the formulae of the compounds to determine their valency. The number given to a group showed its valency in relation to oxygen. For example, if the formula of the compound of an element was R_2O it was placed in the first group and if the formula was RO it was placed in the second group. Can you tell what will be formula of an oxide from group three?

In this way, the valences of the first, second and third group are 1, 2 and 3 respectively.

4.6.1 Achievements of Mendeléev's periodic table

a. Used in the study of elements: Periodic changes are observed in the properties of elements within the same period in the periodic table. At the same time, similarities are seen in the properties of elements belonging to the same group. Therefore, if we know the properties of one element of a group we can easily find out the properties of other elements of that group. Thus, Mendeléev's periodic table is useful in the study of elements.

b. Useful in discovery of new elements: Mendeléev left some gaps in his Periodic Table. Instead of looking upon these gaps as defects, Mendeléev predicted the existence of some elements that had not been discovered at that time. Mendeléev named them by prefixing Eka to the name of preceding element in the same group. For instance, scandium, gallium and germanium, discovered later, were called Eka-boron, Eka-aluminium and Eka-silicon, respectively.

c. Corrections in disputed atomic weights: The atomic weight of beryllium was corrected on the basis of its valency in Mendeléev's periodic table. It was considered divalent rather than trivalent and placed between lithium and boron. Similarly, the atomic weights of the elements indium, euronium etc. were also corrected.

d. Space for inert gases: Inert gases such as helium, neon and argon had not been discovered during Mendeleev's times so no space was kept in the periodic table for them. When they were discovered, they were placed in a separate column which was added to the periodic table as the zero group by the scientist Ramsay.

4.6.2 Limitations of Mendeléev's periodic table

a. Uncertainty in hydrogen's position: Hydrogen gives H^+ ions similar to those (K^+, Li^+) given by alkali metals and like the ions formed by halogens (Cl^-, Br^-), it can also form H^- ion. Therefore, it difficult to decide the correct group in which hydrogen should be placed.

b. Placing heavier elements before lighter elements: When elements were arranged according to valency, in some places heavier elements were placed before lighter elements in violation of Mendeleev's rule. For example, cobalt (atomic weight 58.9) was placed before nickel (atomic weight 58.7).

c. Positioning of isotopes: We know that isotopes of the same element have same chemical properties but different atomic weights. According to Mendeleev's law, each isotope should have been given a separate position but Mendeleev's periodic table did not have any space for isotopes.

d. Irregular increase in atomic weights when moving from one element to the next: Since the atomic weights did not increase in a regular manner when going from one element to the next, it was difficult to predict how many elements could be discovered between two elements - especially when we consider the heavier elements.

Questions

1. What was the basis of classification of elements as done by Lothar Meyer?
2. Write the names and symbols of the first four elements found in groups I and II of Mendeleev's periodic table?
3. Some spaces were left empty in Mendeleev's periodic table. Write the names of the elements that were later placed in these gaps.
4. Name the two elements whose atomic weights were corrected by Mendeleev.
5. Why were inert gases placed in a separate group? Write the reasons.

The limitations of Mendeleev's periodic table were overcome in the 20^{th} century with the discovery of sub-atomic particles and a better understanding of the structure of the atom.

4.7 Moseley's modern periodic law

British scientist, Henry Moseley (1887-1915) studied the X-ray spectrum of different elements. He observed that the wavelength of X-rays emitted by an element was related to its position number in Mendeleev's periodic table. Atomic weights of elements were known when Mendeleev proposed his periodic table. Another characteristic of elements, which was named atomic number, was discovered through Moseley's work. Atomic number is a fundamental property and gives the number of protons present in the nucleus of an atom of any element. On the basis of his results, Moseley suggested that atomic number rather than atomic weight should be the property used in the classification of elements. He showed that the chemical properties of elements depend on their electronic configuration which is decided by the atomic number of the element. Therefore, he modified Mendeleev's periodic law and gave the modern periodic law in 1913. According to the modern periodic law, the physical and chemical properties of the elements are periodic functions of their atomic numbers.

The modern periodic table

Key: 1 — atomic number; H — Symbol; Hydrogen — Name; 1.0 — atomic mass

Legend: metals | metalloids | Non-metals | noble gases (inert) | Research ongoing

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1.0																	2 He Helium 4.0
3 Li Lithium 6.9	4 Be Beryllium 9.0											5 B Boron 10.8	6 C Carbon 12.0	7 N Nitrogen 14.0	8 O Oxygen 16.0	9 F Fluorine 19.0	10 Ne Neon 20.2
11 Na Sodium 23.0	12 Mg Magnesium 24.3											13 Al Aluminium 27.0	14 Si Silicon 28.1	15 P Phosphorus 31.0	16 S Sulfur 32.1	17 Cl Chlorine 35.5	18 Ar Argon 39.9
19 K Potassium 39.1	20 Ca Calcium 40.1	21 Sc Scandium 44.9	22 Ti Titanium 47.9	23 V Vanadium 50.9	24 Cr Chromium 52.0	25 Mn Manganese 54.9	26 Fe Iron 55.8	27 Co Cobalt 58.9	28 Ni Nickel 58.7	29 Cu Copper 63.5	30 Zn Zinc 65.4	31 Ga Gallium 69.7	32 Ge Germanium 72.6	33 As Arsenic 74.9	34 Se Selenium 79.0	35 Br Bromine 79.9	36 Kr Krypton 83.8
37 Rb Rubidium 85.5	38 Sr Strontium 87.5	39 Y Yttrium 88.9	40 Zr Zirconium 91.2	41 Nb Niobium 92.9	42 Mo Molybdenum 95.9	43 Tc Technetium (98)	44 Ru Ruthenium 101.1	45 Rh Rhodium 102.9	46 Pd Palladium 106.4	47 Ag Silver 107.9	48 Cd Cadmium 112.4	49 In Indium 114.8	50 Sn Tin 118.7	51 Sb Antimony 121.8	52 Te Tellurium 127.6	53 I Iodine 126.9	54 Xe Xenon 131.3
55 Cs Caesium 132.9	56 Ba Barium 137.3	57 * La Lanthanum 138.9	72 Hf Hafnium 178.5	73 Ta Tantalum 180.9	74 W Tungsten 183.9	75 Re Rhenium 186.2	76 Os Osmium 190.2	77 Ir Iridium 192.2	78 Pt Platinum 195.1	79 Au Gold 197.0	80 Hg Mercury 200.6	81 Tl Thallium 204.4	82 Pb Lead 207.2	83 Bi Bismuth 209.0	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium (226)	89 ** Ac Actinium (227)	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (263)	107 Bh Bohrium (262)	108 Hs Hassium (265)	109 Mt Meitnerium (267)	110 Ds Darmstadtium (281.2)	111 Rg Roentgenium (282.2)	112 Cn Copernicium (285.2)	113 Nh Nihonium (286.2)	114 Fl Flerovium (289.2)	115 Mc Moscovium (289.2)	116 Lv Livermorium (293.2)	117 Ts Tennessine (294.2)	118 Og Oganesson (294.2)

The number given in brackets ( ) is the atomic mass of the isotope of the element having the longest half life.

Lanthanides *	58 Ce Cerium 140.1	59 Pr Praseodymium 140.9	60 Nd Neodymium 144.2	61 Pm Promethium (145)	62 Sm Samarium 150.4	63 Eu Europium 152.0	64 Gd Gadolinium 157.3	65 Tb Terbium 158.9	66 Dy Dysprosium 162.5	67 Ho Holmium 164.9	68 Er Erbium 167.3	69 Tm Thulium 168.9	70 Yb Ytterbium 173.0	71 Lu Lutetium 175.0
Actinides **	90 Th Thorium 232.0	91 Pa Protactinium (231)	92 U Uranium 238.0	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (254)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)

Figure-3: Modern periodic table

4.8 Modern Periodic Table

Bohr used Moseley's law to organize elements into a table where they were placed in ascending order of their atomic numbers. This table was called Bohr's periodic table. The 92 naturally occurring elements known at that time were placed in the table. This periodic table is also known as the modern periodic table or the long form of periodic table (figure-3). The elements that come after atomic number 92 (till atomic number 118) have been chemically synthesized and have been given space in the modern periodic table.

The long form of periodic table has 18 (vertical) columns known as groups and 7 horizontal rows called periods.

Group – In Mendeleev's periodic table, the group number of an element is decided by its valency but in modern periodic table, it is decided by the electronic configuration.

- Elements found in groups 1,2,13,14,15,16,17 and 18 are called main group elements.
- Elements found in groups 3-12 are called transition elements.

In group 3, the 14 elements that come after lanthanum (La, atomic number 57) are placed in a separate panel below the periodic table and are called lanthanides. Similarly in group 3, the 14 elements that come after actinium (Ac, atomic number 89) are placed in a panel below the periodic table and are called actinides. They are displayed below the periodic table so that it takes a more convenient form.

Period – In the modern periodic table, the numbers of shells of all elements belonging to a particular period is equal.

On moving from left to right in a period, the atomic numbers of the elements increase by one and the number of valence electrons also increases by one. The number of valence electrons are different in lithium, beryllium, boron, carbon, nitrogen etc. and therefore they are members of different groups but because the numbers of shells occupied is same for all, they are placed in the same period. Can you tell the number of the period to which they belong?

We can tell the number of elements present in each period by calculating the maximum number of electrons that can occupy a shell. We know that the maximum number of electrons that can be placed in a shell is calculated using the formula $2n^2$ where n = shell number.

For example, for the first period, the maximum number of electrons in n = 1 (K shell) is $2\times(1)^2 = 2$. Therefore, the first period has 2 elements.

Using the calculation given above, can you tell how many elements will be present in the third period? If we calculate the maximum number of electron in the m shell, we get 18. But we also know that according to Bohr-Bury rule, the maximum number of electrons in the outermost shell cannot be more than 8. Since M is the outermost shell here, therefore it cannot have more than 8 electrons and this is the reason why the number of elements in the third period is 8.

In the periods after this, the number of electrons in a shell is decided by some other rules which we will study in higher classes.

- The first three periods of the modern periodic table are known as short periods and have 2,8 and 8 elements respectively.
- The two periods after the first three are called long periods and both have 18 elements each.
- The sixth period has 32 elements and with the discovery of 4 new elements, the seventh period also has 32 elements.

4.8.1 Characteristics of the Modern periodic table

- The periodic table is based on atomic number.
- The position of each element has been decided based on its electronic configuration.
- Periodic changes in properties of elements are shown more clearly.
- Because hydrogen is capable of forming both negative (H^-) and positive (H^+) ions, it is similar to the elements of both group 17 (which give negative ions) and of group 1 (which give positive ions). Therefore, similar to Mendeleev's periodic table, the position of hydrogen in the modern periodic table is also not fixed. However, usually hydrogen is placed at the top of group 1.

Questions

1. According to the modern periodic table, the properties of an element are a periodic function of what?
2. What will be the number of elements in the second period?
3. Can you fix the position of different isotopes of an element in the modern periodic table? Explain.
4. How have the positions of argon and potassium been determined in the modern periodic table?
5. If the atomic number of three elements x, y and z are 6, 10 and 18 respectively then:
   (a) Which of the two elements belong to the same group?
   (b) Which of the two elements belong to the same period?

4.8.2 Periodic properties of elements

According to the periodic law, when elements are arranged in increasing order of their atomic number, their properties show periodicity. Periodic variation in electronic configuration with increase in atomic number is the reason for this periodicity in properties.

When we move down a group or from left to right in a period then we observe a periodic variation in the physical and chemical properties of elements. Let us study some periodic properties.

1. Valency

Valency is an important property of elements. We can understand valency on the basis of electronic configurations of elements. Valency is the number of electrons present in the outermost shell of an element or the number of electrons needed to complete the octet. Now, can you tell how valency will change when we move down a group or from left to right in a period? Let us understand by looking at table-4 which shows the elements of second period and their respective hydrides.

Table-4: Periodic variation in the valency of the elements of second period

Element	Li	Be	B	C	N	O	F	Ne
Hydride	LiH	BeH2	BH3	CH4	NH3	H2O	HF	-
Valency	1	2	3	4	3	2	1	0

In the second period of the periodic table, the valency of elements relative to hydrogen first increases from one to four and then decreases to zero.

Questions

1. How will you calculate the valency of an element given its electronic configuration?
2. How does valency change when we move down a group?

2. Atomic size

The size of atoms of different elements is also different. Their sizes can be compared using the values of their atomic radii. Atomic radii implies the distance between the centre of the nucleus and the outermost shell of an atom.

Table-5 shows the atomic radii of the elements of group 17. Arrange them in increasing order and answer the following questions:

1. Which elements have the largest and the smallest atoms?
2. How does the atomic radius change we move down a group?

We find that atomic size increases on moving down a group. This is because a new shell is added as we go down which increases the distance between the nucleus and the outermost shell.

Table-5: Some atomic radii

Elements of group 17	Atomic radii (pm)
Br	114
F	64
I	133
Cl	99
At	144

Table-6 shows the atomic radii of elements belonging to the third period.

Table-6: Atomic radii of elements of the third period

Elements of the third period	Na	Mg	Al	Si	P	S	Cl
Atomic radii (pm)	186	160	143	117	110	104	99

- How does the atomic radius change as you go from left to right in a period?

We see that the atomic radius decreases in moving from left to right along a period. This is due to an increase in nuclear charge which tends to pull the electrons closer to the nucleus and reduces the size ofthe atom.

3. Metallic and Non-metallic Properties

118 elements have been discovered so far. Each element has some characteristic properties which are used to classify them into two groups – metals and non-metals.

Table-7: Elements of the second period

Second period	Li	Be	B	C	N	O	F
Atomic number	3	4	5	6	7	8	9

Look at table-7 and tell:-

- Which elements will form negative ions and which will form positive ions?
- On which side of the Periodic Table do you find the metals and on which side do you find the non-metals?
- How do the metallic and non-metallic properties change as we move from left to right?

We know that elements which lose electrons to form positive ions are called metals, for example, iron, zinc, sodium etc. Those that accept electrons to form negative ions are called non-metals, for example, oxygen, chlorine etc. Let us understand better through some more examples.

In the Modern Periodic Table, a zig-zag line separates metals from non-metals. The borderline elements - boron, silicon, germanium,arsenic, antimony, tellurium and polonium - exhibit the properties of both metals and non-metals and are called metalloids or semi-metals.

On observing the periodic table we find that there is an increase in metallic character and decrease in non-metallic properties as we move down a group.

- Think: Do these properties also change in a period?

4. Ionization energy/ ionization potential

The energy required to remove the most loosely held electron from an isolated gaseous atom is called ionization potential or ionization energy. To obtain an isolated atom, first the solid or liquid element is converted into its gas state and if the element is in its molecular form then it is first broken into its constituent atoms. The unit for ionization energy is electron volt.

Let us see the electronic configurations of the elements of the first group.

Table-8: Electronic configuration of elements of first group

Element	**Atomic number**	**electronic configuration**
H	1	1
Li	3	2,1
Na	11	2,8,1
K	19	2,8,8,1

When we move from hydrogen to potassium, along with increase in number of electrons, the number of shells also increases and so does the distance between the nucleus and the outermost electron. This is the reason why less energy is needed to remove the outermost electron. Thus, the value of ionization energy decreases as we move down a group.

Now, let us see the second period.

Table-9: Ionization energy of elements of second period

Element	Li	Be	B	C	N	O	F	Ne
Ionization Energy (eV)	5.6	9.9	8.3	11.3	14.5	13.6	17.4	21.6

Is there any change in the shell number as we move from lithium towards neon? We find that number of shells is two (K and L) in all cases but the atomic number is increasing leading to increase in nuclear charge. Thus, due to increased nuclear attraction more energy is needed to remove the electrons in the outermost shell.

Questions

1. How does the ionization energy change in a group?
2. How does the ionization energy of elements belonging to the same period vary? Explain why?

5. Electron affinity

We know that metals can give up electrons to form positive ions. Elements of groups 1 and 2 have respectively 1 and 2 electrons in their outermost shells. They lose these electrons to form monovalent (+1) and divalent (+2) ions. These elements are located on left side of the periodic table.

On the right side of the periodic table we have non-metals which accept electrons to form negative ions. When one electron is added to any atom, it acquires a negative charge with release of energy. The energy released is called electron affinity.

Generally, as we move from left to right in a period, the value of electron affinity increases and it decreases as we move down a group.

6. Electronegativity

If a covalent bond exists between two different types of atoms, then one of the atoms has a greater tendency than the other atom to attract the electron pair towards itself. For example, HCl molecule has one pair of shared electrons. Here, as compared to the hydrogen atom the chlorine atom attracts the shared electron pair towards itself. Therefore, the electron pair is closer to the chlorine atom. The atom that attracts the shared electron pair towards itself is more electronegative and it acquires a partial negative charge.

The tendency or ability of an atom in a chemical compound to attract shared electrons to itself (and thus gain a partial negative charge) is called electronegativity.

Generally, as we move from left to right in a period, the value of electronegativity increases and it decreases as we move down a group.

Electron affinity and electronegativity are different from each other. Electronegativity is the property of an atom to attract the shared electron pair in a covalent bond with another atom towards itself. Therefore, it is a relative quantity which does not have a unit whereas electron affinity is the energy released when an electron is added to an isolated gaseous atom and its unit is eV.

Questions

1. How does electron affinity differ from electronegativity?
2. The elements of which group have the highest electron affinities?

What we have learnt

- Elements are classified on the basis of similarities in their properties.
- Efforts to organize and classify elements had begun even before Dalton gave his atomic theory in 1808 but his theory gave a new direction to other scientists by showing that there is a relation between the atomic weight of an element and its properties.
- Döbereiner arranged elements having similar properties into groups of three called triads.
- Newlands gave the law of octaves to classify elements and compared this to musical notes.
- Lothar Meyer used the term periodic while describing the property of elements and this directed Mendeleev's efforts in developing his periodic table.
- Mendeléev arranged the elements in increasing order of their atomic weights.
- Mendeléev left gaps in his Periodic Table that helped predict the existence of some yet to be discovered elements.
- Moseley gave the modern periodic law based on atomic numbers.
- The Modern Periodic Table has 18 vertical columns called groups and 7 horizontal rows called periods in which 118 elements have been arranged according to their electronic configuration.
- Different properties of elements – such as valency, atomic size, metallic and non-metallic character, ionization energy, electron affinity and electronegativity – show a periodic variation across groups and periods.
- Periodicity in the properties of elements is due to the periodic variation in the electronic configurations of outermost shells.

Keywords

Law of triads, law of octaves, periodic function, periodicity, atomic size, atomic radii, ionization potential, electron affinity, electronegativity

Exercises

1. Choose the correct option–
   - (i) The position of which of the following elements is not fixed in the periodic elements
     - (a) Sodium (b) Chlorine
     - (c) Helium (d) Hydrogen
   - (ii) Elements in Mendeleev's periodic table have been arranged according to–
     - (a) Increasing order of molecular weight
     - (b) Increasing order of atomic weight
     - (c) Increasing order of atomic number
     - (d) Increasing order of atomic radii
   - (iii) The modern periodic law was proposed by–
     - (a) Newlands (b) Moseley
     - (c) Mendeleev (d) Döbereiner
   - (iv) On moving down a group, the metallic character–
     - (a) Neither increases nor decreases (b) decreases
     - (c) Increases (d) First increases, then decreases
   - (v) Which of the following depicts increasing atomic sizes of Na, Li, K –
     - (a) $Li<Na<K$ (b) $K<Na<Li$
     - (c) $Na<Li<K$ (d) None of the above
2. The physical and chemical properties of elements belonging to the same group are similar, why?
3. Hydrogen should be placed in which group and which period? Give reasons.
4. In each of the given pairs, choose which element will have the bigger atom. Give reasons for your choice.
   - (a) Mg (atomic number 12) or Cl (atomic number 17)
   - (b) Na (atomic number 11) or K (atomic number 19)
5. The atomic numbers of three elements A, B and C are 5, 7 and 10 respectively. Which two of these will have similar properties? Give reasons.

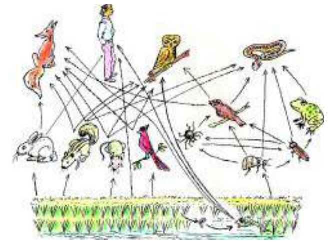
6. The atomic numbers of three elements are 5, 7 and 10 respectively. Which of these:
   (a) Belongs to group 18
   (b) Belongs to group 15
   (c) Belongs to group 13
7. 'A', 'B' and 'C' are three elements that form a triad. If the atomic weight of 'A' is 7 and that of 'C' is 39 then according to Döbereiner's rule of triads what will be the atomic weight of 'B'?
8. The figure shows a part of the periodic table:

Li	Be	B	C	N	O	F
Na	Mg	Al	Si	P	S	Cl

   If we move horizontally from left to right
   (i) How does the metallic character of the elements change?
   (ii) How does electronegativity change?
   (iii) How does electron affinity change?
9. Why did Mendeleev leave gaps in his periodic table? Use an example to illustrate your answer.
10. Are Döbereiner's triads seen in Newlands' octets? Compare and write.
11. Give the trends shown by the following properties when we go down a group or from left to right in a period in the modern periodic table – valency, atomic size, ionization potential, electronegativity
12. The electronic configuration of an element B is 2, 8, 7 and it forms an ionic compound AB_2 with another element A. What is the valency of element A?
13. Compare the arrangement of elements in Mendeleev's periodic table and the modern periodic table.

CHAPTER 5

OUR ENVIRONMENT: ENERGY FLOW IN THE ECOSYSTEM



You had studied in class 9 that the habitat of 'Kaani machri' is Kotumsar Caves. You had also studied about the habitats of several other organisms in the same chapter. Habitat is very important for the survival of organisms. The interrelationship of abiotic and biotic factors in the habitat of an organism play an important role in its life. We have studied in Chapter 1, Evolution that adaptation of organisms occur in different ways in habitats due to different abiotic and biotic conditions. The population of adapted organisms increases and impacts the population of other organisms of the same habitat. Come let us do an activity to study the interrelationship of organisms in their habitat.

5.1 Study of Interrelationships

Activity-1

Select an area around your house or school. It could be a part of a garden or a grassy field. The area should be such that you could observe it regularly (at least twice daily, both in the morning and evening) for 5 days. Mark a one meter by one meter area here. Observe carefully, do you find any insects, frog, bird or any other organism in the marked area? Write the name of the group of insects and the number of them that you observe there (as for example grass 20, ants 28 etc.). Dig the soil as well to count organisms. Try to keep counts such that you count a particular organism once only. If there are any trees, herbs, bushes etc. count them under the group of plants. Answer the following on the basis of your observations-

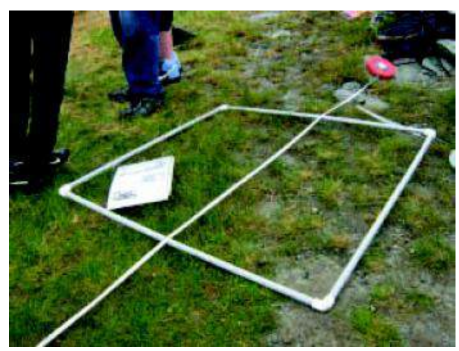


Figure-1: 1m X 1m Area

- Could you observe any food chain or food web in the marked area? Give an example.
- Could you observe any food web or food chain in the whole garden? Give an example.
- What are the biotic and abiotic factors in your area?
- What are the differences in abiotic factors of morning and evening hours?

Now calculate the average number of organisms observed per day in the area from the total organisms observed in 5 days(as for example if total number of ants were 50 those observed per day were 10 and this number multiplied by the area gives you and approximate number of ant population in that area)

- Do you think the organisms in the area have enough resources for their survival?

All organisms in an area depend on each other and their environment for some basic needs like food, reproduction and shelter.

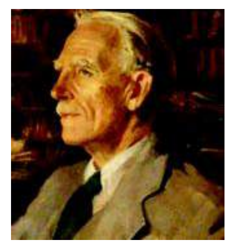
We can study this interrelationship of organisms and their environment on the basis of-

1. Interrelationship between biotic components- we shall study this with the help of food chains, food webs and ecological pyramids.
2. Interrelationship of biotic and abiotic components(the effect of environmental factors like soil, air, water, weather, climate etc. on organisms)- we shall study this with the help of nutrient cycle.

We shall try to study the flow of energy mainly among biotic components with a mention of about energy flow into the abiotic environment.

Food chain, food web, ecological pyramids, nutrient cycles are models that help us to study, present and understand the interrelationships of diverse organisms and their environment in either certain areas or in general. These help us to predict the environmental conditions and make comparative studies of different areas. We often use ways like that used in activity -1 to collect data regarding different parameters in an environment that we shall study as an ecosystem.

5.2 Meaning of an Ecosystem


A.G.Tansley

A self- coordinated systemdevelops in an environment, which we call as "Ecosystem", due to the interrelationship of environmental components. The word ecosystem was first used in the year 1935 by an environmentalist named A.G.Tansley. According to him the interrelationship of biotic and abiotic components in an environment forms a system of continuous exchange of nutrients energy etc.. By collecting, comparing and analyzing data collected of different parameters in the environment we can predict and find out the effect of certain specific parameters on the environment. Thus the study of the interrelationship based mainly on exchange of nutrients and energy between biotic and abiotic components is the study of an environmental system or in short ecosystem.

It is not by any means essential for conditions to remain same in a particular ecosystem. Conditions in an ecosystem undergo continuous changes due to diverse natural phenomena. Human interventions cause severe changes in environmental conditions in an ecosystem.

We can study the ecosystem of diverse areas of the environment like, a tree, garden, farm, forest etc. The habitat of Kani machri of Kotumsar caves would be an ecosystem study if we make an attempt to study the interrelationship of biotic and abiotic factors of the habitat.An example of a large ecosystem would be an ocean while a small one that of a cell. There are several microorganisms in a cell like bacteria, virus etc. that are present in the cellular environment.

Do you know?

Before the term ecosystem came in use a term called "Ecology" was widely in use. ErntHaekel had first used the term ecology to represent the study of nature as an oder similar to that of home. The literal meaning of the term 'Eco' in Greek is house and 'logos' is study. The definition of ecology was extended in the year 1869 to the study of mutual interdependence between plants and animals as well as with their environment. Ecology is thus a scientific study of identifying interrelationships among organisms along with that of their environment. Interrelationships could be related to food and feeding habits, reproductive behavior, parasitism, effect of environment on life cycles etc. These and several others have been studied over time to understand more about interrelationships.

Let us study an ecosystem to understand more about the interrelationships. We field plenty of rice farms in our state. Let us study the ecosystem of a rice farm.

5.2.1 Ecosystem of a rice farm

Figure- 2: A rice farm

We know that most food chains start with plants. Plants are capable of converting solar energy to that stored in chemical bonds of compounds by the process called as photosynthesis. Plants are thus called as producers. You will study about this in detail in the chapter Life Processes Part-1. All organisms other than producers in a food chain are usually consumers. The producers in a rice farm are mainly the rice plants. Several organisms thrive in a rice farm from the sowing to harvesting season(and even thereafter). Some organisms thrive in the soil while some in the water while some others on the rice plant itself. There are occasional visitors as well that visit a rice farm sometime.We find an ecosystem changing over time on these rice farm. Let's study one-

- You may have observed a rice farm, on the basis of your observation and the figure given here, enlist all the abiotic components in a rice farm.
- Figure 4 shows example of some organisms that thrive in a rice farm. Discuss with your friends and write the interrelationship between the organisms thriving in a rice field and the abiotic components there.
- What are the different food chains that you may observe in the given food web. Select and write any 5 of them.

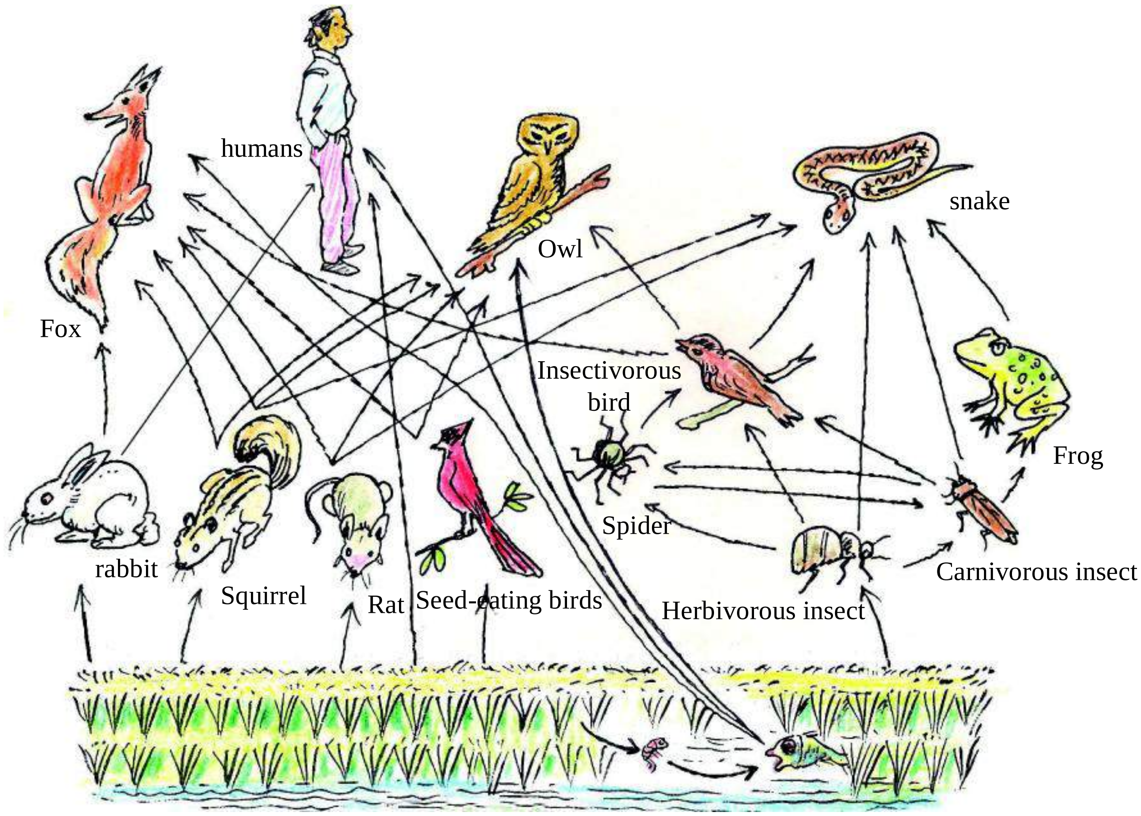


Figure-3: Food web in a rice farm

Studying a food chain of the food web in figure-4 and estimating the number of organisms found in a hectare(1000sqm) of a rice farm it was found that the numbers were in the following sequence-

100000 rice plants $\rightarrow$ 1000 rats $\rightarrow$ 50 snakes $\rightarrow$ 5 hawks.

Discuss with your friends about this example and answer the following-

- Which organisms are consumers in the given food chain?
- How many rice plants would feed a rat?
- A hawk feeds on how many snakes?
- It rats are killed how would it affect rice plants, snakes and hawks?
- If you answer the above question on the basis of the given food web, how do you think the killing of all rats would affect the population of the squirrels and the herbivorous insects (insect feeding on plants)?

There is such a lot of diversity in the living world that the relationship of eating and being eaten cannot be completely understood by a food chain. A food web gives a better preview of the same. We find as we study food chains and food webs that some organisms are solely dependent on plants while some others are solely dependent on other organisms. This gives us an idea that there are different levels in this relationship of eating and being eaten(those being eaten are called prey while those that eat them are predators). We call these levels as trophic levels. The rice plant at one trophic level while the rat another and the snake and hawk still others.

5.2.2 Ecosystem and Trophic levels

You may have observed several food chains in the food web of the rice field. We found there that the food chain started with mainly the rice plants. Those that feed on the rice plants like the sparrows, herbivorous insects, rats, rabbits, squirrels etc. are primary consumers.

- What are the organisms that feed on the primary consumers? These organisms are called secondary consumers.
- Are there organisms in the food web that consume the secondary consumers? Those that feed on secondary consumers are tertiary consumers.

Thus to study organisms feeding at different levels we consider them to be occupying a certain level of feeding called as trophic level that could be either producer or primary consumer or secondary consumer etc. as follows-

Producer	-	First Trophic level
Primary consumer	-	Second Trophic level
Secondary consumer	-	Third Trophic level
Tertiary consumer	-	Fourth Trophic level

Quaternary (usually also top) Consumer- Fifth Trophic level

Usually in a population of organisms of a particular trophic level we may find competitive feeding behavior. Those on a higher trophic level are dependent on the lower trophic level(second level would be dependent on the first). The population of the organisms of a trophic level is controlled by the population of the next or higher trophic level.

There are certain other organisms in nature that either feed on dead or decaying matter or on the wastes of other organisms. These may be scavengers like crows, cockroaches etc. or decomposers like bacteria, fungi etc.

- Which trophic level should these organisms belong to?
- Omnivorous organisms that feed on plants as well as animals, like human beings should be kept at which trophic level?

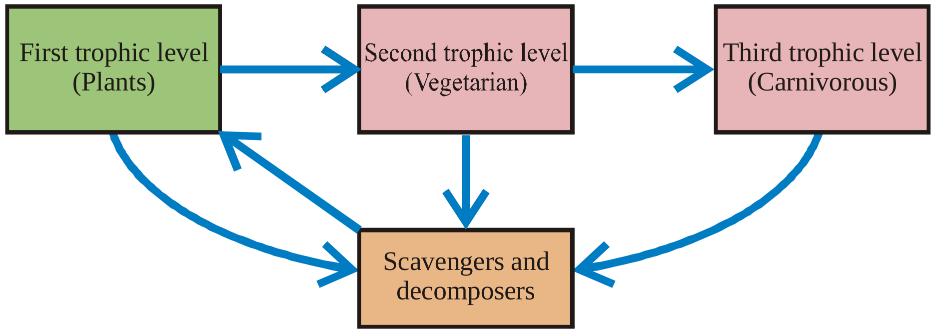


Figure-4: Trophic levels and decomposers

We can observe in figure5 that decomposers help in decomposition at all the trophic levels and help in providing the decomposed matter in the form of nutrient for producers at the first trophic level.

We shall use another model, the ecological pyramids to try to make a quantitative study of the interdependence between organisms, distribution of resources, flow of energy. It becomes easy to make a comparative study of different ecosystems with the help of ecological pyramids.

5.3 Study of Ecological Pyramids

5.3.1 Pyramid of Numbers

Charles Elton, an environmentalist wrote in his book "Animal Ecology" in the year 1927 for the first time about ecological pyramids. He discussed about ecological pyramid of numbers stating that in any area organisms that are present at the end of a food chain are those that produce least number of offspring (babies) in a year. Such an area is usually a habitat for the family of such an organism. Thus the feeding relationship of such an area can be represented in the form of a pyramid. The broad base of a pyramid would be occupied by organisms whose population would be maximum and the top would be with that of those with minimum population. Such a pyramid would represent the availability of food and the number of organisms at each trophic level. We do not find the diagram of ecological pyramids along the description given by Elton in his book. But we find that pyramids have been used extensively after Elton to not only represent numbers but other quantifiable parameters of ecosystems as biomass and energy. In most pyramids drawn so far quantified values have not been represented proportionately.

Charles Elton (1900-1991)

Do you know?

You may have heard about pyramids of Egypt. Pyramids are geometrical structures the base of which are broad and the shape gradually tapers to the top being nearly a point at the top. Usually we find pyramids with a square base with four triangular faces.

The organisms of the food chain of the rice farm can be represented in the form of pyramid as under.

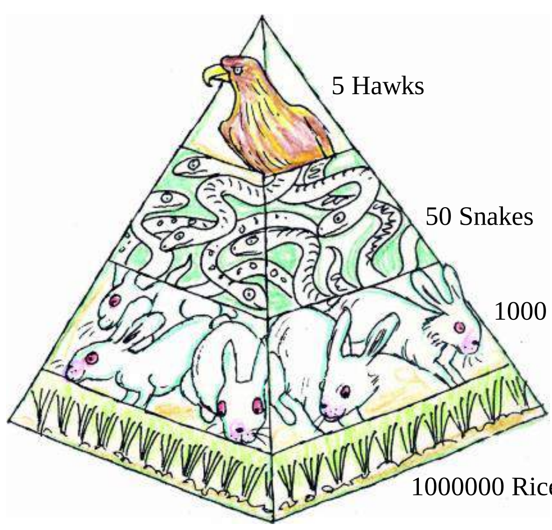


Figure-5 (a): Pyramid of number for organisms in a food chain (rice farm)

- Draw a pyramid to represent the number of organisms at each trophic level as obtained by you in Activity-1
- If we consider all organisms of a food web present at different trophic levels at a particular time the pyramid would look like this-

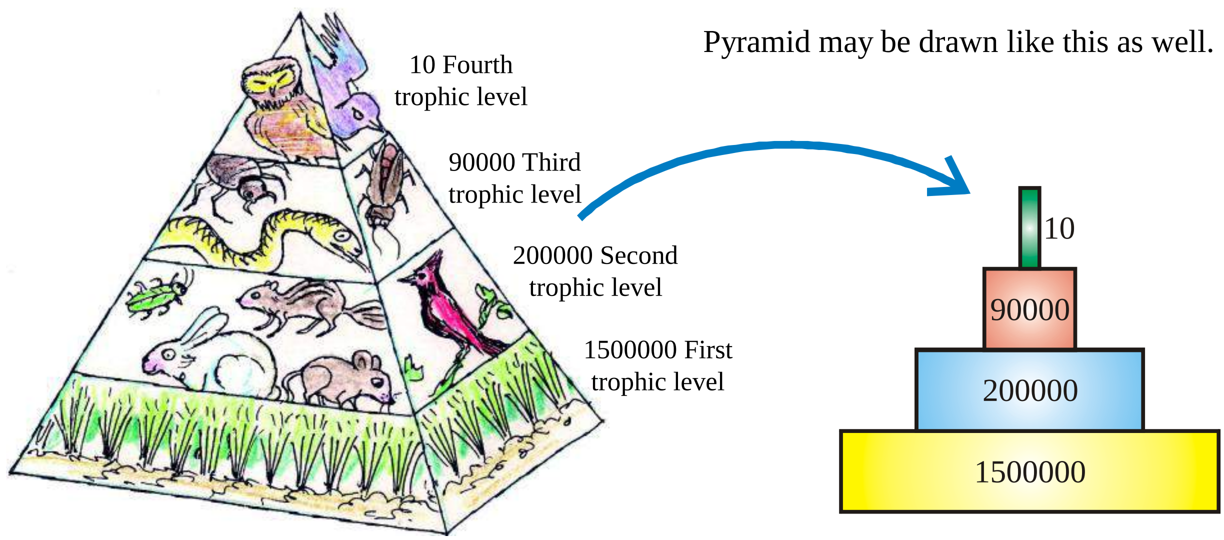


Figure-5 (b): Pyramid of number for organisms in a food web (rice farm)

- When the rice crop is harvested, what do you think will happen to the ecosystem on the farm?
- Do you think there would be the same number of organisms as shown in Figure-7 (b) still on the farm? What do you think will happen to them?

The condition of ecosystems are influenced and changed by human interventions and natural phenomena.

After harvesting several organisms die or move out to other areas where there are resources to sustain their survival.

It is thus often important to maintain certain conditions in an ecosystem for conservation of both biotic and abiotic types of resources.

You must have heard these days that it is recommended to grow more than one type of crops in a field at a time. Pulses are usually grown with cereal crops in many parts of our country. It is also recommended to grow trees in farm areas at particular intervals and also practice fish culture in the water that accumulates in the field. This has several benefits like conserving biodiversity, restoring soil nutrients, biologically controlling crop pests etc. We would need to study some other types of pyramids of numbers to understand these effects.

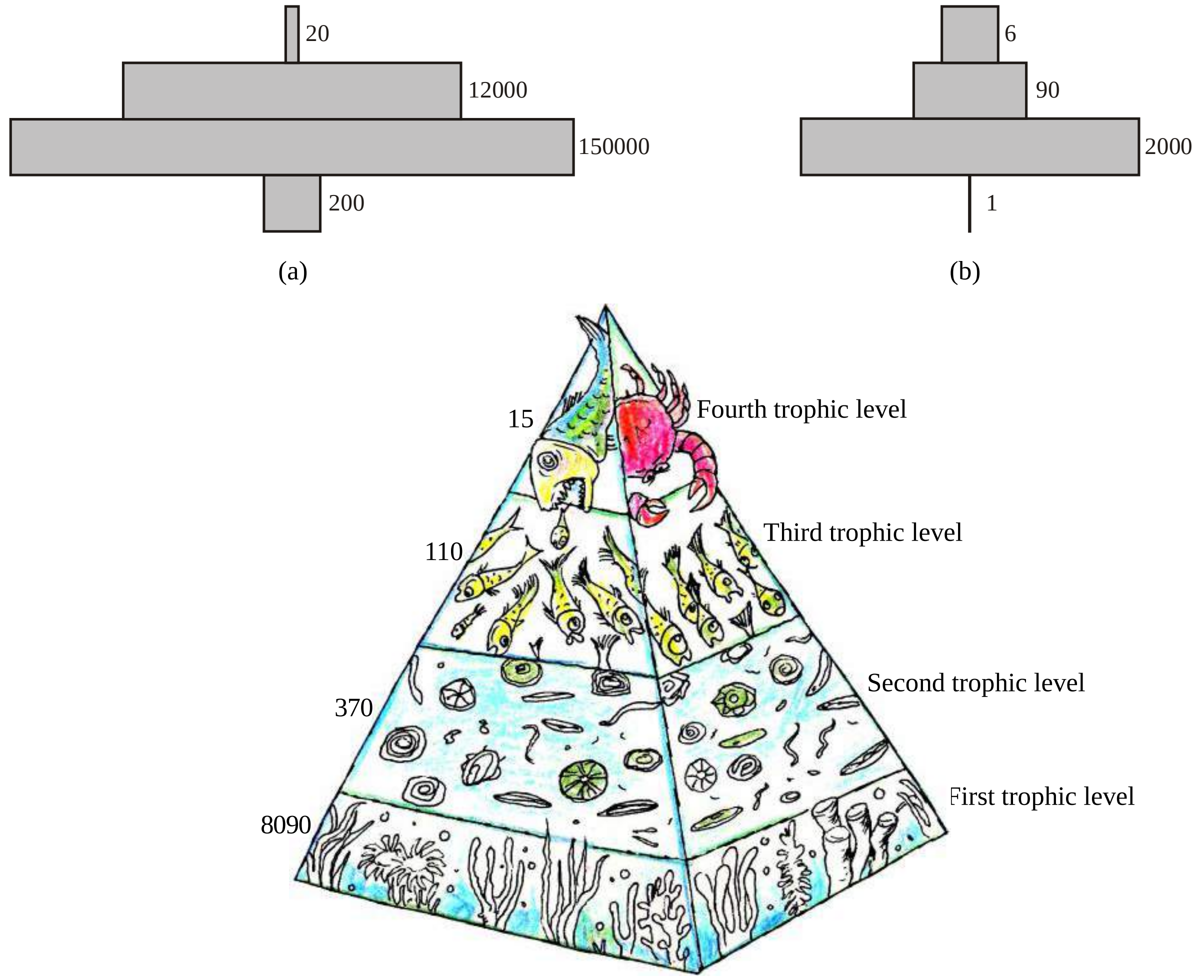


Figure-6: Pyramid of numbers (a) Forest (per hectare) (b) Tree (c) Pond (per hectare)

The ecological pyramid of numbers of a forest and that of a tree shows us that even if there are less organisms at the first trophic level, there are several at the next.

- Write a difference between the pyramid of numbers of the rice farm and that of a tree.
- Figure 8 (c) shows us a certain pyramid of numbers of an aquatic ecosystem. When will you find such relationships among aquatic organisms in a rice field?
- Write a similarity and a difference in the pyramid of numbers as shown in text of a rice field and that of an aquatic ecosystem like a pond.
- What does a broad base of a pyramid (as for example Figure 8 c) represent?
- Draw a food web according to any one of the above pyramids.
- How many trophic levels have been shown in each of the above examples?
- Calculate for each of the pyramids of figure 8 separately the number of organisms of first trophic level on which the next is dependent.
- If the number of organisms at the first trophic level or that of producers is less, will there still be enough food available for organisms of the next trophic level?

5.3.2 Role of Producers and Biomass

Primary production of a plant is the production of carbonic compounds by photosynthesis using solar energy and its accumulation. The sum total of the weight of plants(often by drying and taking dry weight) taken at a particular timerepresents the total primary productivity of that area. In most ecosystems, this is the biomass of the first trophic level or that of producers. Biomass may be calculated in this manner for the other trophic levels by estimating weight of organisms present at that level. A pyramid of numbers also indicates availability of food at each trophic level.Thus the availability of food at each trophic level does not necessarily depend on the pyramid of numbers but also on the pyramid of biomass.

- The pyramid of numbers of a forest and that of a rice farm are different. Do you think their pyramid of biomass would also be different?

5.3.3 Pyramid of Biomass

Examples of pyramid of biomass of some ecosystems is as follows-

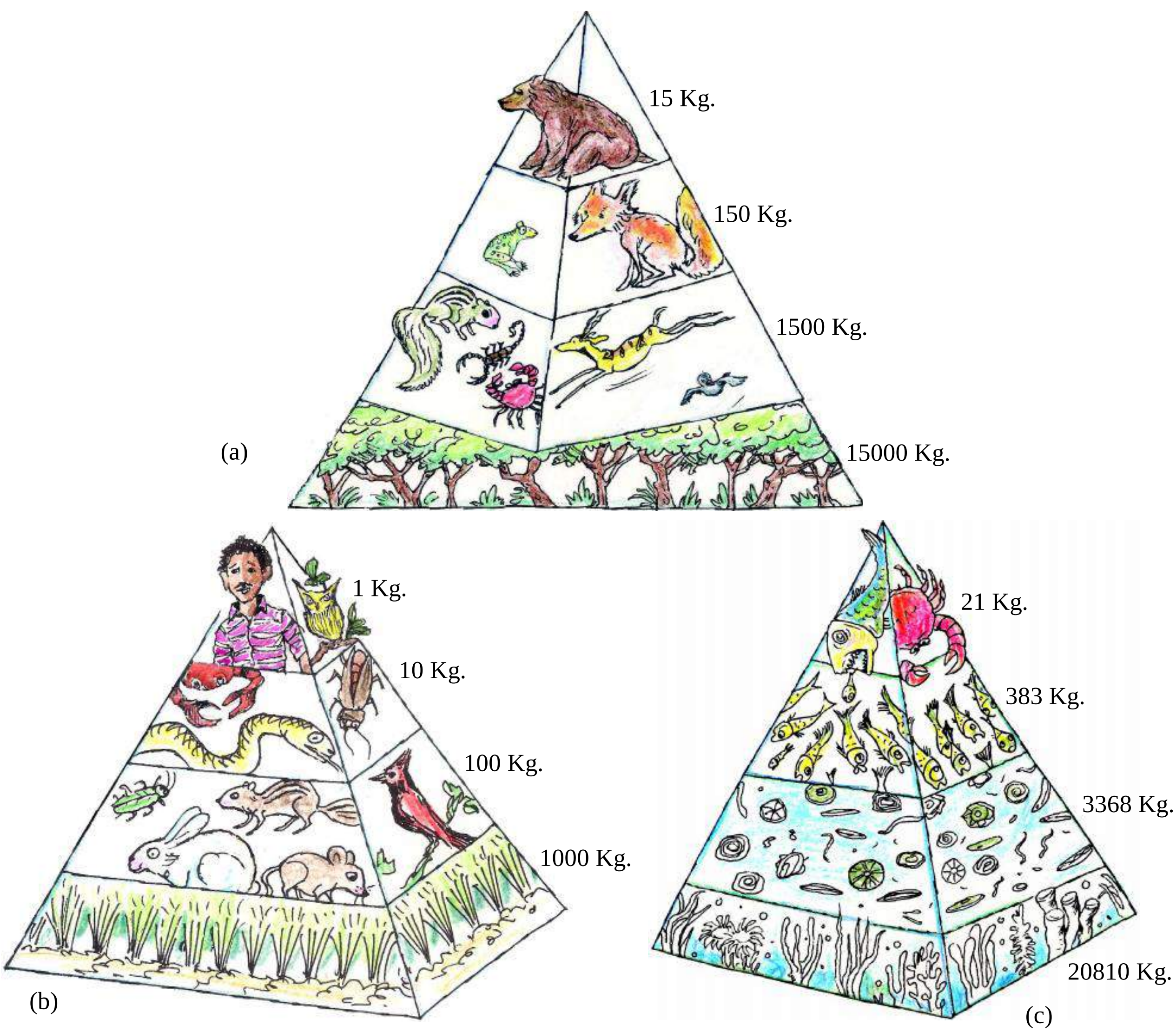


Figure-7: Pyramids of Biomass (Biomass in Kg/1000 square meter)
(a) Forest (b) Rice farm or a meadow (c) A type of aquatic ecosystem

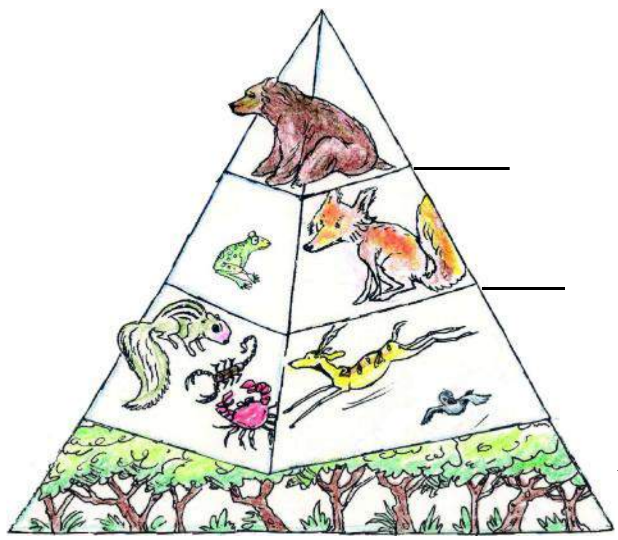
- Can humans be kept at second or third trophic level in the pyramid of biomass shown in fig.9 (b)?
- Write any two similarities between the pyramids of biomass.
- Do organisms at the second trophic level have enough food according to the pyramid of biomass for a forest?

Biomass is directly related to food and we know that we get energy from food.

- Observe the pyramid of biomass and guess if the energy obtained by the second trophic level is same as that of the third and fourth trophic levels.
- By what percentage did biomass reduce as we progressed from first to second trophic level?

5.3.4 Energy flow through trophic levels

It is very difficult to find out the amount of energy at each trophic level. We thus usually presume biomass as a basis to find out the energy at each trophic level. Thus let us find out the percentage of biomass available from first to next and further on to get an idea of the probable amount of energy that might also be available from one level to another (Note: though we usually follow this process of estimation of energy, there are several instances where even less biomass may produce energy equivalent to a lot of biomass).



$$\frac{1500}{15000} \times 100 = 10\%$$

Figure-8: Probable amount of energy available at each trophic level

Plants can convert nearly 1% of solar energy to that stored in bonds of chemical compoundssynthesized by the process of photosynthesis. Of this only 10% (0.1% of solar energy) is available for organisms of the next trophic level. Only a 10% of this again is converted to biomass at the second trophic level and available to those of the third trophic level. Thus efficiency of energy conversion at each trophic level is 10%. The efficiency of energy conversion in different ecosystems varies and values ranging from 2% to 24% have been calculated in researches conducted so far. Some amount of energy in plants is used to carry out its life processeswhile some is expended into the environment. Thus a very small amount of energy is available to the next trophic level. Similarly a much lesser amount of energy is available the third fourth and fifth trophic levels. Thus the base of all energy pyramids starting with producers at the first trophic level is broadest. Such pyramids are never inverted. This helps us to understand that no matter how varied ecosystems maybe, the energy flow in most of them occurs in a similar manner.

- How many trophic levels were there in the food chain that you observed in activity 1?
- What were the maximum number of trophic levels in the rice farm?

- How many trophic levels do we find in any food chain? Why do you think it is so?
- If in a rice farm there is 5000 kilocalories of energy at the first trophic level /or the level of producers, then how many trophic levels will be there till 0.5kilocalories of energy? Calculate and draw a pyramid to show energy at each trophic level(note that at each level the efficiency of energy conversion is 10%). Does the food chain of activity 1 have similar number of trophic levels?

Any food chain actually represents the pathway of flow of energy. A food web shows several such pathways. It becomes clear from food chain and pyramid of energy, that the flow of energy is unidirectional. The energy converted by plants cannot be converted back to solar energy. See figure 11 to understand more about energy flow through trophic levels.

Think and discuss

- Do you think energy in lost/ destroyed at each of the trophic levels?(remember you had studied in chapter 3 about conversion of energy from one form to another)
- What do you think is the role of decomposers in the flow of energy (see figure11)

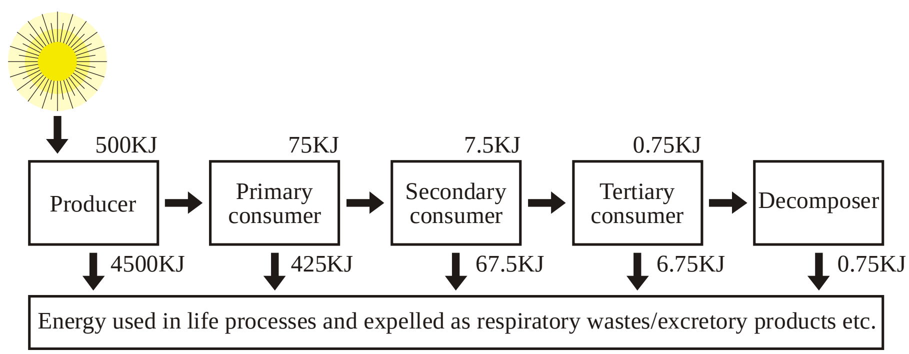
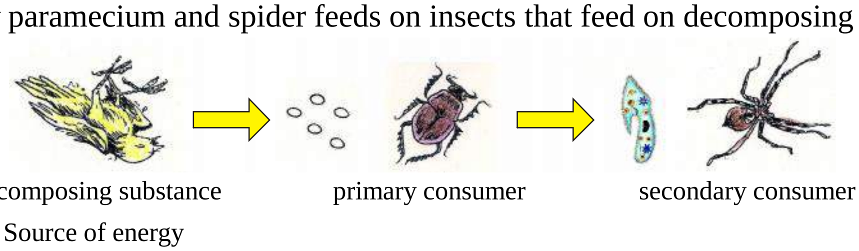


Figure-9: Estimated energy flow in an ecosystem

Do you know?

Food chains and food webs also start with decomposing substances. You had studied about one such pathway in the habitat of kani machri of Kotumsar caves. Here is another such example. Organisms that grow on a decomposing body of a bird like certain bacteria or yeasts are eaten by paramecium and spider feeds on insects that feed on decomposing wastes.



At the bottom of oceans where solar energy does not reach, there are food webs that start with bacteria that thrive not on solar energy but energy in the chemicals of the hot springs. These hot springs arise at the vents of volcanoes at the ocean floor and the temperature is often as hot as 400°C.

We observed that at each trophic level energy is expelled or expended through wastes or in running life processes respectively. Wastes produced contain energy that are no longer of use to the organism that produces them. They can be useful to others and thus substances in nature are constantly being recycled. Chemical compounds in abiotic substances in nature like wastes of living organisms and other chemicals present in soil, air and water are in constant circulation from a biotic to abiotic source and vice versa. We may study about this in the form of cycle of nutrients.

5.4 Nutrient cycles- flow of substances

You know that there are over 100 elements on earth. These elements are either in solid, liquid or gaseous states in nature. Bodies of living organisms are formed by some of these elements. Several organic compounds like carbohydrates, proteins, fats, nucleic acids etc. are synthesized in living bodies which are all carbon compounds. Often we study about these as carbon, nitrogen or other cycles.

Think and note

- Where do we find carbon dioxide gas?
- What are the different sources of carbon dioxide?
- Through which life process carbon compounds are synthesized in plants?
- How do these compounds reach the body of animals?

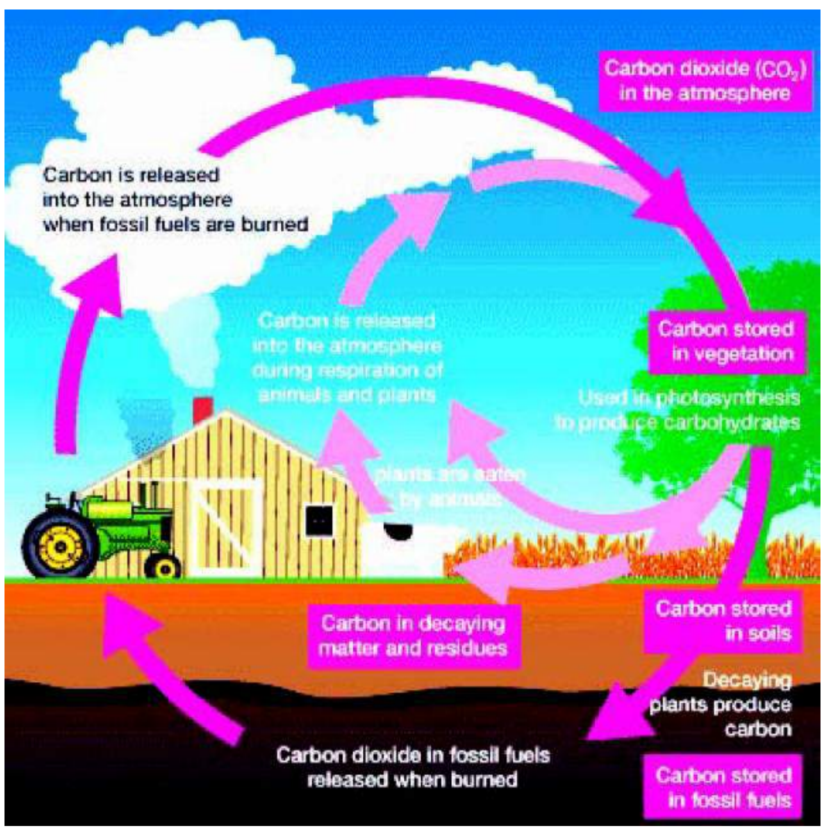


Figure-10: Carbon cycle

- Observe the figure and find out the sources from which carbon dioxide reaches the atmosphere?

Usually carbon cycles mainly in the form of a gaseous cycle of carbon dioxide. Green plants use atmospheric carbon dioxide to synthesize several carbon compounds. These are used and certain other carbon compounds(mainly proteins and fats) are often synthesized by consumers. The combustion of these compounds by different processes sends carbon-dioxide (CO_2) back into the atmosphere. The process of respiration (also a process of combustion) in living organisms is one such process. The process of decomposition also releases carbon dioxide into the atmosphere. Other simple carbon compounds formed also enter the nutrient cycle of nature.

5.5 Human intervention in ecosystems

Human beings impact ecosystems in several ways. We may see in the cabon cycle itself that the excess use of fossil fuels increases the level of oxides of carbon and carbon particles (both being potent sources of pollution).

Think, discuss and write

- Which abiotic components of the atmosphere do you think have been adversely affected by human intervention?
- Which biotic components have been adversely affected by humans?

Let us take the example of a rice farm, humans for their own benefits, destroy most organisms of the second trophic level.

- What will be the effect of this on the ecosystem of the rice farm?
- How will the impact of introduction of a new species of organism into a food chain in a rice farm?
- If 0.01milligram of arsenic accumulates in a rice plant due to use of arsenic containing pesticides, what will the total amount of accumulation in 30 plants? If you feed on grain obtained from around 30 plants everyday, think how much arsenic reaches your body every day?

We know that to protect our farms and get maximum produce we use different types of chemicals. Several of these like herbicides, insecticides, fungicides etc. are used to remove unwanted plants growing in farms, insects and disease causing macro and microorganisms. Some of these chemicals are decomposed quickly while several others remain in the soil for long periods of time as such and adversely affect crop plants, beneficial organisms etc. along with the harmful organisms. Sometimes they are absorbed into crop plants and affect humans and other organisms feeding on them adversely by causing several harmful diseases.

Chemicals that remain in the soil often affect the physical and chemical properties of the soil turning it unfit for our crops. This reduces crop production over time. Conversion of such areas into fertile land is very difficult, thus it is suggested that use of artificially manufactured chemicals be reduced to protect both our environment and us.

- Write about some ways in which observe around you how humans adversely affect the environment.

- What could be your role to save the environment from any harm(even if it is just at home or in your locality)? Write in detail about it.

Do you know?

Water hyacinth is a fast growing water plant. You may have observed these spread over the surface of in ponds and other water bodies of your locality. This plant was imported from America to our country. The introduction of this new species mainly for ornamental purpose has adversely affected both biotic and abiotic components of several water bodies.

What we have learnt

- All organisms in nature are interdependent. They also depend on the nonliving or abiotic components of the environment.
- Ecosystem is a system of interdependence for energy among biotic and abiotic components of nature.
- Most plants convert solar energy to energy conserved in bonds of chemical compounds by the process of photosynthesis and thus are called as producers.
- Primary productivity is the rate at which energy is converted by mainly photosynthetic plants to organic substances. The total amount of productivity in a region or ecosystem is total primary productivity.
- Total primary productivity of a given area also gives us the biomass of producers of a given area(it may be determined by taking the weight of producers in the area).
- All organisms other than producers are mainly consumers in a food chain.
- In the food and feeding relationships as observed in food chains or food webs, each level starting mainly from producers is called as trophic levels.
- Number of organisms, biomass or energy at each trophic level can be represented by drawing pyramids of number, biomass and energy.
- Biomass may be estimated by weight of organisms of a trophic level of a certain area at a certain time.
- Plants can convert nearly 1% of solar energy to that stored in bonds of chemical compounds by the process of photosynthesis of which only 10% is available for organisms of the next trophic level. Only a 10% of this again is converted to biomass at the second trophic level and available to those of the third trophic level. Thus the efficiency of energy conversion at each level is around 10%.
- Nutrients are constantly cycled in nature between biotic and abiotic components.

Key words

Ecology, ecosystem, trophic level, ecological pyramid, biomass, nutrient cycle

Exercise

1. Choose the right option.

(i) There are about 2234 insects, 56 birds and 3 snakes on a mango tree. The pyramid of energy would be-

(a) Straight (b) Inverted (c) rectangular (d) uncertain

(ii) Fungi started growing on a moist piece of bread left in the open. After sometime some insects like houseflies etc. were seen there. The organisms at the last trophic level would be-

(a) Food (b) bread (c) house fly (d) none

(iii) There are 3 stages in the life cycle of an insect - egg, larva, pupa, adult. If the stages of egg, larva and pupa are completed in the body of a particular organism then the insects life cycle is completed in how many ecosystems?

(a) 1 (b) 2 (c) 3 (d) 4

(iv) What will happen if all insect eating birds were removed from a particular cropland area?

(a) Crop production will increase (b) Insect infestation will increase

(c) Increase in the number of other birds (d) No effect

(v) Cow feeds on grass. Its dung is used to make dung cakes which are used as fuel. The burning of the dung cakes produce smoke that reaches the atmosphere and the ashes are mixed with soil. This adds nutrients for grass to grow. This process is an example of-

(a) Food chain (b) Food web (c) Nutrient cycle (d) Life cycle

(vi) The food chain in a pond starts from some water plants that are eaten by certain fishes those eaten by others extending finally to humans. The energy here from one trophic level to another will-

(a) Gradually decrease (b) gradually increase

(c) will be same (d) will be less sometime and more sometime.

(vii) The number of organisms in a garden was estimated as 5567 grasses, 453 shrubs, 23 trees and 7769 animals. The primary productivity of this area will be nearly equal to-

(a) Biomass of all organisms of the garden

(b) Biomass of all the plants of the garden

(c) Biomass of the animals of the garden

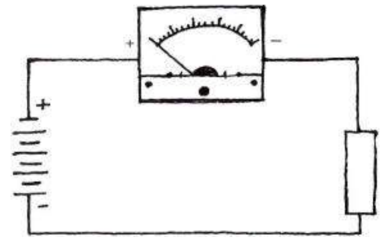
(d) Biomass of only 5567 grasses

2. A type of fungi is grown on rice husk. We eat the fungi. Does it show a food chain. Illustrate the food chain. What is the source of energy for this food chain?
3. How does energy flow in any ecosystem? Explain in your own words.
4. What will happen if only plants and humans are left on earth as living organisms or biotic component?
5. What will happen if the natural flow of energy in an ecosystem is disrupted? Explain with an example.
6. How does the availability of energy affect the number of organisms at different trophic levels?
7. Site an example where you find the effect of human beings on an ecosystem. Explain why you think so and suggest some means to minimize the same.

Note: The numerical values given in most of the illustrations have been provided only for study and are not meant to be learnt by rote. Also note that ecosystems are so varied that values of such type cannot apply universally. Even two ponds would not have same values.

Chapter 6

Electric Current and Circuit



In your previous classes, you had learned to make some simple electrical circuits. Can you make an electrical circuit using only a wire, a single bulb and a battery? In how many different ways can you connect the above components? Remember that you have to use only a single piece of wire without cutting it.

In this chapter, we shall study several concepts of electricity. You already know that electricity exists in two forms, static electricity and electric current. Static electricity is that form of electricity where the electric charge remains stationary. While in an electric current, the electric energy flows due to the potential difference between two points in the circuit. We have studied static electricity in previous classes. We shall now learn about current electricity in this chapter.

6.1 Electric Current

Let us try to understand the concept of electric current through an activity:

Activity-1

Required materials – connecting wires, iron nail, wooden twig or a pencil, electric bulb and a cell.

Case 1: Form a circuit, as shown in figure-1(a), using connecting wires. Connect the bulb, nail and cell together. After completing the circuit check the state of the bulb. Does the bulb light up?

Case 2: Now, replace the iron nail with a wooden pencil in the circuit, as shown in figure-1(b). In this case, does the bulb light up on completion of the circuit? If not, why?

Case 3: In the circuit, leave a gap between the connecting wires, as shown in figure-1(c).What happens to the bulb, does it light up?

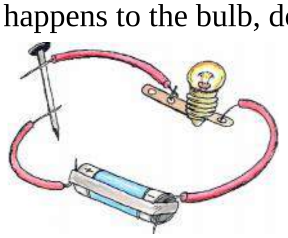


Figure-1 (a)

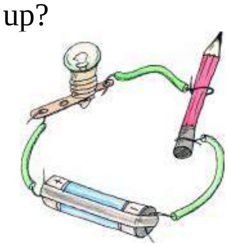


Figure-1 (b)

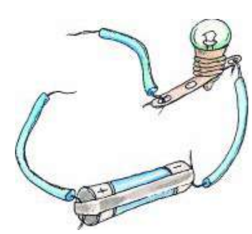


Figure-1 (c)

You can also use a coin, a glass rod, paper, rubber, or anything else in place of the nail and repeat the above observations.

We observed that, when the circuit is closed using connecting wires, or if any conducting material is present with the connecting wires in the circuit, then the bulb lights up. In this case, the electric current flows through the circuit without any obstruction. But if the circuit is broken, that is if the connecting wires are not connected properly or a non-conducting material is present, then the current does not flow through the circuit and hence the bulb does not light up. Group the materials used by you in the above experiment into two categories, conductors and non-conductors.

We can state that conductors allow the flow of electric current through them, while, non-conductors or insulators prevent or resist the flow of current. Remember, the flow is not of electric current but of electric charges, which in turn produces electric current. However, for simplicity, we call it flow of current. This is similar to the water current produced due to the flow of water molecules. Here, the quantity of water molecules is analogous to the quantity of electric charge. We shall try to understand some concepts of electricity using similar analogy.

Remember that unlike the molecules of water, molecules of current do not exist. This is because electric current is not matter but is a form of energy. Therefore, though you can see the flow of water through a cut pipe, you cannot see the flow of electricity through a cut wire, rather cutting a wire stops the flow of current.

Electric current is the total electric charge that flows across a cross section area of a conductor, in a unit of time. The measuring unit of electric charge is Coulomb. If 'Q' Coulomb charge flows in 1 second across a conductor, then the quantity of electric current flowing across the conductor would be,

Current, $I = Q/t$ …….. (1)

French Scientist Sir Andre-Marie Ampere (1775-1836) is known as the 'father of electrodynamics '. The unit Ampere is named after him.

The SI unit of measurement of electric current is Ampere, represented as 'A'. This is a vector unit.

From equation (1), we can derive that when 1 coulomb of charge flows across a cross section of conductor in 1 second, the current flow is defined as 1 ampere.

1 ampere = 1 coulomb/1 second

Sometimes, smaller units than ampere are used like milliampere (mA) or microampere (μA).

$1\ mA = 1/1000\ A = 10^{-3}\ A$

$1\ \mu A = 1/1000000\ A = 10^{-6}\ A$

Electric current in an electrical circuit is measured using an Ammeter. It is an instrument which shows the quantity of electric current flowing.The positive terminal of the ammeter is attached to the Positive terminal of the cell and the negative terminal to the negative in a series combination. Ammeter has very low resistance to current and hence is attached in series combination in the circuit, so that maximum current can flow through it.

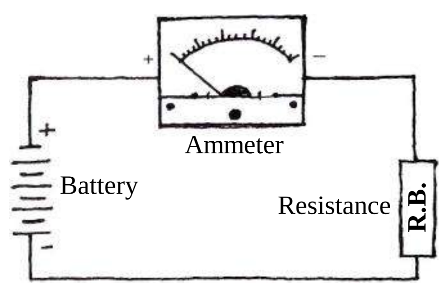


Figure- 2: Ammeter connected

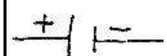
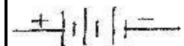
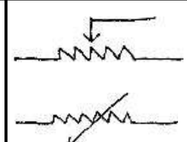
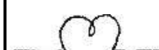
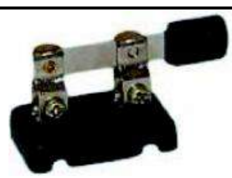
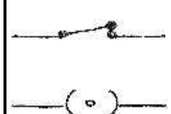
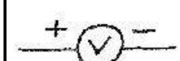
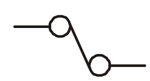
Questions:

1. If a 0.4A electric current flows in a circuit for 10 minutes, then, calculate the total charge flowing in the circuit.
2. Write the definition for the unit of measurement of electric current.

6.2 Components of an Electrical Circuit

Electrical components like connecting wires, electric bulbs, switch, ammeter, voltmeter etc.,can be parts of an electrical circuit. We usually show an electric circuit by drawing a line diagram. The various components of a circuit are shown by the signs, as listed in (table-1). Try to collect these components and any other that you can find, and study and tabulate them.

Table-1: Signs used in circuit diagrams

Electrical component	Picture	Sign	Electric component	Picture	Sign
cell			Battery		
Connecting wires			Resistor		
Joining wires			Variable resistor		
Electric bulb			ammeter		
Key/switch on			voltmeter		
Key/switch off			fuse		

Questions:

1. Can you tell whether a current is flowing in an electric wire by observing it? If not, how will you test the flow of current?
2. Why should we use items made of wood or rubber to detach a live wire from an electrocuted person?

6.3 Electric Potential and Potential difference

We have observed in our day to day life that water always flows from a container having a higher level to the container having a lower level, till the water level of both become equal. Normally, this water flow is due to the pressure difference, and it continues till the pressure in both the container becomes the same. In the above case, the water flows automatically, from higher to lower pressure as soon as the two containers are connected.

Similarly, for an electric current to flow in any circuit, the presence of potential difference is necessary. Due to difference in electric potential in a circuit, an electric charge flows from the point at a higher potential towards the point at a lower potential. This flow of charge is known as electric current. To maintain the flow of electric current, we have to create a potential difference in the circuit by using a source of voltage. Electric cell and battery are types of voltage source.

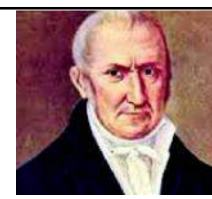
Electric Field

The area surrounding a charge, within which it experiences a force of attraction or repulsion due to the presence of another charge, is known as the electrical field of the charge. If a positive charge 'Q' is kept at a point, an electric field is created around it. The intensity of the field is strongest near the charge and weakens as the distance from the charge increases.

The force experienced by a single positive electric charge positioned at any point in an electric field is known as the intensity of the electric field at that point. It is represented by 'E' and its unit is Newton/Coulomb.

If a positive charge 'q', experiences a force F, then the force for a unit (singular) of charge would be F/q, thus,

Intensity of electric field, $E=F/q$



The unit volt is named after the Italian physicist Alasandro Volta.

The electric potential at point P in an electric field is equal to the work done to bring a unit positive charge from infinity to that point P. If W is the amount of work done to bring a charge 'q' from infinity to point 'P' of the electric field, then work done to bring a unit charge from infinity to that point would be W/q.

$$\text{Potential } V=W/q = \frac{\text{work done}}{\text{charge}} \qquad \text{................ (2)}$$

The unit of measurement of potential in SI system, Volt = Joule/ Coulomb.

Similarly, the potential difference between two points in a circuit is the amount of work done to move a unit positive charge between the two points. The potential difference is measured between two points of a circuit by an instrument, voltmeter. The positive terminal of the voltmeter is attached to the positive of the cell/battery and the negative of the voltmeter to the negative terminal of battery, in a parallel combination.

The unit of measurement of potential difference in the SI system is Volt, denoted as 'V'. We know that the electric potential in a cell or battery is higher at the positive terminal than the negative terminal. When we move from the positive to the negative terminal of the battery, in an electric circuit, there is a decline in the potential difference which is known as voltage drop.

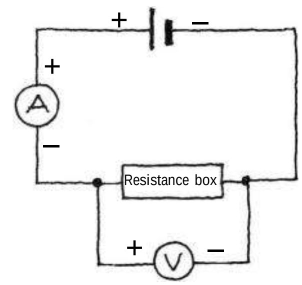


Figure-3: Voltmeter in a circuit

6.3 The Ohm's Rule

George Simon Ohm

In 1827, the physicist George Simon Ohm, established the relation between the potential difference, resistance and electric current in a circuit. We shall undertake the following activity to understand it-

Activity-2

Make an electric circuit as shown in Figure-4. The components needed are – a 0.5 meter long nichrome wire (XY), an ammeter, a voltmeter, four electric cells of 1.5 volts each.

We shall use only one cell in the beginning. To measure the current 'I', flowing across XY, an ammeter is used and a voltmeter is used to measure the potential difference 'V', between the two cell terminals. Note down the ammeter and potential difference readings in table-2.

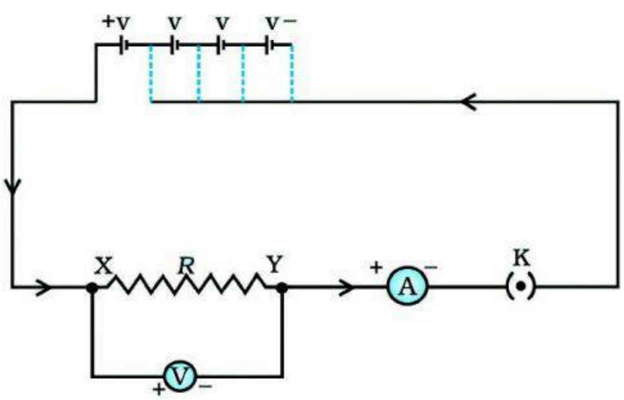


Figure-4: Circuit to demonstrate Ohm's rule

Now join two cells in the circuit and note the values of potential difference and current as reading-2. Similarly, we join 3 cells and four cells and note the measurements as readings-3 and 4, respectively, in the table.

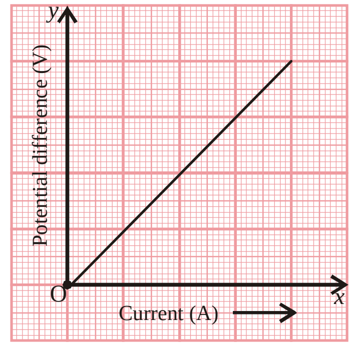
Table-2

S.N.	No.of cells in the circuit	Current I, flowing in wire XY	Potential Difference V, between X and Y	V/I volt
1.	1			
2.	2			
3.	3			
4.	4			

- What are the values of V/I for each pair of potential difference V and current I?
- Draw a graph between the values of V and I and observe the relation between them.

In this activity, you will find that the value of V/I for each reading remains almost constant.

This is shown in graph-1, where V/I is a straight line drawn from the initial point. It means, V/I, is a constant ratio. Therefore, $V \propto I$.



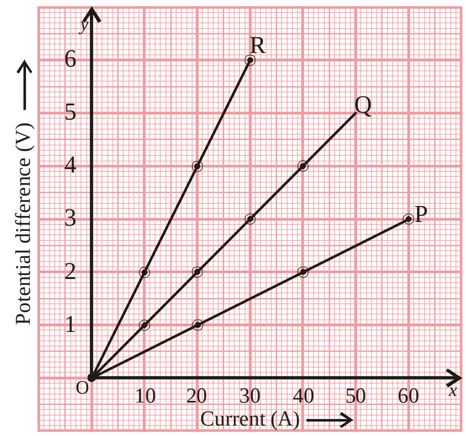
Graph 1

V = RI (where R is a constant)

Or, R = V/I or I = V/R ....(3)

Here R is a constant which is known as the resistance of the wire. The measuring unit of resistance in the SI system is Ohm (Ω). From eq. (3), if the potential difference between two terminals of a conductor is 1 V and a current of 1 A, flows in it, then the resistance R of the conductor is said to be 1 ohm.

$$1 ohm = \frac{1 Volt}{1 Ampere}$$



Graph 2

It is clear from eq. (3), that the current flowing in a resistor is inversely proportional to the value of resistance R. Thus, if the potential difference remains constant, the amount of current falls to half when the resistance is doubled. In practice, it is often necessary to increase or reduce the current in a circuit without changing source voltage, and this is done by using a component called variable resistor. It is also known as rheostat (current controller).

Question :

The values of potential difference and current in three resistors P, Q and R are shown in graph-2. Find out the resistances of the resistors and establish the ratio between them, i.e., P:Q:R.

6.4 Resistance and Conductance

You must have observed that in the electric circuits in our homes, in some places thick electric wires are used and in other places thinner wires are used. You know that the amount of current flowing in a circuit depends on the potential difference in the circuit as well as the resistance offered by the circuit. In wires with equal cross section thickness, the resistance offered by the longer wire is more than that offered by the shorter wire. Similarly, in wires of equal length, the thicker wire will have a lower resistance than the thinner wire.

Therefore, current flow is easier in a circuit having thicker and shorter wires, and hence in our homes attention is given to the thickness and length of the wires used in the circuits. The resistance in a conductor depends on the following –

- length of the conductor
- cross section area of the conductor
- property and nature of the conductor material
- temperature of the conductor

Activity-3

(Part 1 – Length of the conductor)

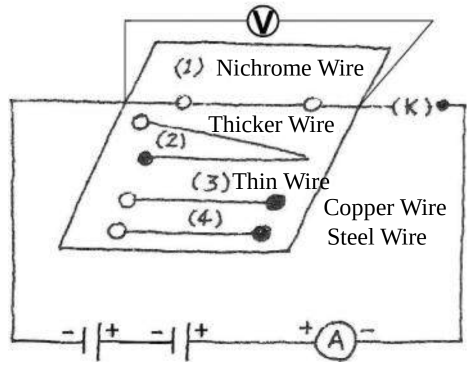


Figure- 5: Study of resistance

- Take a 100 cm long Nichrome wire.
- Mount the two ends of the wire tightly, checking that the wire is not coiled.
- Now attach two cells of 2 V each in series, a voltmeter and ammeter to complete the circuit.
- Measure the current, I and the voltage, V across the Nichrome wire and fill the values in table-3(a).
- Now using the mount, change the legth of the wire to 80, 60, 40 and 20 cm and fill table-3(a), accordingly. Draw a graph between the values of resistance and length of wire and establish the relation between them. Did you find that R and *l* are proportional?

Table-3

	Length of wire *l*	Electric current I	Potential difference V	Resistance (V/I)
3(a)	100 cm			
	80 cm			
	60 cm			
	40 cm			
	20 cm			
3(b)	Cross section area			
	Thin wire (10 cm)			
	Thick wire (20 cm)			
3(c)	Material of wire			
	Nichrome (100 cm)			
	Copper (100 cm)			
	Steel (100 cm)			

(Part 2 – Cross section area of the conducting wire)

- Take two Nichrome wires of 100 cm length but of different thickness.
- One by one tighten the wires tightly, on the mount, and note the current in the wire and the potential difference between the wire ends, and fill in the values in section-3(b) of table-3.
- Establish the relationship between the cross section of the wire and its resistance.
- Remember that the thicker wire has a larger cross section. Would the resistance of the thicker wire be larger than the thinner wire? What did you observe?

(Part 3 – Nature of the wire material)

- Take Nichrome, copper and steel wires of equal length and thickness.
- Mount them in the circuit, one by one, and fill in the values of I and V, in section-3(c) of table-3.
- Which of the above wires has the highest and lowest resistance?

After the activity, we find that, Resistance $R \propto l$ ....(a)

$R \propto 1/A$ ....(b)

From (a) and (b)

$R \propto l/A$ ....(c)

or, $R = \rho\, l/A$ ....(d)

Here ρ (rho), is a relational constant, which is called the 'resistivity' of the conductor. The SI unit of resistivity is Ohm-metre (Ω-metre). It is an inherent property of all materials. Generally, metals and their alloys have low resistivity, which ranges between $10^{-8}\,\Omega$ to $10^{-6}\,\Omega$, and thus they are good conductors of electricity. The resistivity of metals increases with temperature and decreases with lower temperature. But the high resistivity of some special metal alloys like Nichrome, manganin etc., does not depend on temperature. This is the reason that these alloys are used in appliances and heating devices like electric irons, toasters, ovens etc. Tungsten metal is used to make the filament of electric bulbs. Copper and aluminium are used in the manufacture of wires and cables for transmission of electricity due to their extremely low resistivity.

The electrical resistivity of any material does not depend on its length or cross section area but is solely dependent on the nature of the material.

If we take a wire of unit length and unit cross section then,

Resistance, $R = \rho\, l/A$, as $l = 1$ and $A = 1$

Thus, $R = \rho$

Therefore, the resistivity of a wire of unit length and unit cross section is equal to its resistance.

The electrical resistivity of any material is inversely proportional to its conductivity. Materials with low resistivity are good conductors of electricity while those with high resistivity are non conductors.

No material is purely a conductor or a non-conductor. Materials can be depicted from high to low conductivity as shown in figure-6.

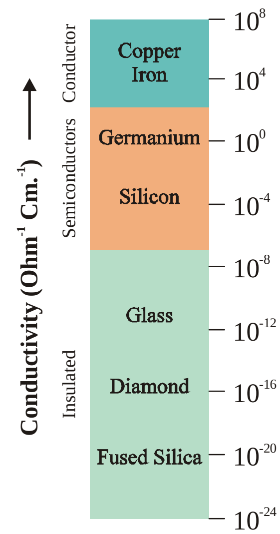


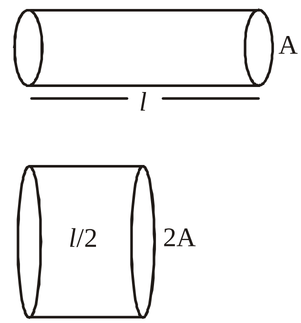
Figure- 6: Increasing conductance of materials

Example-1: If a wire with 8 Ω resistance is melted and a new wire made with double the cross section, what would be the resistance of the new wire?

Solution: Given R = 8 Ω, when the thickness of the wire is doubled, as the volume of metal is fixed, the length of the wire decreases by half. We know that –

$$\text{Resistance} = \text{resistivity} \times \frac{\text{length of wire}}{\text{Cross section}}$$

$$R = p\frac{l}{A}, \qquad R_{New} = \rho\frac{\text{Half length}}{\text{Double cross section}} = \rho\frac{l/2}{2A}$$



$$\frac{R_{new}}{R} = \left[p\frac{l/2}{2A}\right] / \left[p\frac{l}{A}\right] = \frac{1}{4}$$

$$\text{Therefore, } R_{new} = \frac{R}{4} = \frac{8\Omega}{4} = 2\Omega$$

The resistance of new wire is 2 Ω.

6.5 Combination of Resistances

As we know, a complete circuit made of many components is required for the flow of current. The circuit components consist of resistance, bulb, cell, connecting wires etc. Whenever a circuit contains more than one resistance, the resistances can be connected in the following two ways –

1. Series combination 2. Parallel combination

6.5.1 Series combination

When in an electrical circuit, the second terminal of a resistor is connected to the first terminal of the second resistor, and the second terminal of this resistor is connected to the first terminal of the third resistor, and so on, this type of combination is known as a series combination. We can extend this series as required. Also, we can add other components like cells, switches, ammeter etc., between the resistors combined in series.

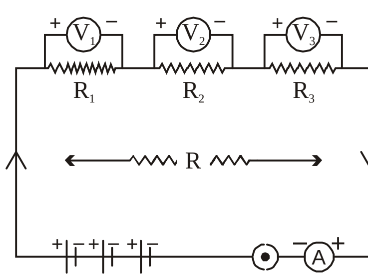


Figure-7: Series combination

In the given diagram three resistors R_1, R_2 and R_3 are combined in a series. If a single resistor replaces all the resistors in such a way that the value of current flowing in the circuit remains the same, then this single resistor is known as equivalent or effectual resistance.

In figure-7, if the current flowing in the circuit is I, then the same amount of current I will flow across each of the resistors. As we know, each point in a circuit has a different potential difference, therefore, each resistor combined in series will have different values of potential difference. If potential difference of resistor R_1 is V_1, R_2 is V_2 and of R_3 is V_3, then as per Ohm's law:

V = IR

Therefore, $V_1 = IR_1$, $V_2 = IR_2$, $V_3 = IR_3$ ....(i)

The total potential difference in a series is the sum of individual potential difference across each resistance.

$V = V_1 + V_2 + V_3$ ....(ii)

According to equations (i) and (ii),

$IR = IR_1 + IR_2 + IR_3$

$R = R_1 + R_2 + R_3$

Thus, in a series combination the total resistance is equal to the sum of all resistances. Equivalent resistance of the series is therefore equal to R.

The main drawback of a series combination is that if any component of the circuit malfunctions, the flow of current is broken at that point and the whole circuit becomes defective and no component works.

Similarly, ammeter and voltmeter also offer resistance to current flow. The resistance of ammeter is very low and therefore it is connected in series in a circuit so that maximum current flows through it. But the voltmeter is always connected in parallel, because of its higher resistance, so that less current passes through it.

6.5.2 Parallel Combination

In a parallel combination, the first end of all resistors in the circuit, are joined to one point and the last end of the resistors to another point of the circuit. Such type of combination is known as a parallel circuit. We can increase the number of components in the circuit as required. In figure-8, three resistors R_1, R_2 and R_3 have been joined in parallel combination. In the circuit, battery, switch, ammeter and voltmeter have been added. In a parallel circuit, each resistor has the same potential difference, but the amount of current flowing in each resistor is different.

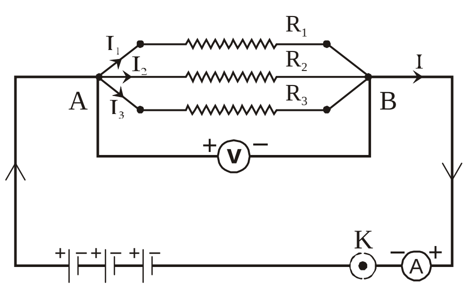


Figure-8: Parallel circuit combination

If in resistors R_1, R_2 and R_3 the amount of current flowing is I_1, I_2 and I_3, respectively, then according to Ohm's law,

$$I_1 = \frac{V}{R_1},\ I_2 = \frac{V}{R_2},\ I_3 = \frac{V}{R_3}$$

If the equivalent resistance of the three resistors is R, then,

$$I = \frac{V}{R}$$

But, $I = I_1 + I_2 + I_3$ (In parallel circuit total current is equal to sum of individual currents in each resistor)

In the above equation,

$$\frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

Equivalent resistance, $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

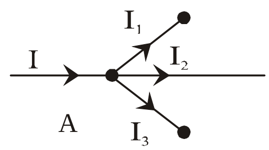
As you have seen, the equivalent resistance in a series combination is greater than the largest resistance in the circuit, but in a parallel combination the equivalent resistance is lower than the smallest resistance in the circuit.

Kirchoff's Rule

According to diagram, a current I passes through point A, and then branches out in three paths I_1, I_2 and I_3.

Therefore at point A, $I = I_1 + I_2 + I_3$

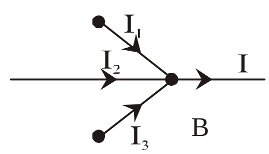
$I - I_1 - I_2 - I_3 = 0$



At point B, the three branched paths join together and the value of current becomes equal to the value at point A.

At point B, $I_1 + I_2 + I_3 = I$

$I_1 + I_2 + I_3 - I = 0$



This is the mathematical representation of Kirchoff's rule. Therefore, according to Kirchoff, the algebraic sum of current flowing in to any point or junction of a circuit is equivalent to the sum of current flowing out of that point or junction. There is no storage of current at any point in the circuit and it is constantly flowing. This rule of Krichoff is in accordance with the law of conservation of charge. This first rule of kirchoff is also known as junction or nodal rule of current.

Discuss :

The old style string of festival lights consisted of all bulbs joined in a series. If even a single bulb fused or malfunctioned, the whole string would stop working. Why? If all appliances in our home are connected in series, what would happen?

Questions :

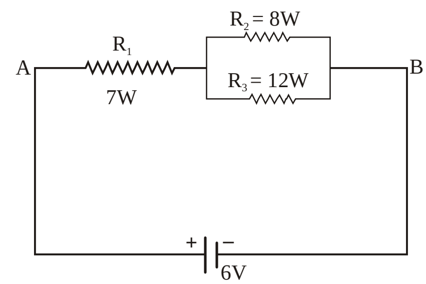
1. If two wires made of the same material, one thick and the other thin, are connected to an equivalent source of current, then, in which wire would the current flow more freely and why?
2. The value of two resistors in a series is in the ratio of 1:4, and a 10 ampere current flows in the circuit. If these two resistors are combined in a parallel circuit, then calculate the ratio of the current flowing through the resistors.

Example-2: Answer the following questions pertaining to the circuit diagram given alongside.

(a) Equivalent resistance of the circuit?

(b) Total current flowing in the circuit?

Solution : (a) We need to calculate the equivalent resistance of the resistances R_2 and R_3 combined in parallel,

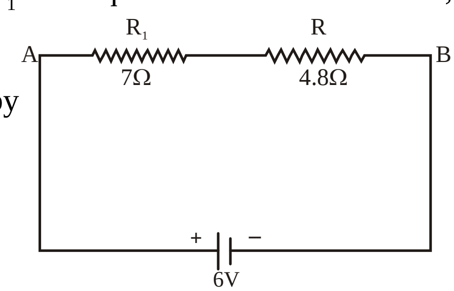


$$\frac{1}{R} = \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{R} = \frac{1}{8} + \frac{1}{12} = \frac{3+2}{24} = \frac{5}{24}$$

$$R = \frac{24}{5} \text{ Ohm} = 4.8 \text{ Ohm}$$

(b) Now, we will calculate the equivalent resistance according to the new circuit diagram given alongside, where the equivalent resistance R, of the parallel resistances R_2 and R_3, has been combined in series with resistance R_1. The equivalent resistance now is,



$R' = R_1 + R$ $\quad R' = 7\Omega + 4.8\,\Omega \quad = 11.8\Omega$

The potential difference created in the circuit by the battery,

V= 6 volts

Equivalent resistance of the circuit = 11.8Ω

As per Ohm's law,

I = 6/11.8

= 0.508 A (ampere)

6.6 Thermal Effect of Electric Current

We use many different electrical appliances in our daily life and are aware that they generate heat when used for a prolonged time. For example, bulbs and motors become hot after some time.

When current flows in any conductor, some electric energy is lost. As per the law of energy conservation, energy cannot be created or destroyed, but can only be converted from one form to another. Therefore, the electric energy last is transformed into heat energy. This effect is known as the thermal effect of electric current. The heat generated in a circuit is due to this thermal effect of current.

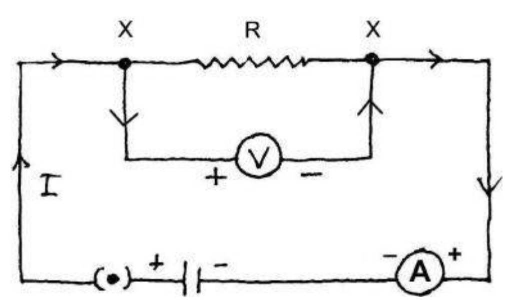


Figure- 9: Joules law of heating

Thermal Rule of Joule: Given that, I current flows for t seconds across a resistance R, and a potential difference V is set up between the two terminals of the resistance,

The charge flowing in the wire in t seconds, = current × time

or, $Q = I \times t$ …….(i)

From the definition of potential difference, the work done to move a charge q, in time t, across the two terminals is,

$W = QV$ and $Q = I \times t$ equation (i)

Therefore, $W = V \times It$ …..(ii)

The work done to move charge q from one end to the other end across the resistance R, manifests itself as the heat generated in the resistance.

Thus, in eq.(ii), if heat H, is substituted for W, $H = VIt$ ….(iii)

Therefore, the heat generated H in the resistance by current I (in time t) is as follows: $H = I^2Rt$ (V=IR, as per Ohms law)

This is known as the Joule's law of heating.

According to this law,

1. The heat H, generated in the resistance, is directly proportional to the square of the current I, flowing across it. Thus $H \propto I^2$
2. The heat generated in the resistance is directly proportional to the resistivity R.

   Thus, $H \propto R$
3. The heat generated in the resistance is directly proportional to the time t, of current flow.

   Thus, $H \propto t$

   $H = I^2Rt$ ….(iv)

6.6.1 Electric Power

The rate at which electric energy is converted into any other form of energy is known as electric power. It is equal to the product of the electric current and potential difference. The rate of loss of energy in any electric circuit is also called electric power. In other words, the rate of work done is known as Power and is denoted by P.

Assume that, in an electric circuit, current I flows across a potential difference V, then the loss of electric energy in t seconds, W = VIt.

Therefore, the loss of energy in 1 second = $\frac{W}{t} = \frac{VIt}{t} = VI$

This is known as Electric Power

$$P = \frac{W}{t} = VI \quad \text{.............(v)}$$

The SI unit of electric power is watt.

From eq.(v), the energy produced in a circuit by a source in time t, is P × t, which equals VIt.

H = VIt ....from (iii)

$H = I^2Rt$ (V = IR)

The value of electricity consumed, H is represented by the unit RWh.

1 kilowatt hour = 1 unit = 1000 watt × 1 hour

1000 watt × 3600 seconds = 36×10^5 watt second

= 3.6×10^6 watt second = 3.6×10^6 Joule

The electric energy consumed is measured by the following equation-

Electricity consumed (in units) = [No. of electric appliances × power of appliance (watt) × Time (hours) × No. of days]/1000

Example-3: In a house, if 4 bulbs of 60 watt burn for 4 hours daily, and 2 fans of 80 watt are used for 10 hours daily, then calculate the electricity consumed in one month and the value of consumed electricity if the rate of electric power is Rs. 2 per unit.

Solution: The electric energy consumed by 4 bulbs of 60 watts used 4 hours per day,in a month

$$= \frac{4 \times 60 \times 4 \times 30}{1000} = 28.8 \text{ units or } 28.8 \text{ Kwh}$$

and energy consumed by the 2 fans

$$\frac{2 \times 80 \times 10 \times 30}{1000} = 48 \text{ kwh}$$

therefore, total electric consumption = 28.8 + 48 = 76.8 units/month

Cost of 1 kilowatt hour = Rs. 2.00

76.8 × 2 = Rs. 153.6 = Cost of consumed electricity

Example-4: If 100 joule heat is being generated by a 4Ω resistor then calculate the potential difference between the two terminals of the resistor.

Solution: H = 100 joule, R = 4Ω , t = 1 second, V = Ω

According to Joule's law of heating

$H = I^2Rt$

$$I^2 = \frac{H}{R \times t}$$

$$I = \sqrt{\frac{H}{Rt}} = \sqrt{\frac{100}{4 \times 1}} = \sqrt{25} \text{ ampere} = 5 \text{ ampere}$$

Therefore, according to Ohm's law,

V = IR = 5 × 4 = 20 volts

Note: In an electric bulb the filament is made of a thin tungsten metal wire which appears short in length, but actually it is 6 feet long and is made by tightly coiling the wire.

6.7 Domestic Electric Circuit

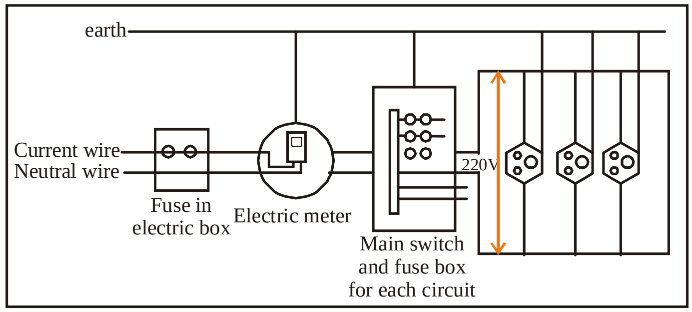


Figure-10: Domestic electric circuit

We receive our electric power in our homes, from the main lines of electric supply. It reaches in our homes by means of a 3 wired electric cable. The three wires of the cable are colour coded. Red is for live current, blue or black for neutral phase and green wire is for earth. In our country, the potential difference between the current (live) wire and neutral wire is 220 volts. The earth wire is of thick copper, and the end of it is joined to a copper plate which is buried deeply underground. It is then joined to the main switch through the electric meter. The live current wire and the neutral wire coming from the electric supply pole, are first attached to a stationery box housing the electric meter. The whole circuit is protected from current overload or short circuit by using fuses combined in a series. If the live current wire and neutral wire get accidentally combined, then the resistance of the circuit becomes null (zero), and heavy current flows in the circuit. This leads to damage of electric appliances in the circuit and can produce sparking and lead to fire. Fuse is a wire made of any metal or metal alloy which has a particular melting point, for example, aluminium, copper, iron, lead etc. If the current flowing in the circuit exceeds a particular value, then the fuse wire heats up and melts. Thus, the circuit is broken and current flow stops. In domestic circuits, usually fuse wires with current ratings of 2A, 3A, 5A or 10A are used. The electric current is transmitted, from the power producing station, in the form of alternating current (A.C.). In this form of current, the direction of the current flow is constantly changing. For domestic use, current of 5A, and for industrial use 15A is supplied and it has a frequency of 50 Hertz.

The current produced by a cell or battery has a fixed direction and its frequency is zero hertz. This is known as Direct Current (D.C.).

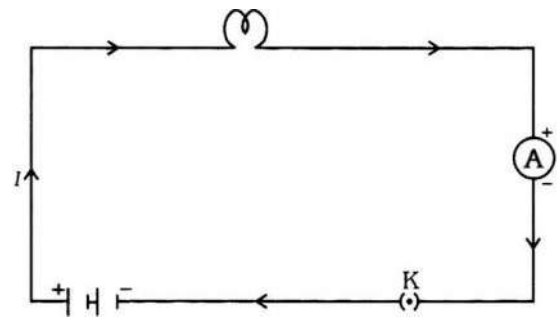
6.8 Precautions while using Electricity

As we have seen, there is a danger of fire in an electric circuit due to overload or short circuit. Therefore, the following precautions should be taken during use:

- Switches and plugs should be fitted tightly.
- Wires having proper covering insulation should be used.
- Damaged or wires in poor condition should be immediately replaced.
- The circuit should be immediately switched off in case of fire or any accident.
- All circuits should be protected by fuse wires of proper material and rating.
- All electric appliances should be properly earthed.
- Never touch any part of the circuit with wet hands.

Solved Numerical Problems

1 In a electric bulb, a current of 0.5 A flows for 10 minutes. Calculate the electric charge flowing in the electric circuit?



Solution: Given that, I=0.5 A, t=10 minutes = 600s

$Q = I \times t$

$= 0.5\text{ A} \times 600\text{ s}$

$= 300\text{ C}$

2. A metallic wire of length 1 meter has a resistance of 26Ω at a temperature of 20°C. If the diameter of the wire is 0.3 mm, then what is the resistivity of the metal composing the wire at the given temperature?

Solution: Given that the wire Resistance, R = 26Ω, dia, = 0.3 mm = 3×10^{-4}m, $r = \frac{3\times10^{-4}}{2}$

$= 1.5\times10^{-4}$ and length of wire l = 1 m

Therefore, according to the equation, the resistivity of the wire,

$$\rho = (RA/l) = (R\pi d^2/4l) = \frac{R\pi r^2}{l} = \frac{26\times22\times1.5\times10^{-4}\times1.5\times10^{-4}}{7\times1}$$

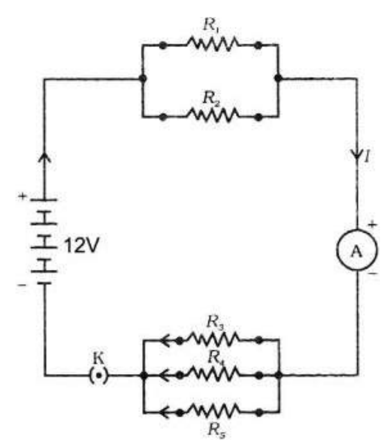
By solving the above, we get,

$\rho \Rightarrow 1.84 \times 10^{-6}\ \Omega\text{-m}$

Thus, the electric resistivity Ω, of the wire metal at 20°C is $1.84 \times 10^{-6}\ \Omega\text{-m}$

3. In the diagram given alongside, R_1 = 10Ω, R_2 = 40Ω, R_3 = 30Ω, R_4 = 20Ω and R_5 = 60Ω. This configuration of resistors are connected to a 12 V battery. Find out

(a) Total resistance in the circuit, (b) The total current in the circuit.



Solution: Let us substitute the combinations of resistors R_1, R_2 and resistors R_3, R_4, R_5 with equivalent resitances R' and R" respectively. Then, by using the equation, we get,

1/R' = 1/10 + 1/40 = 5/40 i.e., R' = 8Ω

Similarly, 1/R" = 1/30 + 1/20 + 1/60 = 6/60

i.e., R" = 10Ω

Therefore, total resistance R = R' + R" = 8Ω + 10Ω = 18Ω

To calculate the total current using Ohms law, we get,

I = V/R = 12V/18Ω = 0.67 A

4. In an electric iron, at the highest thermostat setting, electric power is consumed at 840 watt and at the lowest setting at 360 W. If the source voltage is 220 V, then what is the resistance in the two situations?

Solution: We know that power consumed,

$P = VI$

So, $I = P/V$

(a) When the rate of heating is highest, then I = 840 W/220 V = 3.82 A

Therefore, the resistance of the iron is, R =V/I = 220 V/3.82 A = 57.60 Ω

(b) When the rate of heating is lowest, then, I = 360 W/220 V = 1.64 A

Therefore, the resistance of the electric iron is, R = V/I = 220 V/1.64 A = 134.15 Ω

Keywords

Electric current, electric potential, electrical potential difference, ammeter, voltmeter, resistance, resistivity, electric non conductor, equivalent resistance, electric power, direct current, alternating current, fuse, overload, short circuit, semi conductor, variable resistance

What we have Learnt

- For electric current to flow in any conductor, a closed circuit is necessary.
- The quantity of electric current in a conductor is the amount of electric charge that flows in 1 second through any point of the conductor.
- To measure the electric current in a circuit we use the ammeter, which is combined in a series in the circuit.
- A potential difference must be present for electric current to flow in any electric circuit.
- To measure the potential difference in any electrical circuit, we use an instrument called the Voltmeter, which is attached in parallel combination in the circuit.
- According to Ohm's law, in any electric circuit, at manual temperature, the potential difference and electric current flowing in two terminals of a wire are directly proportional i.e. $V \propto I$ or $V=IR$.
- Any resistance offered by a conductor, shows that it has resistance to the flow of current through it. This is called electric resistance and denoted by R.
- ρ (rho) is a relational constant, which is termed as the resistivity of the material of the conductor. It solely depends on the material composition and temperature.
- The equivalent resistance of resistors attached in series combination, is given by $R = R_1 + R_2 + R_3$...... and so on. The same amount of current flows in each resistor arranged in a series combination, but the potential difference between any two points of the circuit varies.

- Resistors combined in parallel have an equivalent resistance $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ and in each resistor different quantity of current flows but the potential difference between the two terminals of each resistor is the same.
- The rate at which electric energy is converted into another form of energy is called electric Power. Electric power is equivalent to the product of electric current and potential difference, i.e. P = V×I

Exercises

1. Choose the correct option :

(i) Which one of the options given below is a good conductor of electricity–

(a) Wood piece (b) Sheet of paper (c) Copper wire (d) glass rod

(ii) The instrument used to measure current in a circuit is–

(a) voltmeter (b) ammeter (c) odometer (d) none of these

(iii) The relation between V and I for a conducting wire is–

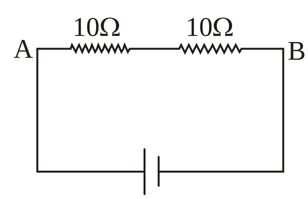
(a) a variable ratio (b) a fixed ratio

(c) sometimes variable sometime fixed (d) none of these

(iv) The resistance of an electrical instrument is 2.2 ohm and potential difference is 220 volts. Find out the value of current on connecting the instrument to a electric source–

(a) 5 A (b) 20 A (c) 25 A (d) 10 A

(v) The equivalent resistance of the following diagram would be–



(a) 25 Ω (b) 20 Ω (c) 10 Ω (d) 35 Ω

2. Fill in the blanks–

(i) The potential difference of resistors connected in a series would be ....

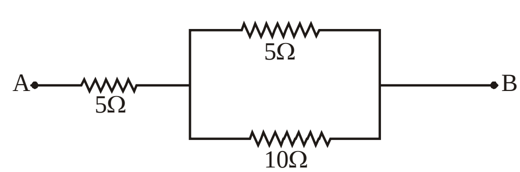
(ii) In resistors connected in a parallel combination, the current flowing across each resistor would be ....

(iii) We show the consumption of electricity in Kwh or in ....

(iv) The filament used in electric bulbs is made of .... metal.

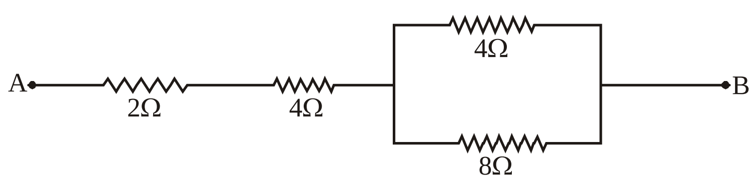
(v) The .... of a conductor increases with temperature.

3. Find out the equivalent resistance of the circuit given along side– **(8-33 t)**



4. What is a fuse and of what material is it made?

5. Explain the Ohm's law in your own words and establish the relation between V & I by drawing a graph.
6. If an electric bulb consumes 2400 J energy in a minute, calculate the power of the bulb? **(40 w)**
7. An electric heater has 3 kw, 220 v, stamped on it. Find values of the following–
   (a) Electric current **(13.6 A)** (b) Resistance of the heater **(16.12 ohm)**
   (c) Cost of electricity if unit cost is Rs. 1.50/kwh and heater is used for 10 hours **(Rs. 45)**
8 Answer the following questions-
   (i) Why are domestic circuits not arranged in a series combination?
   (ii) Why is only tungsten metal used to make filaments of bulbs?
9. If a current of 0.5 A flows for 20 minutes in a filament of a bulb, then what would be the quantity of electrical charge flowing in the circuit?
10. In a house, 4 electric bulbs of 40 watt burn for 5 hours, 2 bulbs of 60 watts for 6 hours and 3 fans of 80 watts run for 6 hours, daily. What would be the cost of electricity, for one month of that home, if the rate is 50 paise per unit? **(Rs 44.4)**
11. Discuss the following questions -
   (i) What would be the effect on the circuit if one bulb out of three bulbs arranged in a series combination becomes fused?
   (ii) What would be the effect if one bulb out of three arranged in parallel combination malfunctions?
12. Find out the equivalent resistance between A & B in the circuit diagram given below? **(8.66t)**



13. If the potential difference generated by a battery across a circuit of two bulbs, combined in series, is 6 volts, and the potential difference at the first bulb is 2 volts, find out the potential difference at the second bulb? **(4 volts)**
14. If two conducting wires of the same length and cross section are combined first in a series and then in a parallel combination, what would be the ratio between the quantity of heat generated in the two series and parallel circuits? **(4:1)**
15. A 9 volt battery is arranged in series combination with resistors of 2Ω, 3Ω, 4Ω, 5Ω and 12Ω, what would be the current flowing across the 2Ω resistor?
16. List the various appliances working on the thermal effect produced by the electric current, which are used in our homes, and discuss their working?
17. On a bulb, 200 V - 100 W is printed. What would be the resistance of the bulb? If 5 of these bulbs burn for 4 hours, what would be the amount of electricity consumed and the cost of electricity, if the rate is 50 paise per unit? **(400t, 2Kwh, Rs.1)**
18. How would you combine 3 resistances of 2Ω, 3Ω, and 5Ω, so that the equivalent resistance is 2.5Ω. Draw a diagram to show the circuit.

CHAPTER 7

LIFE PROCESS: NUTRITION, TRANSPORTATION, RESPIRATION, EXCRETION

Some life processes like nutrition, transportation, respiration, excretion etc. are essential for the survival of a living organism. Energy is required for the processes to be carried out in our body. This energy is obtained from food.

- What do you think; do all organisms acquire energy from the same source?

We had studied earlier in food webs that plants are mainly the source of food for most organisms in the living world. We have also studied that solar energy is stored in the carbon compounds formed by the process of photosynthesis. Thus, plants are called as producers.

Consumers are dependent on producers in the whole living world. There are certain similarities as well as some fundamental differences in the life processes of producers andconsumers. In nutrition for example, while the first step in producers (mainly plants) starts from some simple substances like carbon dioxide, water etc. that in consumers(mainly animals), it starts with complex carbon compounds like carbohydrates, proteins etc. The life processes in multicellular plants and animals are carried out in specially arranged system of organs.

7.1 Development of organ systems

We had studied about the surface area to volume ratios of cells. We had found that as the size or diameter of a cell increases, its surface area to volume ratio decreases and so does the rate of functions going on within it.

- See the graph and suggest what do you think will happen if the length of a unicellular organism increases? (read values in graph on both axis per 10-16m)

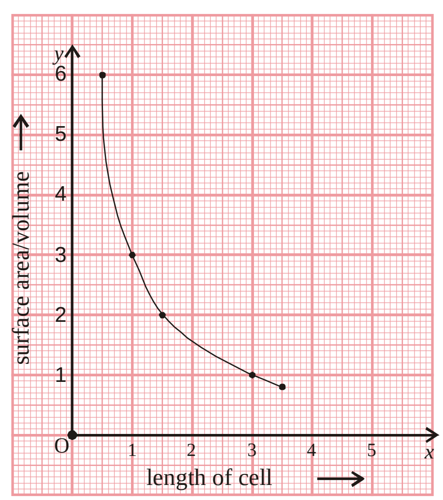


Figure-ure-1: Length of cell versus ratio of surface area to volume

You may have observed that as the length of a unicellular organism increases, its surface to volume ratio decreases. Apparently this could have a large impact on the availability of food resources for the organism. We may say that passage of resources into the body would be inadequate for the survival of the organism. With the increase in number of cells, the size of a multicellular body increases and this is just what happens in its body. Without a separate arrangement, resources fail to reach all the cells in its body. Moreover not all cells in the body of a multicellular organism are in direct contact with resources. Thus, there are certain arrangements as follows such that resources reach all cells adequately all the time in a multicellular body -

- Enfolding in layers resulting in increase in area of absorption or passage of materials
- An arrangement by which several substances may be carried collectively via certain fluids thereby increasing rate of transport.
- Having mechanisms to reduce friction, likesecretion of mucous as required or having a moist surface etc.
- Favourable conditions for chemical reactions to take place.

Evolution has led to the development of such fundamental arrangements in the bodies of several multicellular organisms. Elaborate systems of membranes, reaction sites, tubes etc. are found in plants for photosynthesis, transport etc. while we have such elaborate systems in our digestive, respiratory, blood vascular, lymphatic, excretoryand other systems.

We shall study about all such systems and life processes in humans and in plants that are related to food and nutrition , starting from the intake of food, its utilization in the body and release of energy to excretion.

7.1.1 Digestive system in humans

Different components of food are required to maintain energy in our body. Processes like growth, repair and maintenance of body temperature require energy which is obtained by the breakdown of food components like carbohydrate, fats and proteins. We have studied and tested the presence of components of food in our previous classes(annexure to this chapter contains the details of the testing processes so that you may try doing them again). Apart from these, our body requires other substances like vitamins, minerals, salts, water etc. The process of digestion helps to maintain their required levels in our blood. This helps to fulfill the diverse requirement for resources of the numerous and diverse cells present in our body.Sugar (a type of carbohydrate) is required by most of the cells of our body. Sugar levels are thus maintained in our body. A fall in the level of sugar stimulatesthe transmission of a signal to the brain. A response from the brain results in contraction of muscles in the walls of the stomach, we feel it as a mild pain, signaling hunger pangs.

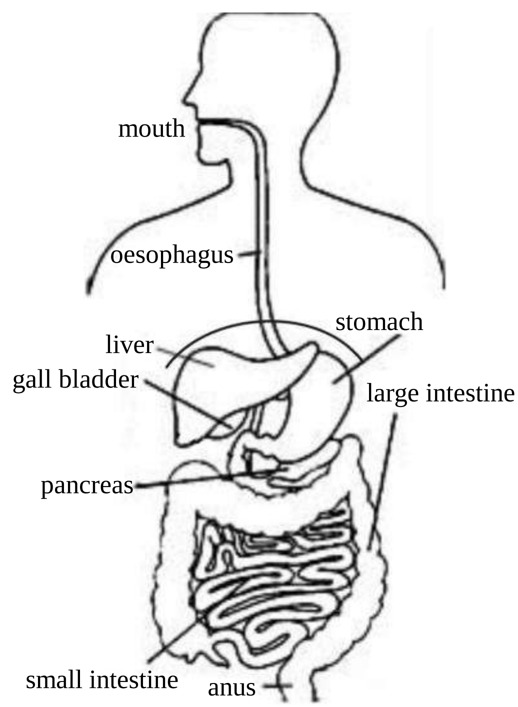


Figure-2: Human digestive system

- Think of some situations that make you feel hungry. What happens when the scent of a favorite dish reaches you?

Our digestive system mainly consists of a tube (nearly 27 feet long) extending from mouth to anus(also called as the digestive tract or gut). Different regions of this tube have different names due to structural and functional variations in them. The walls of this tube are folded in layers, somewhere the folds are numerous, long and dense as in the intestine somewhere it'sotherwise as in the tube between mouth and stomach. In some areas within the walls of the tube or outside it are certain organs that secrete substances that aid in digestion, these are called as digestive glands like salivary glands in mouth and gastric glands in stomach are internal while liver, gallbladder and pancreas are external. Secretion from these glands as well as from certain other cells of the wall of the digestive tube helps in the process of digestion. Large molecules of our food are change to smaller molecules in this process.

- What are the different parts that have been shown in the diagram of human digestive system?

7.1.2 The process of digestion

Digestion starts as soon as we start chewing food and saliva mixes with it. Saliva is secreted by numerous salivary glands in our mouth.3 pairs of them are quite large.Saliva has an effect on certain carbohydrates like starch in the food that we eat. Let us do an activity to study this.

Activity-1

We would need a teaspoonful of wheat flour (you could dilute and use the starchy fluid drained out of boiled rice as well), distilled water, dropper and iodine solution (preferably 1% solution of tincture iodine), two beakers, two test tubes and a test tube stand.

Now, add half a teaspoon of wheat flour to half a beaker (around 125ml) of distilled water, mix well to prepare a solution. Now take a little of this solution in a test tube add a few drops of tincture iodine and see if it turns blue black or not that is gives confirmatory test for presence of starch . In case it doesn't, add more of wheat flour till you get a confirmatory test for starch. Now start your experiment with this solution. Now take two test tubes and label them as A and B respectively. Keep them in a test tube stand. Add 20-25 drops of wheat flour solution to both test tubes.

Now to test tube A add a similar amount of your saliva. Do not add anything to test tube B. Leave the set ups for about two hours. Then add a few drops of iodine solution to both test tubes A and B. Observe which one shows presence of starch.

- What happened after adding iodine to both test-tubes A and B?
- Why do you think this may have happened?
- What do you think is the effect of saliva on wheat flour solution?

Now let us observe the nature of the medium (that is acidic, basic or neutral) on the effect of saliva.

Activity-2

As in activity 1, use wheat four solution or starch solution from drained from boiled rice for experiment. Now take three test tubes and label them as A, B and C respectively. Add 8-10 drops of lemon juice in test tube A. Add around the same number of drops of washing soda solution (prepared by adding a pinch of soda to a test tube full of distilled water) to test tube B. Add same number of drops of distilled water to test tube C. Use universal litmus paper to find out the pH of each of the substances of test tube A, B and C respectively. Now add 20-25 drops of wheat flour solution to each of the test tubes. Now add a similar volume of saliva to each test tube and leave for around 2 hours. After two hours, use 1% iodine solution to test the presence of starch in each of the test tubes.

- What is the nature of solution (acidic, basic or neutral) in test tubes A, B and C respectively?
- Which of the solutions A, B and C shows the presence of starch?
- Why do you think that even though we started with the same amount of solution of wheat flour and saliva, our experiment does not show presence of starch in all the test tubes?

In this activity we observe that in test tubes B and C there in an effect of saliva on starch while in A we do not see any effect indicated by presence of starch till the end.

A substance present in saliva called as 'enzyme' (in this case salivary enzyme) is found to act only in specific conditions like particular pH range (here basic and neutral), temperature etc.

Do you know?

Stomach with a window and discovery of effect of enzyme on digestion

In 1822, an American soldier named Martin was accidentally shot in the stomach and was brought to Dr. Beaumont. The doctor treated his wound which healed with a hole in the stomach covered with a flap of skin. A pipe could be inserted through this hole and digestive juice could be drawn out from the stomach. Beaumont started experimenting with this juice and found that food was digested inside the stomach at a much faster rate as compared to that outside the body using the same digestive juice. Thus he recognized that certain specific conditions were required for the digestive juice to function in the process of digestion which he concluded was not only a mechanical process of grinding and churning but also a chemical process. Around a decade after this finding, a French scientist, Anselme Payne discovered a substance extracts of barley sprouts that could change starch to sugars, he named it as diastase. It was later found to be a group of compounds called as amylase which is found in parts of the human digestive system (salivary glands, pancreas etc.), several bacteria, some types of fungi, certain plants etc. These substances in the digestive juice, in barley sprouts and other sources were collectively named as 'enzymes' in the year 1877. The word meant 'to leaven'.

Most enzymes are proteins. There are numerous of these present within a single cell of our body. All reactions related to synthesis and breakdown are speeded up and mediated by enzymes. Enzymes have some remarkable properties. Take for example the enzyme 'Pepsin' secreted in our stomach, it can digest around 50 times its weight of proteins in our food in an hour and continue doing so for some hours. Most of our life processes are accomplished by enzymes secreted within cells or by cells of our body. Digestive enzymes are either secreted directly from walls of gut into the cavity or by glands outside the gut and flow into it by some other tubes.

7.1.3 Function of the digestive system

After digestion in the mouth, food reaches the stomach. The passage of food is lubricated by mucus secreted by walls of the gut and pushed forward by a process called as 'peristalses. This is a series of wave like motion due to alternate contraction and relaxation of muscles in the wall of the gut. Food passes from mouth to 'oesophagus' (literally meaning to eat and carry) via a muscular structure called pharynx.Thereafter by peristalsis it passes through oesophagus to the stomach.Hydrochloric acid and an enzyme called pepsin (which functions only in acidic medium) are mainly released from glands in the wall of the stomach that help in the digestion of proteins. Churning, grinding and mixing with digestive juices in the stomach turns food to a thick fluid that passes in spurts into the small intestine. Small intestine is nearly 20 feet long.The process of digestion completes here and nutrients are absorbed into vessels (blood and lymph) that carry them to other parts of the body. Digestive juices from liver and pancreas that reach the small intestine aid in the process of digestion. Pancreatic juice contains sodium bicarbonate that renders the medium alkaline and enzymes present in the digestive juices become functional. Thus most of the carbohydrates, fats and proteins are digested here. There are certain stimulators as well that are secreted from different parts of our digestive system (these are certain hormones). You would be surprised to know that there are several colonies of microbes as well present in our gut that help in the process of digestion.

Do you know?

Amylase, trypsin and lipase present in pancreatic juice help in digestion of carbohydrates, proteins and fats respectively. Constituents of food are broken down from larger and complex to small and simple compounds. Carbohydrates like starch are digested to sugars like glucose, proteins to amino acids and fats to fatty acids and glycerol. Bile present in bile juice secreted by liver has certain salts that help to convert fats to small droplets or micelles (a process called as emulsification) aiding in the functioning of lipase.

The numerous foldings of the small intestine are also called as villi. The surface area of absorption increases due to the villi. The blood vessels and lymph vessels over and inside these villi help to carry the absorbed digested nutrients to different parts of the body. Some water and salts are also absorbed in the small intestine. The rest of the food which is largely undigested matter passes to the large intestine where most of the water and certain salts are absorbed. The stool (mainly undigested matter) and certain gases pass out of the anus.

Do you know?

A wonderful ecosystem specific to an individual exists in our gut. There are several colonies of bacteria in it. The life processes of these bacteria not only aid in digestion they also convert certain proteins and vitamins into forms usable and absorbable in our body. Several gases like hydrogen sulphide, methane, ammonia etc. are formed due to the life processes of these microbes.

- How does digested food reach different parts of our body?

7.1.4 Structures related to transport and their function

The structures involved in transport of digested food and several other substances are mainly vessels carrying the fluids blood and lymph. The whole network is called as blood vascular system. People even a thousand year ago knew that blood flows in vessels that are connected to the heart. They believed that with each beat blood flowed out of the heart into the vessels to different parts of the body and was

William Harvey (1578-1657)

absorbed back into the heart. Different blood vessels were observed and named but the actual mechanism of functioning of the heart and the flow of blood was not known until the researches done from 15th to 17th century. The credit goes to a doctor of the 17th century, William Harvey who described the mechanism of flow of blood in our body and the role of heart. Harvey was inspired by the discovery of valves in veins allowing flow of blood only in a certain direction. Harvey performed several experiments to observe the flow of blood. You may also try doing one of his experiments.

Activity-3

Tie the hand of a friend as shown in figure 3 B. Ask your friend to close his fist tightly and quickly move the hand from elbow to fist at least 4-5 times. Now keep your fingers as shown in the figure on the bluish prominent vessels of your friend's hand. Press your fingers down and move one towards fist and the other towards elbow.

- Did the bluish colour disappear between these points?

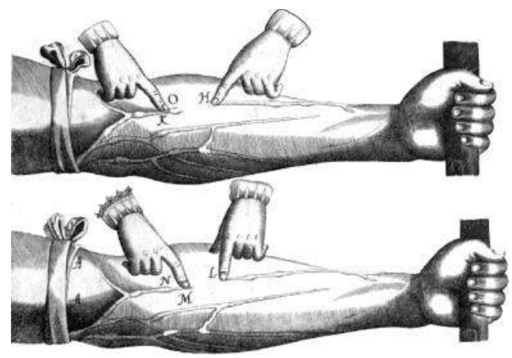


Figure-3: Illustration of an experiment by William Harvey

Now remove your finger towards the fist of your friend. Observe what happens. Now repeat the experiment and remove your finger towards the elbow of your friend.

- Towards which side (elbow or fist) do you find blood vessels fill up faster? This shows the direction of blood flow.

Harvey observed that blood flows from palm to elbow (as you may have also observed), thus these vessels were definitely carrying blood from our body to the heart. Thus he defined veins to be vessels that carried blood from different parts of the body to heart and arteries as vessels that carried blood from heart to different parts of our body. He suggested that blood flowed in a circular pathway in our body starting from heart and returning to it. Harvey could not show the connections between veins and arteries but suggested their presence. Their presence was later confirmed when they were observed and named as capillaries.

Veins can be observed in different parts of our body as apparently bluish vessels under the skin. Blood flowing through them is dark red and not blue. Arteries are usually present deeper inside so we may hardly observe them. Some of them are present near the surface like those in our wrist, ankle or side of neck. We can feel them pulsating with each beat of the heart. Blood flowing through them is bright red in colour. Let us feel one of the arteries.

Activity-4

Keep thefingers of one hand on the wrist of the other as shown in figure 4.

- Could you feel it pulsating?

As the heat beats, so does the arteries and we feel the beat as a pulse in an artery.

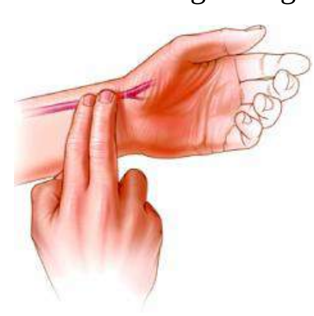


Figure-4

Do you know?

All blood vessels are made up of cells. The space between cells increase or decrease according to conditions around them as substances flow in or out of the vessels. For example if you have a cut, certain substances flow out that help in healing and forming the clot.

7.1.5 The role of heart in transport

Heart functions as a pump in our body as well as that of most other animals. Around 7000 liters of blood (4.7-5.5 liters in each of the nearly 1500 circuits) is pumped through our heart which is no more than the size of our fist. There are 4 major chambers in our heart. The two upper chambers are called as auricles and the lower ones are called as ventricles. There are valves between auricles and ventricles as well as between auricles and blood vessels or ventricles and blood vessels that arrest backflow of blood. The left side of the heart is separated from the right by a partition called septum thus no mixing of blood of chambers in right with those in left occur. The chambers in the right have deoxygenated blood while those on left have oxygenated blood. Auricles contract together and blood flows out through them into the ventricles. As ventricles contract blood flows out from the heart into arteries and simultaneously, blood flows into the auricles from veins.

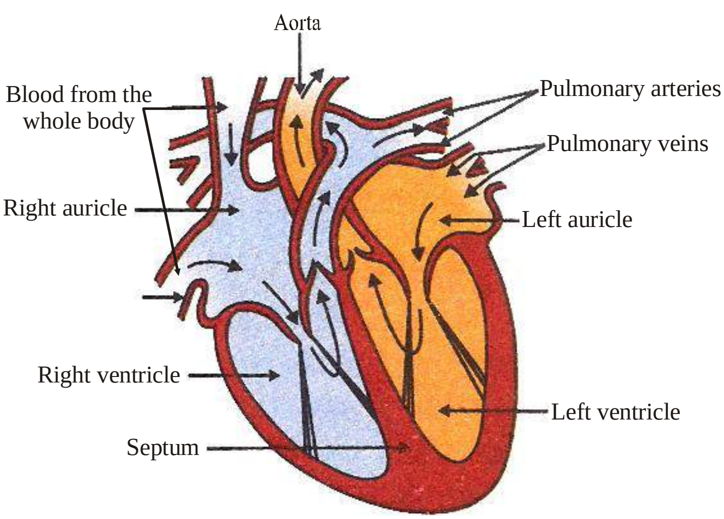


Figure-5A: Chambers of Heart

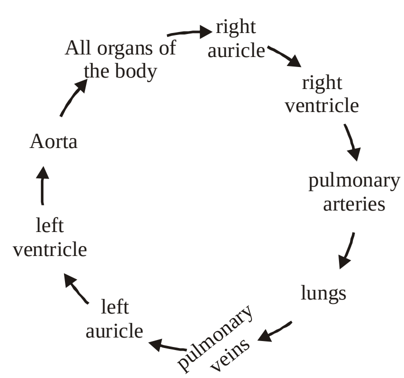
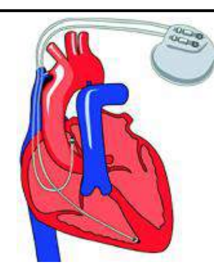


Figure-5B: Circuit of blood flow

The function of the heart is controlled and coordinated via nerves from the brain as well as an elaborate network of nerves in the heart.

Do you know?

We call the major network of nerves of the heart as Sino auricular node. When this fails to function, a pacemaker device is implanted into the heart that carries out the function of this node for some years.



Pacemaker

The circuit that we see in fig 5B actually represents two pathways that differ functionally. That is in one pathway de-oxygenated blood from heart is oxygenated via lungs and returned to it. While in the other oxygenated blood is deoxygenated via all parts of the body (including thelungs) and returned to heart. The two pathways are shown in Figure- 6. We can trace these pathways from the heart. As the left ventricle contracts oxygenated blood flows out into the large artery called aorta that divides into several arteries carrying blood to the tissues. Capillaries thereafter carry blood to the cells and carry deoxygenated blood back to veins that collectively carry back blood to the right auricle of heart. This is one pathway. The other starts with contraction of right ventricle as deoxygenated blood flows out through pulmonary arteries to the lungs. There arteries and capillaries carry blood to sites of gaseous exchange from where oxygenated blood is returned via capillaries to veins to the pulmonary vein that carry blood to the left auricle of heart.

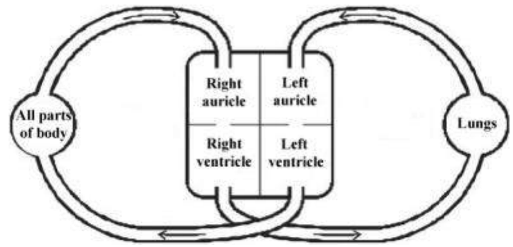


Figure-6: Double circulation of blood through heart

- Does oxygenated or deoxygenated blood usually flows through our veins?
- "Vein do not always carry deoxygenated blood" do you agree to this statement? Why/ why not?

The contraction of the ventricles creates a pressure that maintains blood flow in the arteries. There is hardly any pressure in the veins. We had studied that the valves in veins arrest backflow of blood. These along with contraction and relaxation of muscles around veins maintain blood flow in them.

Do you know?

The pressures on the walls of the ventricles when they contract and when they relax are represented by the values 120 and 80 respectively as normal blood pressure. The sounds of heart beat are sounds of closing of valves between auricles and ventricles and those between the ventricles and blood vessels as the ventricles contract and relax respectively.

- From where does blood flow into the right auricle?
- Where does blood go from right ventricle?
- Where is blood oxygenated?

The division in aorta is such that the network formed carries blood nearly at the same rate to all parts of our body as it flows out from the heart. We call this a parallel system of flow as the arteries reach the organs simultaneously. A series arrangement of arteries enhances resistance and slows down the rate of flow as blood passes from one part to another. This facilitates the exchange of materials between blood and cells.

- What do you think would happen if blood flowed in series from heart to other organs of our body?

The flow of blood from intestine to liver and to heart is a series pathway. It is inevitable that there should be nutrients in the blood flowing into the liver. There are several such nutrients the higher levels of which would be fatal for the body. Some such substances like excess sugar and fat are removed from the blood in the liver. When their level falls they are returned back to blood. Several toxic substances are also either removed or changed into non- toxic substances in the liver. Most of these functions occur between cells of the liver and blood.

7.1.6 Role of blood in transport

Our knowledge of blood and its constituents is nearly 400 years old. After the discovery of cells, an observation of blood showed that it was not just a watery fluid but it contained several types of cells as well. Blood was thus said to be composed of two major components-

1. A fluid part that was called as plasma 2. Certain structures found in plasma that were called as blood cells.

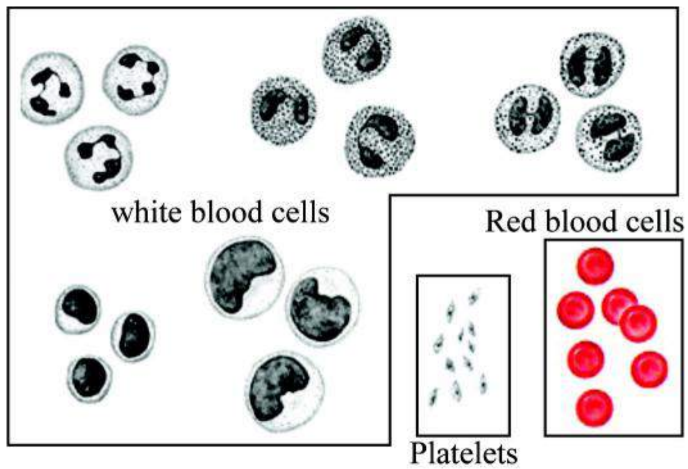


Figure-7: Some types of blood cells

Blood cells were later categorized as red blood cells, white blood cells and platelets. The red blood cells were found to be non- nucleated disc shaped structures having an iron rich protein compound called as hemoglobin. This is a pigment that rendered the cells red. Oxygen binds with the iron of hemoglobin and nearly 97% Oxygen in our body is carried in this way. Oxygen flows from blood to cells where its concentration in less and carbon dioxide reaches blood from these cells. The white blood cells lack colour and are of different shapes and sizes. Our body is protected from several infections and diseases due to these cells. A clot is formed in the area of a cut or injury by mainly another group of cells called as platelets. There are several other substances in blood that have different functions for example a group of substances circulating in blood dissolve unnecessary clots. Glucose, calcium, potassium, hormones, enzymes, urea, salts are among several other components of blood. The levels of several components of blood are indicators of our health and can be tested.

> **Do you know?**
>
> You may have heard about cholesterol (a type of fat). Accumulation of this in the arteries of heart can cause a heart attack. A particular amount of this is essential for the lubrication between cells especially in our gut. The absorption and use of certain vitamins also are facilitated by cholesterol. Thus a certain amount of it is not harmful but rather very useful for our body.

7.1.7 The role of lymphatic system in transport

Lymphatic system is mainly a large and complex system of vessels,several nodes that are tissue aggregates and certain organs. It is believed that the pressure in blood vessels cause some plasma to drain out of blood vessels. This combines with intercellular fluid. This is lymph which is collected into vessels (like the capillaries and veins) that help to return the drained out fluid into veins.The flow of lymph is maintained by peristalsis and valves in the walls of lymph vessels. Lymph contains some proteins, fats,glucose,salts etc. and cells called as lymphocytes which are specialized white blood cells. Protection from infections, removal of toxic substances, repair of tissues etc. are some functions of this system. Fats are mainly transported through lymph vessels. Lymph does not carry gasses which are transported by blood.

7.1.8 Respiration and associated structures

We find that blood and lymph carry nutrients to our cells where food is oxydised and energy is released, a process called as respiration. This energy helps to run all life processes. All living organisms whether plants or animals respire all through the day. This requires a constant exchange of gases between the body of the organism and its environment. There is an elaborate system of vessels, stomata and other structures in plants while there are vessels, gills or skin or lungs and other structures in animals that facilitate gaseous exchange. We have a pair of lungs and respiratory tubes extending from nose to lungs that help in gaseous exchange, the whole network being termed as respiratory tract (see Figure- 8). Right lung is slightly larger than the left one.

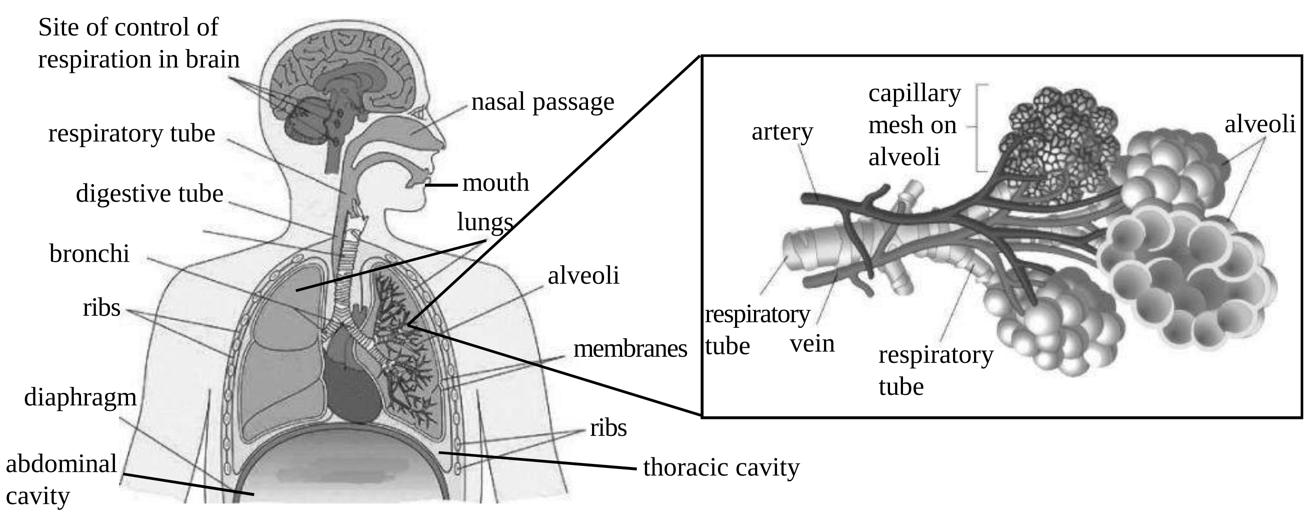


Figure-8: Respiratory System

Lungs are spongy structures with a vast branched network of respiratorty tubes. The extremities of the tubes have bunches of several air sacs which are bubble like structures called as alveoli. If all the alveoli were spread out they would cover an area of nearly 100 square meters. This providesa vast surface for gaseous exchange. Blood vessels and alveolar walls have a fine interface facilitating oxygenation of blood that has come from the heart.While mainly oxygen diffuses into the blood vessels, carbondioxide diffuses out from blood vessels to alveoli.The lungs may be affected by infections, dust and smoke.

Breathing in or out is a process that ultimately helps to maintain the internal environment of cells by maintaining the level of certain substances in them. The movement of diaphragm which is a muscular structure between thoracic and abdominal cavity and movement of ribs by muscular movements facilitates expansion or contraction of lungs. When diaphragm contracts and becomes flat, and rib cage extends out,volume of thoracic cavity increases and air flows into lungs through tubes starting from our nose. Contrary to this, relaxation of diaphragm causes most of the air to flow out of the lungs. A maximum of nearly 4-6liters of air may fill into the lungs with each breath. Not all of this flows out in a living individual. Nearly 1.5-2.5 liters of air is always present in the lungs.

If one of our lungs become non functional, the other takes over the function. This happens in the case of our kidneys as well. We may never feel any difference all through our life. Several functions go on in our body that complement each other. All systems of our body work in mutual coordination. Certain structures show such pathways. One such structure between respiratory tract and gut is shown in Figure-8.

Warning!

Smoking causes swelling in the respiratory tract. It also stimulates secretion of more mucus that eventually narrows the passage. Incidence of infections also increase thereby leading to fatal diseases the symptoms of which start with coughing, difficulty in breating etc. Smoking adversely affects the individual an its family.

- Have you ever felt the connection? How?

While swallowing food our breathing stops for a moment. Lets do an activity to feel this.

Activity-5

Hold a small piece of paper near your nose and observe it as you breathe in or breathe out.The paper sticks to your nose when you breathe in while moves away from nose as you breathe out. When you stop breathing the paper does not move.

Now try to swallow food.

- What do you observe? Why do you think this happens?
- Why do you think we get sometimes get choked while swallowing food?

The valve between digestive and respiratory tract remains open while we breathe. When we swallow food it stuts close the respiratory tract. While swallowing hurriedly it may not close properly and food may pass into our respiratory tract. This instantly stimulates muscle contraction in it to expel food from it as we start coughing. Air filled in the tract is pushed out along with the food particle.

While breating air passes in and out of the respiratory tract. The air we breathe out or 'exhale' is slightly warmer,with less oxygen and more carbondioxide and more water vapour compared to air we breathe in or 'inhale'. Let us do an activity to compare cabondioxide levels in atmospheric air(we inhale) and air exhaled to observe the difference.

Activity-6

You would need two boiling tubes/test tubes, a test tube stand, lime water (freshly prepared), two straws/empty refill (nib removed)/two glass tubes, rubber corks with two holes, a little wheat dough/plasticine, watch. Arrange your apparatus as shown in practical section. You may use a syringe/pichkari in place of sucking air out. Pour same volume of freshly prepared lime water in both boiling tubes and

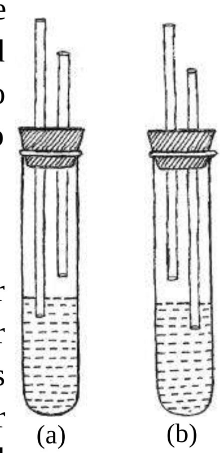


Figure-9

mark them as A and B respectively. Blow air into 'A' through a straw while use a syringe or pichkari to pass air into 'B'.

Do you know?

At resting phase, nearly a volume of 1 square foot of oxygen is used in our body. Nearly ten times of this volume is used during exercise. Carbon dioxide formed and expelled is slightly less than oxygen used by the body. If the amount of carbon dioxide increases and that of oxygen decreases in blood we start panting. When that of oxygen increases and carbon dioxide decreases we start breathing normally.

- Lime water turns milky faster in which of the two boiling tubes? Why?

Our observation that lime water turns milky faster when we blow air into it indicates that there is more CO_2 in exhaled air than in inhaled air(or atmospheric air)..

- Where did this extra CO_2 in exhaled air come from?

We would have to know about the reactions in our cells that ultimately lead to this observation. We have studied that digested food(carbohydrates especially sugars, proteins mainly amino acids and fats or fatty acids)and gases reach cells via blood. Energy is obtained from all the consituents of digested food. Let us take glucose for example (see fig 9), oxidation of glucose releases a large amount of energy. When we exercise or walk a lot, there is a dearth of oxygen in the cells of our muscles when glucose still breaks down and energy is released. The amount of energy is lesses as that during complete oxidation. There are certain chemicals in which energy is stored and utilized as and when required, these are called energy currencies and a compound named as adinosine tri phosphate(ATP) is such a compound.

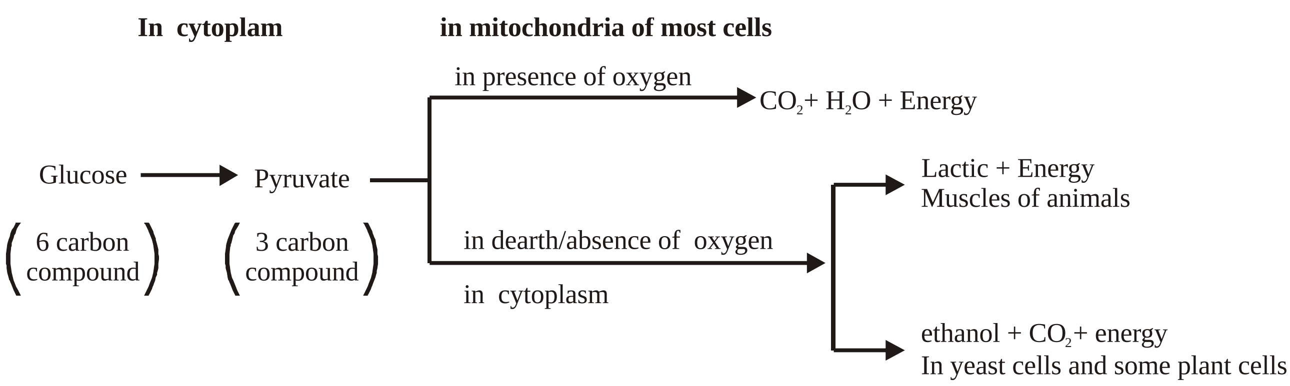


Figure-10: Pathways of breakdown of glucose

Do you know?

Fermentation is a process of breakdown of glucose in the absence of oxygen(also called as anaerobic condition). This naturally occuring process has widespread industrial use and several carbon compounds like ethanol, lactic acid,citric acid etc. are produced.

The process of breakdown of glucose to release energy occurs in the whole living world by pathways as shown in Figure- 9. Respiration is a process that involves all the processes from gaseous exchange to the breakdown of digested food to release energy. Several products of respiration are useful to our body while some are harmful and are expelled from the body.

- Which product of respiration (after glucose breakdown)is expelled from our body? How?
- Apart from glucose what other compounds release energy?
- What are the other processesin which products formed are expelled from our body?

Certain products formed by our life processes or those that we consume and are in excess are removed from our body. For example mainly carbon dioxide is removed as we breathe out, excess salts are mainly removed in sweating, urea and uric acid is mainly removed by urine.

We have a system that mainly forms urine from blood that flows through it, controls its volume and expels it from our body which we call as excretory system.

7.1.9 Structures and functions related to the excretory system

Normally about 1.5 litres of urine is produced daily. You may have observed that during hot and dry seasons the volume reduces.

- What happens to the volume of unine when we drink a lot of water?
- Does the volume of urine increase if we sweat a lot?

When we drink a lot of water the amount of urine expelled increases. Apart from water, urea and uric acid there are several other substances present in our urine. Doctors usually ask us to get our blood and urine tested to compare the levels of these sustances that indicate several aspects of our health.

Activity-7

Let us study some values of levels of certain substances in the urine and blood of a person to observe how they vary. A table has been prepared by collecting some values from blood and urine reports of a person and presented in this section.

Table-1: Some values for comparative study of substances in blood and urine

Substance	In Bood		In Urine	
Result	**Normal range**	**Result**	**Normal range**	
Glucose	82mg/dl*	70-100mg/dl	65mg/dl	50-80mg/dl
Urea	29mg/dl	15-40mg/dl	35mg/day	20-30mg/day
Uric acid	7.5mg/dl	3-5mg/dl	800mg/day	600mg/day
Total protein	7.2g/dl	6-7.5g/dl	0.9g/day	<0.1g/day

*Value shows fasting sugar(in result and range)

mg/dl milligram/decilitre

g/dl gram/decilitre

- Observe the table and find out the substances that are have value above the normal range in urine.
- What are the substances in blood that have values above normal range?
- Do same substanceshave high values in both blood and urine?

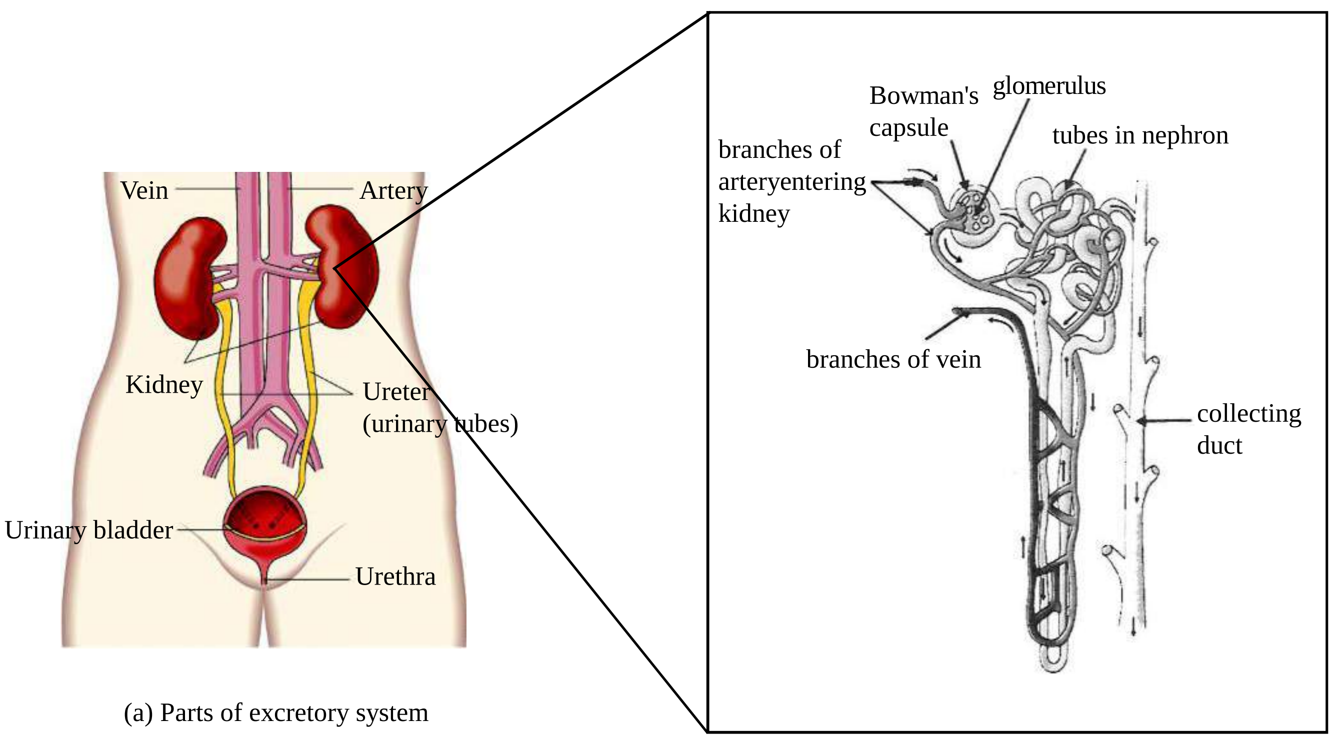
Several life processes go on in our body and several reactions either related to synthesis or break-down takes place. Some products formed in them are utilized while others are expelled. Nitrogenous products like urea and uric acid formed by breakdown of proteins are expelled through our excretory system that mainly consist of a pair of kidneys.

- See figure 10A and write the names of the other major parts of this system

Kidneys are located at the back of body wall on both sides ofvertebral column. They are beanshaped, about the size of fist and dark reddish brown in colour. Blood passes to the heart from all parts of the body and from heart to different parts, kidney being one of them. Blood flows into our kidneys through arteries and flows out through veins. If we compare the substances present in the arteries and veins we would find a marked difference in their levels. For example the level of urea in arterial blood entering the kidney is very high ascompared to veinous blood leaving it.

Do you know?

About 170litres of blood flows through the kidneys of a human adult in a day. Only about 1.5 litres of urine is produced, while the rest of the fluid goes back into circulation.



(a) Parts of excretory system

(b) Nephron

Figure-11: Human excretory system

Structure and function of the unit of excretory system: the nephron

We have studied that gaseous exchange occurs across capillaries and alveolar walls in lungs. Similarly in our kidneys, exchange of substances occur across walls of the nephron and capillaries present over them. Some substances like urea, uric acid, salts, some proteins, water etc. flow out of blood vessels passing through the cup shaped structure called Bowman's capsule in the first part of a nephron. These flow through the tube of nephron. Several of these substances may enter back into the blood vessels around the nephron. The amount the would return to blood vessels depends on the level of these substances in the blood. The fluid that flows out of a nephron is urine which is collected via collecting ducts or tubes that collectively form a larger tube called the ureter.Urine passes through the ureter into the urinary bladder and gets collected there till adequate pressure created does not signal its expulsionoutside our body, through urethra. The muscles of the bladder are under control of nerves from our brain, thus the expulsion of urine may be controlled voluntarily to a certain extent.

Do you know?

Artificial kidneys are elaborate system of artificial tubes and membranes that help in removing excretory wastes. Often when our kidneys fail to function, the patients' blood is passed through this arrangement that removes wastes from the body. Blood from an artery is passed into the machine and after removal of waste, returned back to the body via a vein. The process of removal of waste is called dialysis which is normally carried out by our kidneys in our body

Several substances that are expelled from our body are useful for other organisms in the living world. We had studied earlier that nutrients cycle in nature and waste ofcertain organisms are nutrients of others.

- Which substances expelled by humans and other animals are useful for plants?
- How do plants use them?

Let us study life processes in plants to find out more about substances used by plants to synthesise other substances. We shall also study the processes in which plants synthesize certain substances, that makes the whole animal world dependent on them.

7.2 Life Processes in plants

People believed, for a very long time that life processes that occurred in animals did not occur in plants. Their notion was plants grew solely on nutients from the soil. This was even the belief of people like Aristotle nearly 2000 years ago. Life processes in plants started being studied extensively around 400 years back.

7.2.1 Nutrition in plants

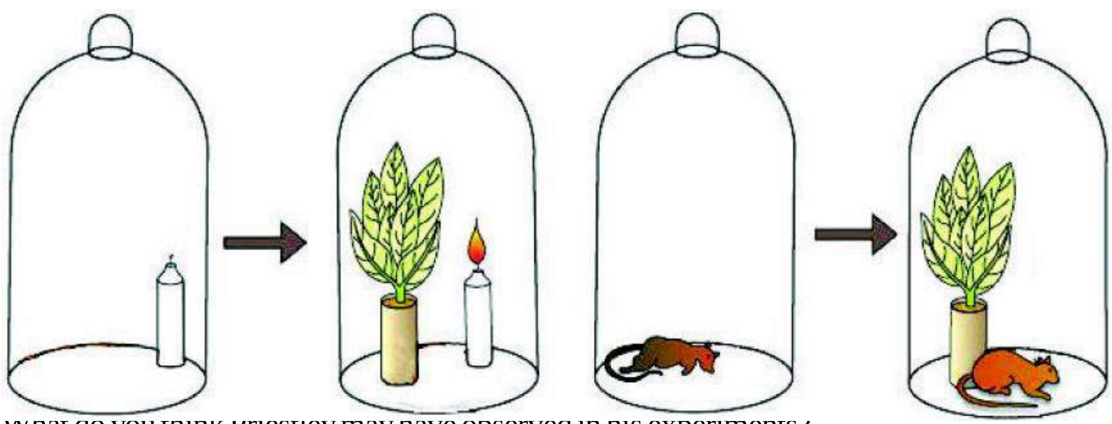

Von Helmont

A naturalist named as Von Helmont was studying plant nutrition and the role of water and soil in the 17th century. He took a 2Kg willow plant and planted it in a pot. He weighed soil that he added. Then he covered the pot with a perforated iron plate in such a manner that he could restrict the addition of extra soil or other materials to the pot. He watered the plant with measured quantity of water at regular intervals. He carried out the experiment for a period of 5 years. After which he found that the plant weighed nearly 35 times while the soil in the pot decreased by only 50 grams. Thus he concluded that plants grew by nutrients from water but not from soil.

Thisexperiment not only broke the notion that plants derived all their nutrition from the soil, but also established the role of water in plant nutrition. Helmont had overlooked the role of air in the experiment. Actually, studies on composition of air and gases present in it had just started during his time. It took nearly another century to establish the role of gases in plant nutrition.

Joseph Priestley

A gas in which substances burnt vigorously was discovered by Joseph Priestley. Priestley had been experimenting on the effect of living and nonliving processes on air, effect of plants and animals etc. Figure- 11 illustrates some of his experiments.



- What do you think Priestley may have observed in his experiments?
- How does the candle keep burning and rat remain alive in 'B'and 'D' respectively?

Priestley observed that the candle burnt out and the rat died in experimental set ups as in A and C respectively. The introduction of mint sprig in set ups as B and D kept the candle burning and the rat alive for a very long time. Priestley concluded that plants restored to air that part which was used up either by burning or by the process of breating in animals. Several years after this observation, this part of air which was a gas was named as 'Oxygen'.

People were relieved that as long as plants were present there would be ample oxygen for animals to survive. But the question was, what enabled plants to produce oxygen ?

We have studied that oxygen and glucose react to form CO2 and water and a large amount of energy is released. Scientists thought what would happen if CO2 and water were allowed to react?

It was observed that apart from respiration that occurred continuously during day and night, a process occurred simply during the day. During this, plants produced oxygen gas and carbohydrates. This process eventually depended on energy.

- Where did plants get this energy from?

J. Ingenhouz a scientist in the 18th century tried an experiment to answer this. Come let us also try doing this experiment.

Activity-8

You would require two beakers, two funnels, two test-tubes, Hydrilla (Cheela) /Elodea, black paper or cloth, a bucket full of water, incense sticks and match box.

Arrange two sets of the experimental set up as shown in the figure12. The set ups have to be arranged under water (use the bucket full of water for the same). Ensure that the test-tube as well as funnel are full of water at the start of your experiment. Cover one set up with black paper and keep it in shade (ensure that it gets minimum heat and light) Let this be labeled as B. Keep the other set up, labeled as A in sunlight. Leave the set ups as such for a minimum of 3-4 hours. Keep observing from time to time. You would find bubbles rising up and gas collecting in the test-tube. Once the test tube of the set up A is around half filled with gas, take the whole set up under water and remove the test tube. Close its mouth with your thumb. Ensure that the gas does not escape. Now bring the test tube out of water, keep a burning incense stick ready and as soon as you remove your thumb, insert the incense stick into the test-tube.

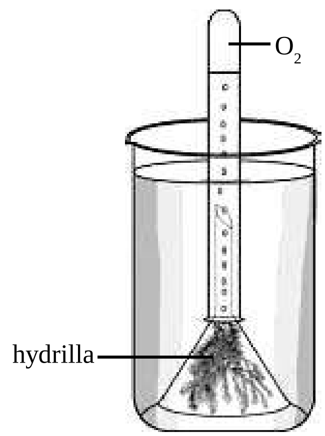


Figure-12: Apparatus with hydrilla

- Did the incense stick start burning more brightly?
- Which gas do you think was collected in the test-tube(Remember testing a gas in earlier classes using a burning splinter or incense stick)?
- In which of the set ups, A or B was the collection of this gas more?

We found that more gas was collected in A. This showed that light was necessary for collection of the gas.The gas present was oxygen. Presence of which is tested by using a burning incense stick /a burning splinter. We found that sunlight was necessary for production of oxygen. This was what Ingenhouz had also concluded.

There is energy in sunlight and it was found that plants could use simple compounds to produce certain complex carbon compounds like pyruvate, glucose, starch, etc. in the presence of sunlight. They released oxygen in the process. Scientists call the process of production of complex substances from simple ones'synthesis'. Light dependent synthesis was thereby called photosynthesis (photo meaning light). Photosynthesis is the most important life process in nature. Most carbon compounds and the whole amount of oxygen in nature are produced by this process. All animals including humans essentially require these for their survival. Foods are mainly carbon compounds most of which may be synthesized from certain carbon compounds produced by photosynthesis. It is observed that the major carbon compound produced during photosynthesis is glucose and the major storage product is starch (produced mainly by combination of several glucose molecules).

- Water gives oxygen and hydrogen then where does carbon for carbon compounds come from?

The answer to this came from experiments done during the end of 18th century and beginning of 19th century. Scientists could state that a combination of same number of carbon and water molecules form carbon compounds and the source of carbon is the gas, carbon dioxide.

We know that as air flows in and out of the stomata and certain areas of loose tissue in the plant body. Carbon dioxide in the air flowing in is utilized by the cells carrying out photosynthesis.

Using the information so far, if we try to write an equation for photosynthesis it could be-

$nCO_2 + nH_2O \rightarrow Cn(H_2O)_n + nO_2$ 'n' represents number of molecules

- What will be the equation when the value of n is 6? What is the carbon compound formed?

We have studied about the equation of respiration in the previous sections of this chapter. If we compare both the equations of photosynthesis and respiration we shall find that they are reverse of each other. Carbon compounds and oxygen are products in photosynthesis, while they are reactants in respiration. Further, in the former, light energy is converted to chemical energy and synthesis of carbon compounds take place while in the latter, chemical energy is converted to other forms with the breakdown of glucose. This energy is utilized in running life processes.

We know that respiration occurs in all cells of a living body.

- Does photosynthesis also occur in all the cells of plants?

Research in this direction had started in the 19th century. It was observed that it occurred only in those cells that contained 'chloroplasts'. The green pigment in chloroplasts was named 'chlorophyll' about this time. After the invention of the electron microscope and advancement of staining techniques in the 20th century, the internal structure of chloroplast could be observed. The study of reaction sites was also possible. Scientists used staining techniques and observed that oxygen was produced by breakdown of water molecule only in the presence of light. Half the number of water molecules used in photosynthesis is expelled as products. Now, we may show the formation of glucose in photosynthesis by the following equation.

$$6CO_2 + 12H_2O \xrightarrow[\text{Sunlight (light energy)}]{\text{Chlorophyll}} C_6H_{12}O_6 + 6O_2 + 6H_2O$$

Let us observe chloroplasts.

Activity-9

We would require a Rheo leaf or algae, a compound microscope, slide, coverslip, needle/pin and watch glass. We would have to take out a thin layer from either the upper or lower surface of the leaf by tearing the leaf with a jerk. Then,prepare a slide of this and focus over a stomata. Now change over to higher magnification, set the microscope and observe the stomatal guard cells. Several green structures are observed. These are chloroplasts. To observe chloroplasts in algae, we would need a needle to separate out stands of algae. Take the finest stand, prepare a slide and observe under microscope.

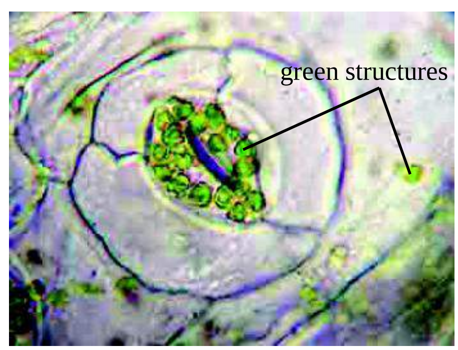


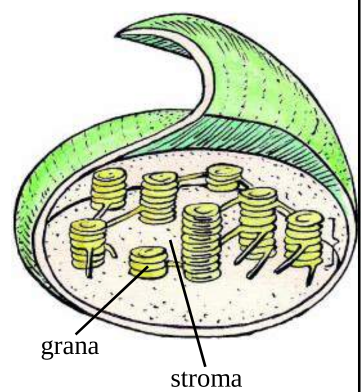
Figure-14: stomata and chloroplasts in Rheo leaf

The green structures in the strands are chloroplasts. Make a sketch of the observation.

- What substances do plants require for photosynthesis?
- How do these substances reach the chloroplasts?

Do you know?

Chloroplasts are twice the size of mitochondria. They are structures enclosed in double membranes. There is a third membrane that folds into stacks of sack like structures called as thylakoids. The stacks of sacks (that resemble stacks of coin) are called as grana and the fluid around these is called as stroma. Julius Von Sachs, a 19th century scientist had for the first time shown the presence of chloroplasts in which the photosynthetic pigment chlorophyll was present. He could not isolate chloroplasts but could further suggest that starch granules are formed in green leaves as a result of photosynthesis. It was later observed that light dependent processes of photosynthesis occurred in the grana where oxygen was released by the breakdown of water molecule. The reactions that lead to synthesis of carbon compounds occurred in the stroma and did not require the presence of light. Apart from sugars, amino acids, fatty acids and other compounds are synthesized in the chloroplasts. Chloroplasts also play a very important role in immune system of plants.



We had studied in class 9 that chloroplasts and mitochondria are examples of organelles formed by endosymbiosis. These cannot be manufactured by the cell, rather the genetic material of these pass on from one generation of cells to the other ensuring their development in each further generation. The seeds of plants have genetic material of chloroplasts.

7.2.2 Structure and function of transport systems in plants

We have studied that substances required for life processes and their products(including the excretory products) are transported across the body in elaborate system of tubes filled with fluids. Plants also have elaborate system of tubes for transport through which different types of substances are transported. We had studied about the vascular tissues xylem and phloem in plants last year. The pattern of arrangement of these may be observed in several plants. Flowering plants usually have patterns of arrangement as shown in Figure- 15 A and B. We usually find vascular tissue located centrally in the roots while in stems they are usually located towards the periphery. These are usually found arranged in concentric circles in dicotyledenous flowering plants. We find vascular tissues scattered in monocotyledenous flowering plants(See Figure-15 A).

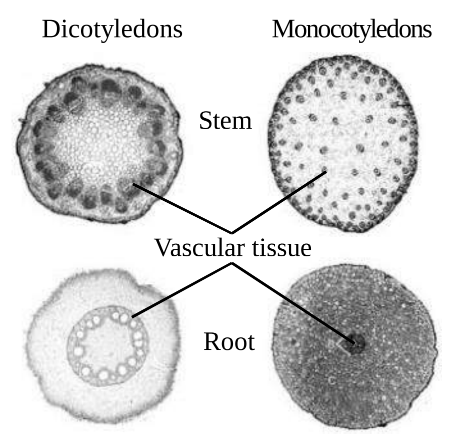


Figure-15(a): vascular tissues scattered in monocotyledenous flowering plants

Apart from stems and roots vascular tissues are also found in parts like theflower, leaf, fruits etc. Several substances like salts and nitrogenous compounds dissolved in water are transported through xylem from roots to other parts of the plant body. Substances are transported through xylem in several ways. The amount of water in soil being greater than that in root cells allows diffusion of water into root cells and to the xylem. The transpiration loss due to movement of water out of the stomata generates vaccum in the xylem tubes reaching the stomata, called as traspiration pull. This facilitates upward movement of water through the xylem. This helps in lifting water to great distances in plants. Most cells of phloem are living cells, thus movement of substances like certain sugars, amino acids etc. through phloem is often mediated by these cells at the expense of energy. Often when flow is towards gravity it hardly requires any energy.

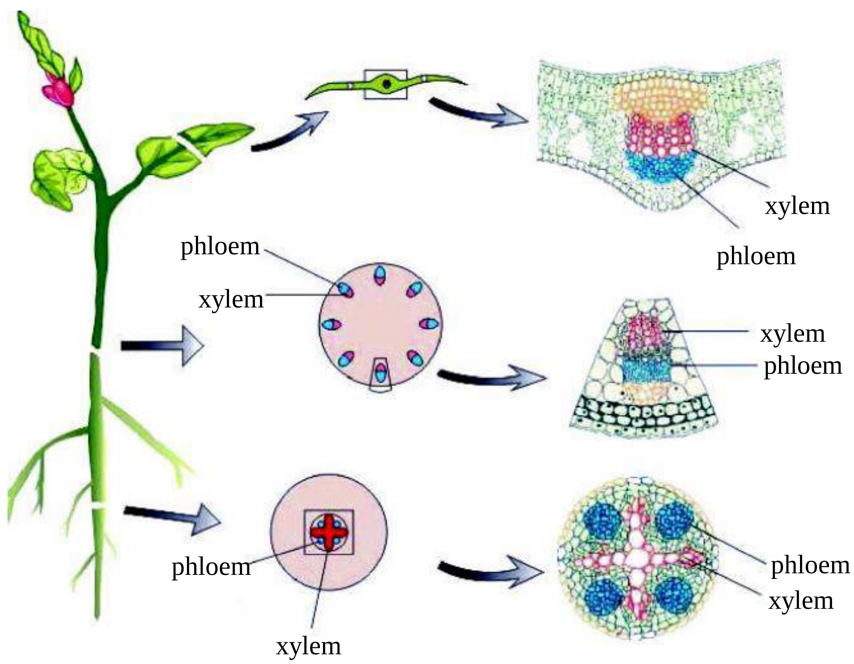


Figure-15(b): Location of vascular tissue in different parts of a dicotyledenous plant

7.2.3 Removal of wastes in plants

Most of the substances in plants are utilized in some or the other manner. The waste of one process being used in the other. Take for example, CO2. This gas is expelled from the body of animals while in plants, most of it is utilized in the process of photosynthesis during day time. It is expelled from the plant body only at night. On the contrary excess O2 (exceeding the amount used in respiration) produced during daytime is expelled from the plant body.

Transpiration (mainly a process of evaporation) causes loss of water and some salts from different parts of plant. Most carbon compounds that are wastes are usually stored away in dead tissues of the plant body.These are removed via leaves, flowers and bark that fall off from time to time. Certain salts are also stored in dead tissues. They are usually present in cell vacuoles. These are often expelled out of the plant body. In water plants they are directly released into the water.

Do you know?

Several substances usually called as excretory products, like latex, gums, resins, tannins, alkaloids etc. These usually have protective functions for the plant. We often use many of these like the latex of rubber plant is used to produce rubber.

Mangroves are a group of plants that grow in salty marshes. The excess salt is expelled through salt glands present at the base of the leaves of such plants.

7.3 Life processes in unicellular organisms

Figure-16 shows intake of food in Amoeba. We have studied that the bodies of unicellular organisms are in direct contact with the environment, thus gaseous exchange, food and excretory products move directly across the cell membrane or any specific part of it. Life processes of these organisms are carried out by different parts of the cell.

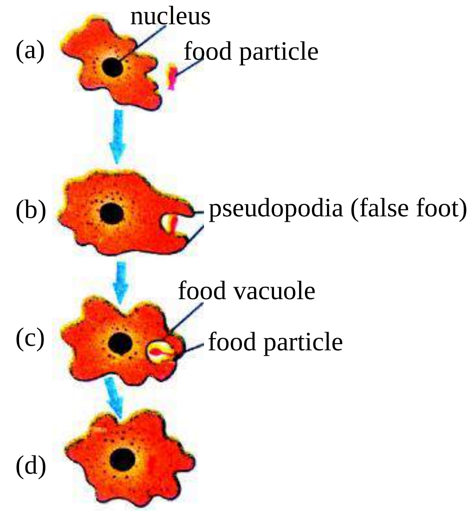


Figure-16: Intake of food in Amoeba

Keywords

Enzymes, peristalsis, villi, alveoli, double circulation, photosynthesis, adenosine tri phosphate,

What we have learnt

1. Human digestive system comprises of digestive tube and glands.
2. The main parts of digestive tube are mouth, pharynx, oesophagus, stomach,small intestine, large intestine and anus
3. Food is oxidised in the presence of oxygen , the products being water and carbon dioxide. A large amount of energy is released in the process which is stored as ATP (adenosine tri phosphate) to be used for life processes.
4. ATP is called as energy currency.
5. Human excretory system comprises of a pair of kidneys, a pair of ureter, a urinary bladder and urethra.Kidneys are composed of several nephrons.

6. Human transport system is mainly a blood vascular system having heart and blood vessels(arteries and veins)
7. Arteries carry blood away from the heart while veins carry blood towards the heart.
8. Plants are producers as they synthesize carbon compounds like sugars, starch etc. in the presence of sunlight (or any light of similar intensity) with the help of chlorophyll, by the process of photosynthesis. Most of the living world depends on plants.
9. Photosynthesis occurs in chloroplasts.
10. Plants convert light energy to chemical energy .
11. Xylem and phloem are mainly vascular tissues of plants that are present in all the parts of plants(stem, root, leaf, fruit, flower etc.)
12. Some excretory products are expelled from the plant via falling leaves, flowers etc. Some others are stored in vacuoles and expelled from the plant body from time to time.
13. Gaseous exchange occurs mainly through stomata and loose tissues in plants.

Exercise

1. Choose the right option
   (i) The internal wall of the stomach is usually not injured by HCl because of-
   (a) Pepsin (b) mucous (c) salivary amylase (d) none of these
   (ii) Gaseous exchange occurs during respiration between-
   (a) respiratory and digestive tract (b) alveoli of lungs and surrounding capillaries
   (c) air alveoli and respiratory tubes (d) respiratory tube and pharynx
   (iii) Oxygenated blood flows from lungs to heart by-
   (a) pulmonary artery (b) pulmonary vein
   (c) pharynx (d) none of these
   (iv) Kidney is composed of several-
   (a) nephron (b) Bowman's capsule
   (c) ureter (d) urinary bladder
2. How is a vein different from an artery?
3. Differentiate between respiration in the presence and absence of oxygen.
4. What are the differences between the sources of energy of producers and consumer? Clarify this.
5. What is the mutual relationship of animals and plants on the basis of food?
6. Why is formation of urine and its removal necessary for plants?
7. What is the difference between substances transprted by xylem and phloem?
8. What is the functionof HCl secreted in the stomach?

9. Cover some branches of a plant with polythene and tie it up. After about 3-4 hours measure the volume of water collected in it. Can you give an estimate of the total water loss by the plant? Justify your answer.

10. Several experiments on transpiration are conducted in agriculture. One such example is given here, 4 leaves of an arhar plant were coated with vaseline. Observe the table and answer the following questions-

Table: Reduction of weight of leaves due to transpiration

Leaf number	Surface on which vaseline was applied	Loss of weight
1	None of the surfaces	40%
2	Both surfaces	2%
3	Upper surface	36%
4	Lower surface	4%

- Maximum transpiration took place from which surface of the leaf?
- Which surface do you think has the maximum number of stomata?
- What happens when a large amount of water is lost from a plant?
- How will a plant be affected if water fails to move out of it?

11. Explain how blood flows in two pathways from the heart?

Annexure

Test for fats

Rub or put a small amount of the substance to be tested on a piece of white paper. Allow it to dry. If the paper turns oily and transluscent, then the substance tested contains fat.

Test for proteins

Take 10 drops of substance to be tested in a test tube. If the substance is a solid, grind it and put a pinch of it in the test tube and add 10 drops of water to it. Now add 2 drops of 2% copper sulphate and 10 drops of 10% caustic soda solution.

If the colour turns violet or purple, then the substance contains protein.

Test for carbohydrates

Prepare solution of substance to be tested, add 2-4 drops of dilute iodine solution(1%). A blue black colour gives conformatory test for starch. Add iodine directly over a cut potato for test.

CHAPTER 8

LIFE PROCESSES: CONTROL AND COORDINATION

You have studied about several life processes. Let us consider a few of them.

While we swallow our food the process of breathing stops momentarily. During the process of digestion of food different types of substances are either secreted or absorbed in different parts of the alimentary canal (gut). As soon as something comes too close to our eyes, the eyelids are shut.

Regarding plants, we find that the leaves of the plant 'touch me not' (chuimui) close as we touch their tips. We often find the stomata open in several plants, during the process of photosynthesis. Such processes go on continuously.

Whether processes go continuously or a process stops as another goes on, there is a continuous exchange of information. A system for communication of information is present in the bodies of all living organisms that enable such functions to occur at certain times.

Let us study about some of these systems. We shall study about them first in humans. Conduction of information in our body is mainly carried out through a system of nerves and some chemicals.

8.1 Systems related to coordination and control in humans

Let us do an activity to observe how certain systems work in coordination with each other conducting information from one end to the other and how fast they do so.

Activity-1

Take a half meter scale or a stick. Keep your fingers around the stick as shown in figure1. Let a friend hold the stick at the top in such a manner that the lower end of the stick is suspended freely between your fingers (mark this point with a marker). Now let your friend release the stick, instructing you to hold it. Make an effort to hold it immediately.

Figure-1: Stimulus (information) and its response

- Could you hold it at the same point marked by you or is the point where you could hold the stick higher than the previous point?
- Why do you think this may have happened?

- How did you know that the stick fell?
- Which part of your body was responsible for holding the stick?
- What could be the other parts involved in the process? Enlist them.

8.1.1 Parts of body involved in conduction of information:

You may have observed in activity 1 that you had received information about the stick through your ears and eyes. You could hold the stick with your fingers. Other parts involved might have been the muscles of your hand, your brain, spinal cord, nerves etc.

The role of brain, spinal cord and nerves has been studied extensively from around 3000 years back. 'Shushrut' a medical practitioner during this time in India is believed to have known that brain had a very important role in exchange of information in our body. Techniques of cure by Shushrut are thought to have involved restoration of function in affected parts of the body and reduction of headache. Certain techniques of Shushrut are believed to be followed in Ayurveda even today. After around 500 years of Shushrut's time, Greek medical practitioners appreciated the role of spinal cord and nerves along with brain in the process of conduction of information. Nerves were believed to be agents of transfer of information and those that rendered movement to our body.

During this time, a Greek medical practitioner named 'Galen' made a remarkable observation while treating a patient. The patient had been injured near the neck and lost sensation in his hand. Yet the functional ability of the hand was not lost. Thus Galen concluded that there must be two pathways of flow of information in our bodies, one for sensations and the other for reactions. He was of the opinion that the brain played an important role in controlling both out sensations and reactions. Also, the spinal cord had a supportive role to the brain and was a medium of transfer of information.

Studies done during the 16th and 17th centuries suggested that the spinal cord not only aided functions of the brain but certain sensations and reactions were controlled by it. It was observed that even in the absence of the brain, sensation and movement in the muscles of the body could be observed for some time.

Further on, after the discovery of cells and observation of arrangement of nerve cells in the body, we also came to know about their probable structure, composition and function. Camillio Golgi who had discovered the Golgi body and Schwann who was one of the proponents of cell theory had independently studied the nerve cells and their distribution in our body. Golgi bodies were observed first in the nerve cells.

You have already observed the figure of nerve cells and tissues in class 9. Let us study the structure and function we know so far of nerve cells.

8.1.2 Structure of nerve cells:

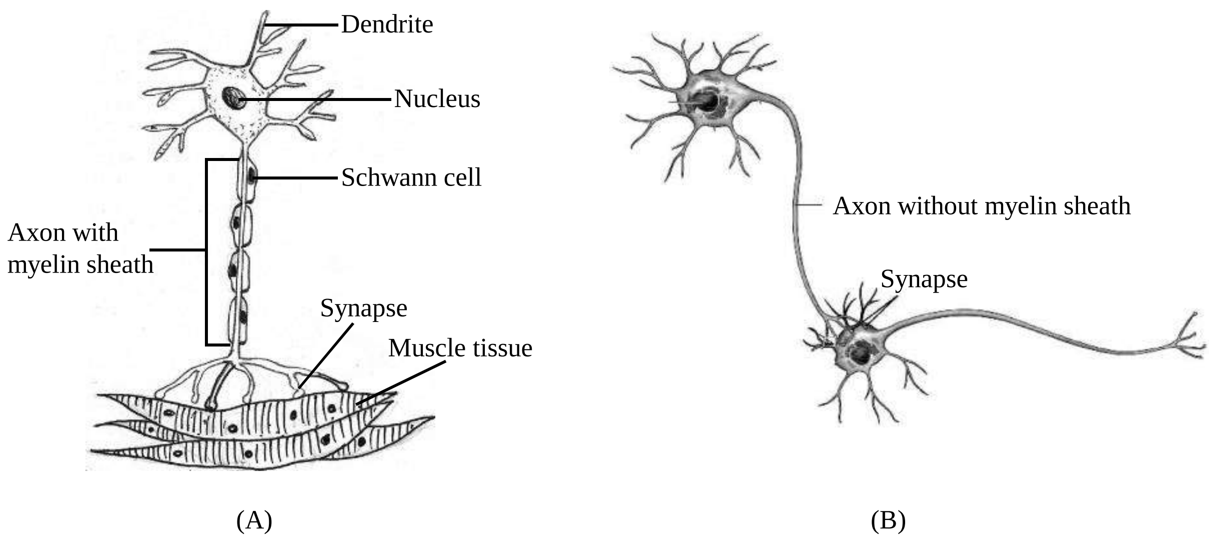


Figure-2: structure of nerve cells (A) with myelin sheath (B) without myelin sheath

Schwann had observed that nerves that carried sensations had fatty covering over them. After about two decades of this observation, a description of nerve cells was presented. This remained unaccepted to the scientific community for a long time as it was a challenge to observe these cells separately. On the one hand these are observed as mesh like structures while on the other it is difficult to separate them from muscle tissues.

After the advancement in staining techniques and microscopes, in the decade of 1910 these cells were observed clearly for the first time and their description given previously was now confirmed. Researches related to the arrangement, growth and development of these cells started during the 1930's. Thus it became clear that nerves were of different types and usually formed of groups of nerve cells. Each nerve cell had a nucleus and several mitochondria, Golgi bodies and other cell organelles.

> **Do you know?**
>
> Camillio Golgi and Ramon Cajal were conferred the Nobel Prize in1906 for their description of the nerve cell. It was similar to the description given by Robert Remak way back in 1850's. Remak's description was unaccepted during his time.

The speciality of nerve cells is that their cell membrane and cytoplasm form extended branch like projections called as dendrites (dendrite: branched tree like). Some of these that are long are called as axons (axon: axis). Axons reach the furthest extremities of our body. Some of the axons are covered with a fatty layer called as myelin sheath. Schwann had observed that the sheath was made of cells which were later called as Schwann cells.

The Schwann cells in a myelin sheath are wrapped up in such a manner over the axons that spaces remain between them. Myelin sheath renders protection and support to the axon and helps in bringing together several axons in a bunch. It also helps in increasing the rate of flow of information. The axons of nerves with their cell bodies in the brain and spinal cords reach different areas of our body. You may be surprised to know that axons may be so long as to start from brain or spinal cord and reach the end of our toes. Thus some of our nerve cells are as long as our height!

- Where do you think is the cell body carrying nucleus of such nerve cells?
- Nerves have protective coverings, what are the protective coverings of our brain and spinal cord?

Apart from nerve cells there are several blood vessels and other mainly protective cells in our brain and spinal cord. All these structures are together wrapped by dermal tissues that have fluid filled between the layers of them. These are further covered by the bony armour of skull and vertebral column. Vertebrae have mainly shock absorbing fluid filled discs between them that also help in smooth movement.

Information is conducted between nerves or nerves and muscles through areas called as 'synapses'. Though the name synapse refers to fixed overlapping connections, in reality these have been observed to be areas of gaps either between nerves or nerve and muscles. Thus certain chemicals in these gaps help in conduction of information. So far we have come to know that the conduction of information across nerves is due to certain electrochemical processes. These are very complex and are a field of ongoing research.

8.1.3 Nerves and Sense organs

We are able to sense several types of sensations or stimuli like heat, sound, taste, light, pressure, smell etc.

- What are the different organs of our body that we may associate with these sensations?

Apart from the sense organs like the eyes, skin, nose, tongue, ears that we have studied earlier, muscles in areas deep inside our body also have areas that have sensations (think of the burning sensation in the stomach). Moreover a particular part may sense different stimuli like the skin may help to sense changes in temperature, touch, pressure, pain etc. All the areas of sensation have several nerve endings or nerve cells that help in the process of sensation. The axon terminals of these may synapse directly with dendrite or axon terminals of those of the brain or spinal cord or with certain connector nerves.

As for example, there are light sensitive nerve cells in the retina of our eyes. The axons of these synapse with the dendrites of certain nerve cells whose axons together pass to the brain(as nerve fiber passing through the retina: area called as blind spot). There they form synapses with the nerve cells in the brain (see figure 3). The axon terminals of nerves coming from the brain pick up sensations inside our nose. Due to such arrangements in our body and others, several functions go on in a coordinated manner in our body. A simple example would be - we often enjoy the taste of food when we get its flavor as well.

Activity-2

Eat a pinch of fennel seeds (saunf). Now wash your mouth well and close your nose and eat a pinch of fennel seeds again.

- Is the taste same in both situations?
- What may have been the cause of this?

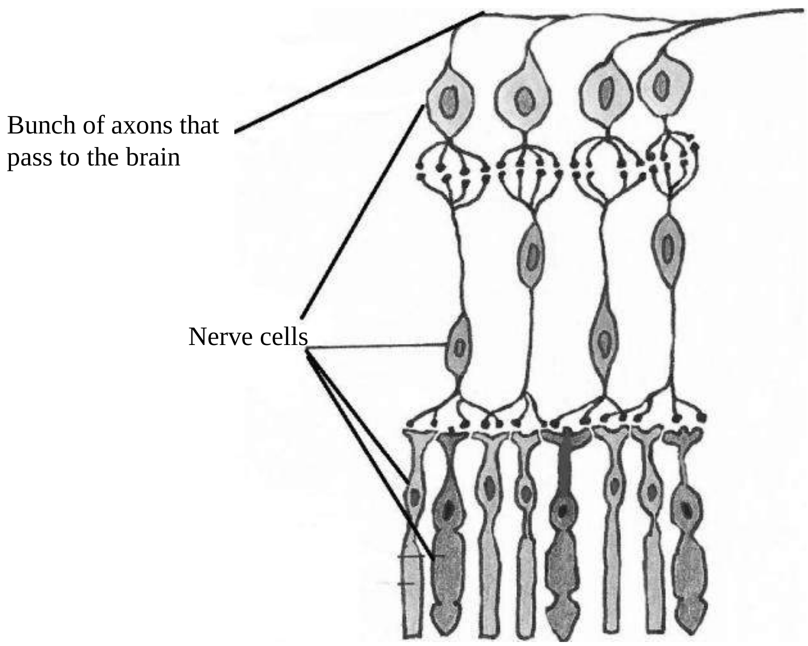


Figure-3:

8.1.4 Structure and function of spinal cord

We studied about the structure of nerves, their arrangement and functions in our body. We shall now study their arrangement in our brain and spinal cord. Spinal cord is a bunch of thread like structure running from brain through our vertebral column. It is composed of nerves. The myelinated axons of these nerves pass out through gaps between vertebrae and reach various parts of our body (represented by the white portion in the section of fig.4). The axons without myelin cover are located towards the inner side(represented by grey portion in the section of fig.4).

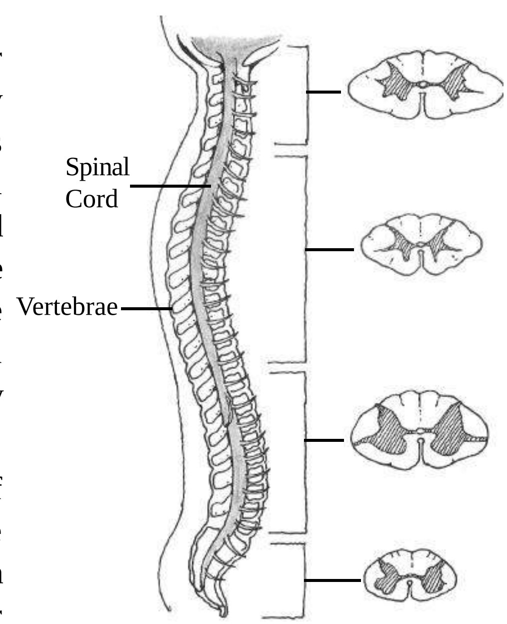


Figure-4: Spinal cord and transverse sections of its different areas

If a person's spinal cord somewhere in the middle of the back is injured such that no information passes to the brain, then there is a loss of sensation in the area of the stomach and that of legs. The person fails to move these parts on her own. But if the sole of the foot is tickled, the foot moves away without her knowing what may have happened!

Several functions occur in our body without our conscious sensation of the same. For example digestion of food, flow of blood through various parts, secretion of digestive juices, movement of the hand as it touches a hot surface etc. We call such functions as involuntary functions as they go on without our conscious effort. Most of these are controlled directly by nerves of our spinal cord. The information of these of course passes to the brain.

8.1.5 Structure and Function of Brain

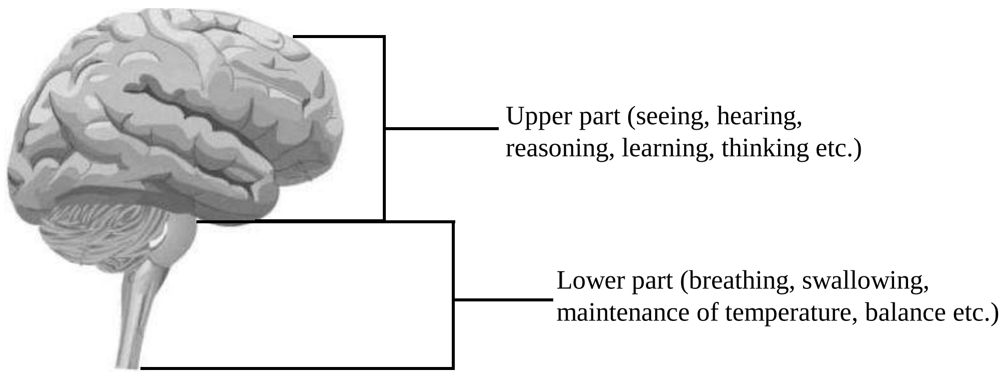


Figure-5: Human Brain

Brain as we know has a very important role in control and coordination of our body. The structure of the brain is very complex and it is very difficult to study the various functions that are carried out in our brain in detail. Scientists study certain sections of brain by arresting function of others to find out about the role of these specific sections. To know about structure and function of our brain we often try to study our brain in 3 parts- front, middle and back. The functions of front and middle as well as middle and back are so overlapping that it creates a lot of confusion to study the brain as such. Thus, it would be easier to state two parts of the brain as upper and lower parts. The upper having roles in seeing, hearing, smelling, reasoning, learning, thinking etc. while the lower part in breathing, swallowing, maintenance of temperature, balance etc. The upper part of our brain is most developed as compared to other animals of our family.

The brain also controls involuntary actions controlled by the spinal cord. As for example when you walk, your hands move in a particular manner according to your footsteps and this happens without your conscious sense about the action. This is when the spinal cord exclusively controls your actions. Contrary to this when you are rehearsing a march past; you move your hands and legs in a pattern intentionally in a conscious manner. This action is voluntary which is being controlled by the brain. Thus we may say that whenever we do something consciously or voluntarily, it's our brain that controls such actions. There are certain involuntary actions as well that are directly controlled by our brain like the contraction of pupil of our eye when exposed to bright light.

Do you know?

Our heart beat is stimulated and controlled by a network of nerves in our heart. It receives signals from the brain for it. But even if the signal stops from our brain the nerves may still keep the heart working if signaled artificially.

- Make a list of all the voluntary actions that you do in a day.
- Write the organs involved in any one of these voluntary actions.

Any of the following three functions (or all of them) may go on if the upper part of our brain functions normally.

1. It may arrest those functions that were stimulated by the lower part or the spinal cord.
2. It can carry the functions stimulated by lower part or spinal cord in a controlled manner.
3. Can control function of muscles directly without the intervention of spinal cord.

Well there are still several other amazing facts about our brain. Another fact is most of the left part of our brain controls functions of most of the right part of our body and vice versa. The responses to informations that reach the brain are expressed in a consolidated manner.

Let's do some activities to observe this.

Activity-3

Keep your hands in a manner as shown in the figure. Let the pointer fingers pint each other.

Now move both your hands in a clockwise direction together. Now roll one of them clockwise and the other anticlockwise simultaneously. Try stopping one to roll the other in clockwise and anticlockwise directions respectively.

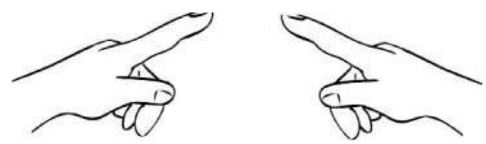


Figure-6: Bringing pointer fingers in front of each other

- Was it easy to roll your handssimultaneously in opposite directions?
- Why do you think it was so?
- Why was it easy to stop one hand and move the other?

While you were rolling both hands together the response from the brain was a combined one. Directions for individual activities came separately. But when we tried doing antagonistic actions here, the combined response from the brain was directed otherwise.

- While walking which hand swings forward as you put your right leg out?

How do you think it happens like this?

Activity-4

Blindfold one student sitting in the center of the class. Ensure that her ears and nostril are not covered. Ask the student to respond to sound of clapping by pointing towards the direction. Now, the teacher may choose students sitting at equal distance behind and in front of as well as towards left and right side of the blindfolded student. These students will clap in turns as the teacher points towards them one by one. The blindfolded student will point towards the source of sound. Rest of the students must sit quietly and watch.

Repeat this with other students to find out whether the observation is similar with them.

- Could the blindfolded student always point correctly towards direction of clapping?
- What happened when the sound of clapping was either from front or from back of the student?

- Through which organ was the student getting the information of the sound stimulus?
- Which organ showed the response?

You may have observed that the student could show the direction of source of sound if it came from left or right sides. The student failed to show correct directions if sound came either from front or back. We can see that our ears are located towards the left and the right side of our face. Now, if a source is located towards the left, sound produced from it would reach our left ear slightly before it reaches our right ear. This minute difference helps the brain to differentiate between directions correctly. In case of sound travelling from front or back, the source of sound is equidistant from our ears, thus, it becomes difficult to decide the direction when we are blind folded. If our eyes were open they would help in stating the direction correctly.

Do you know?

Dr. Shubha Tule is a leading scientist of our country who has made pioneering discoveries on the development of brain and identified genetic material that could have role in development of areas in the brain related to control of involuntary actions and learning. She has attained international acclaim. She was conferred the Shanti Swaroop Bhatnagar award in the year 2010 for her achievements. She is presently working at Tata Institute of Fundamental Research, Mumbai.

8.1.6 Exchange of information: Stimulus and response

Different types of informations both external and internal to our body keep influencing our body in many ways. Without a response at a proper instant these may affect our body adversely. Fox example when our hand touches a hot utensil it instantly moves away from it. The stimulus of heat passes to our hands through the cells that are in direct contact to the stimulus. They are then carried forward by nerves called as sensory nerves to the spinal cord and further to the brain. A response is effected against the stimulus from spinal cord or brain through nerves called as motor neurons. These influence the muscles of our arms in such a way that contraction and relaxation movements occur, eventually leading to the movement of our hand away from the hot utensil. The complete circuit from sensing a stimulus to effecting a response is called as a reflex action. See figure 7 which is a schematic representation of the process. Most reflex actions, that is, actions occurring involuntarily, are effected by the spinal cord.

- What would have happened in the given example if there was no response?
- If a utensil is hot you use it carefully, do you think your brain has any role in doing so?

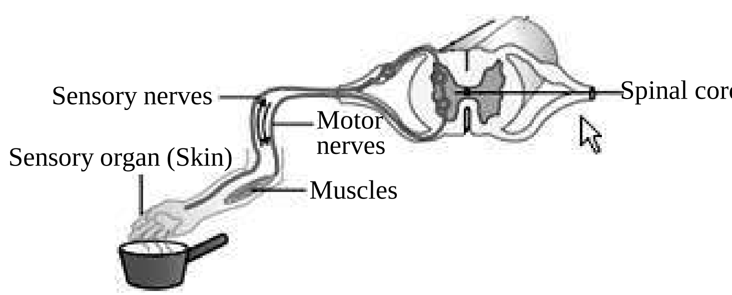


Figure-7: Reflex action- stimulus and response

Now if we consider what we had done in activity 1, we shall find that, we had been able to hold the stick quickly if we got intimation about its fall through our ear and we could observe the stick with our eyes. So, a response was effected by muscle movements against the stimulus to hold a falling stick. Thus, a coordination mainly between eye, ear and hand was necessary.

- Think and state which other parts of our body were involved in the action mentioned above.

If we try to represent the action of catching the scale schematically, it could be as in figure 8.

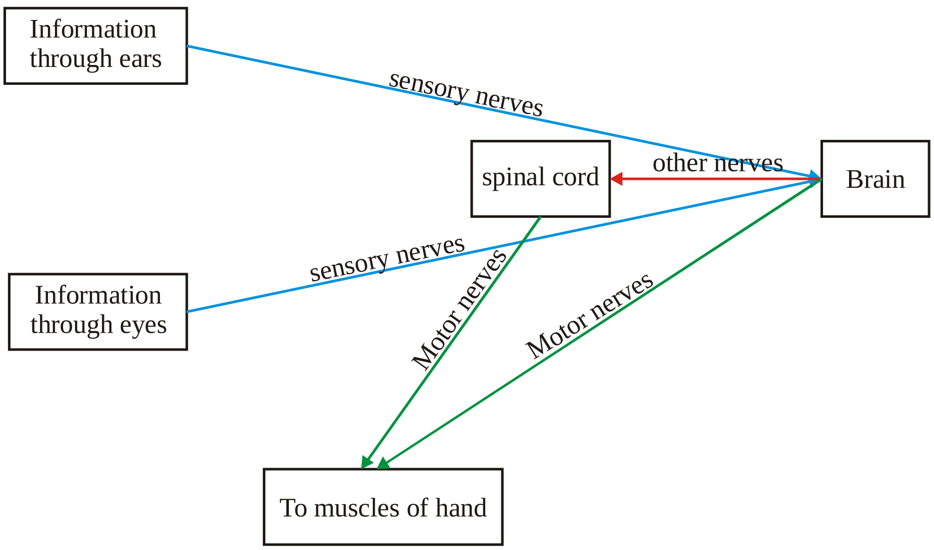
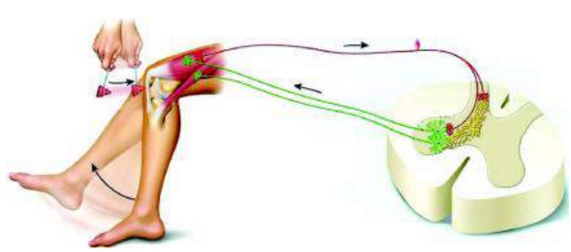


Figure-8: Schematic representation of pathway of information

- Write a few more examples of such reflex actions.
- What do you think happens when our fingers are pricked suddenly? What are the organs involved in the process? Draw a schematic diagram to represent the same.

Do you know?

Doctors often use a reflex hammer to strike the just below the knee joint to check for sensations. This produces a pressure signal which travels back to the spinal cord through the sensory nerves which synapse (without interneurons) directly with the motor nerves in the spinal cord. From there, the motor neuron conducts a response back to the muscles in thigh region, triggering contraction. This contraction, coordinated with the relaxation of the antagonistic muscles of lower portion of our leg causes the leg to kick. This is a reflex which helps maintain posture and balance, allowing tokeep one's balance with little effort or conscious thought. The pain felt later is due to the fact that the information of this act and the pain signals that were produced reach the brain from where responses are effected through a different pathway.



8.1.7 Conduction of information by hormones

Apart from the electrochemical pathways through a system of nerves there are other pathways of conduction of signals or informations in our body. There are certain organs where some chemicals are produced that reach different locations of our body through the blood. These chemicals are mainly proteins and called as 'hormones'(a word of Greek origin that means effecting motion).

Hormones are important agents that help in control and coordination between different parts of the body. Some examples of control and coordination by hormones are as follows.

Other than certain chemicals required for digestion, a hormone called insulin is also produced by our pancreas. Without the presence of insulin, our body fails to use sugar, thus the kidneys pass sugar present in blood into the urine. We are said to be affected by diabetes when we have sugar in urine and more sugar in blood than normal (a normal would a random measure between 80-200mg/deciliter of blood sample). A very high amount of insulin is also fatal for the body. Say if a patient is given high dose of insulin, the kidneys remove all sugar available in blood leading to a dearth of sugar for cells even in our brain. Insulin is essential for each cell of our body. It is important that a proper amount of insulin reaches the cells, thus, its produced in a particular organ the pancreas. It is released and transported through blood to different parts of our body under the control of our nervous system.

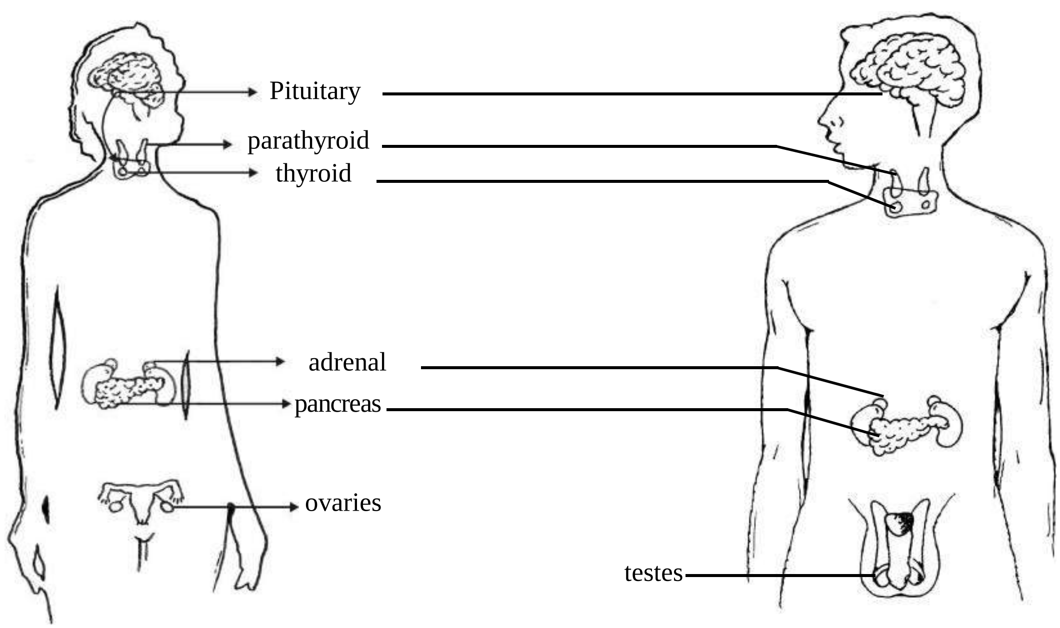


Figure-9: Some organs that produce hormones

There is a gland called 'Parathyroid' in our neck region that produces a hormone that is mainly responsible for maintaining level of Calcium in the blood. A low amount of the hormone leads to low levels of calcium in the blood leading to odd muscular cramps. Perhaps bones take up calcium from blood. A high level of hormone leads to high level of calcium in blood as the bones start softening as calcium passes into the blood from them. Both conditions are fatal for the body.

- Does nervous system have any role in the release of hormone from the parathyroid gland? What do you think?

Another gland called thyroid produces the hormone thyroxin which raises the rate of oxidation in our body. Without this hormone, rate of oxidation is negligible. If the level of this hormone is less in blood, a person becomes fat and sluggish. A high level of the hormone leads to loss of weight as the person becomes thin and hyperactive. The pulse rate increases and several other complications emerge and the person becomes seriously ill. When due to cancer or other complications, this organ is removed, the person is administered a fixed required amount of dosage of the hormone daily. If it is given at a higher dose than daily requirement then the oxidation rate escalates leading to high oxygen demand and the person becomes ill. If a normal required dosage was given to a person with a normally functioning thyroid, then the organ would stop producing the hormone as long as the level of the hormone administered externally remained normal in blood.

Adrenals present above are kidney produce several hormones. They are well known in producing hormones that effect actions related to responses during sudden fear or embarrassment. A particular hormone secreted by this gland helps in controlling level of salt in our body. This hormone is secreted from the outer layers of this gland. In the absence of production of this hormone a person may be kept alive by feeding her with a fixed small amount of salt per day otherwise it would be fatal for the individual.

Hormones are also produced by the testis in males and ovaries in females that bring about various changes during adolescence like development of beard, change of voice etc. in males and development of mammary glands, start of menstruation etc. in females. Hormone from these glands is released in mature individuals as well and helps in the production of reproductive cells eggs in females and sperms in males. Another hormone released in females called as 'progesterone' aids in pregnancy and menstruation.

8.1.8 Control of level of hormones

We have studied about the control of nervous system over secretion of hormones. Some of the glands themselves effect the secretion of other glands. Maximum varieties and amount of hormones are secreted by the pituitary gland (see fig 9 for its location). The hormones secreted by this gland have various roles in our body like growth and development, use of sugar, lactation in mothers' breast feeding their babies, etc. Apart from this, hormones secreted from pituitary control the release of hormones by several other glands like pancreas, thyroid, adrenal, testes ovary etc. The hormones released from other glands also affect the release of the respective pituitary hormone. For example, a hormone of pituitary gland controls the secretion of thyroxin from thyroid. If thyroxin level increases in blood the release of the pituitary hormone stops. The size of testes and ovaries increases during adolescence under the influence of pituitary hormones. These gonad stimulating hormones of pituitary glands also maintain levels of hormones secreted by ovaries and testes. A hormone related to growth, secreted by the pituitary acts antagonistically to the hormone insulin. The release of certain other hormones by the pituitary accelerates the release and activity of other hormones that may further influence the start and stop of the release of the respective pituitary hormone.

One such hormone is a type of adrenal gland stimulating hormone that stimulates the secretion of a hormone from the inner part of the adrenal glands. Our heart rate increases and blood flows into muscles at a higher rate during emotional situations or during exercise due to the effect of this adrenal hormone. The effect of this adrenal hormone as well as the stimulating hormone is very fast contrary to most hormones that slowly affect a function. The release of stimulating hormone stops when there is adequate amount of the required adrenal hormone in blood.

Progressive research in this field has established the fact that most of the actions in our body are carried out by a balance in two antagonistic pathways. We have come to know a lot about hormones now and if we do not use our knowledge properly, it may affect our health adversely.

A connection between nervous system and glands that release hormones exists all through our body, an important and extensive connection being formed in the brain with strands of nervous tissue and the pituitary. This connection between nervous system and glands secreting hormones aids in all life processes and proper functioning of our body. It is because of this connection that often your doctor suggests you to stay in high spirits during your illness so that you may be cured quickly.

8.2 Control and Coordination in plants

Research in the field of control and coordination in plants mainly started around 200 years back. Our knowledge acquired in these 200 years has helped us to believe that most life processes that occur in animals occur in a similar ways in plants. We have also realized that processes of control and coordination also occur in plants. You are aware of the shutting of leaves in the touch- me -not plant. There are several other functions like blooming of flowers in the morning in several plants while in some others like night queen blooming of flowers in the dark, closing of tamarind leaves at night, climbers climbing around a support, seeds sprouting and seedlings growing out of the soil are all examples of processes that indicate responses in plants to certain stimuli, light, temperature, presence of an obstruction etc. These show that there is conduction of information in some way.

Figure-10: Touch-me-not plant

Experiments started by Charles Darwin and his son Francis Darwin in the 1880's that there are certain chemicals that may be involved in the process of sensation in plants.

Scientists had been studying about the effect of various stimuli on plants. They found different types of responses usually effected by growth. Let us take an example. A certain study showed that if the tips of stems of plants were illuminated constantly from a certain direction, then cells in meristematic tissues in the opposite side of the stemstart dividing very fast leading to a bend in the stem towards the source of light. Thus it was speculated that some chemical passed on from tip to the region of growth bringing about the response. The presence of the chemical was later confirmed. It was isolated tested and named as 'Auxin'.

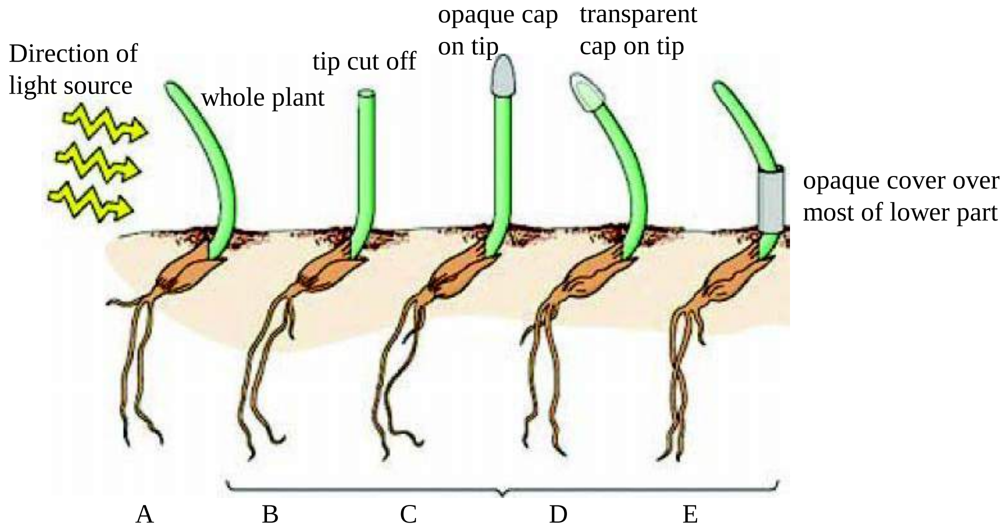


Figure-11: Experiment conducted by Charles and Francis Darwin (different areas of stem are covered for the same direction of light source in plants of similar size and same species).

- Observe the figure and state the conditions (A,B, C, D or E) in which the stem bends towards light. How do you think this happened?
- What inferences may be drawn from this experiment?

We now know that plant respond to various stimuli like presence of water, light, heat, touch, chemical substances etc. The informations of stimuli and the respective response is passed on in the form of certain chemicals in plants which many scientists call as 'plant hormones'. These chemicals aid in actions like opening and closing of stomata, falling of leaves, increase in rate of division of cells, growth of different parts, maturation of buds, blooming of flowers, ripening of fruits etc.

'Auxin' was found to be a growth hormone. Another growth hormone was found to be a different compound and named as 'gibberellin'. A chemical compound 'Cytokinin' is found in large amounts in seeds and fruits. It is found to increase the rate of cell division. Some chemicals like abscisic acid arrest growth in plants.

You may have observed that there are some plants around which no other plants are found to grow (eucalyptus being one of them, you may hardly see any undergrowth at the base of it). This is because a chemical is released from the roots of the plant that arrests the growth of other plants. When a ripe fruit is kept among unripe ones we often find the unripe fruits ripen quickly. This may be due to release of ethylene by some ripe fruits that influence the unripe ones.

You may have observed insects and birds flying around flowers and feeding on the nectar produced in them. This is a sugary fluid produced by glands that may be present on any part like sepal, petal, stamen, carpel etc. This fluid mainly helps to attract pollinators like the insects and birds bringing about pollination in plants. Another sugary fluid released over style attaches the pollen and induces its germination to form a tube carrying the reproductive cells through the style to the ovary. There are other chemicals as well that influence pollen germination.

All life processes whether they occur in a single cell or in multicellular bodies go on with the help of either chemicals or electrochemical means in controlled and coordinated manner.

Do you know?

Once in a certain area in the grasslands of South America, there was scarcity of water due to low rainfall. A type of tree similar to Babul/Acacia grows in those grasslands. The leaves of the plant contain tannin usually in very small amounts that does not have any effect on the animals that feed on it. During this period it was observed that deers and some other animals of the grassland started dying in large numbers. These animals could have moved out of the area due to scarcity of water but they did not. Moreover water scarcity did not seem to be the cause of their death. Scientists examining the dead animals found an alarming amount of tannin in their gut.

Studying the plants showed that the leaves also contained a very high amount of tannin, which was quite unlikely for the plants. Thus the scientists speculated that lowering of availability of water, had caused such a change that as the herbivores died out, these plants would have adequate water available for their survival. Apart from this it was found that trees even in areas where there wasn't any scarcity of water, the leaves still had high levels of tannin. The air had high amount of ethylene everywhere. It was found that the trees released ethylene in the air and it acted as a signal for other plants even in far of areas.

The source of information for this is available on https://www.youtube.com/watch?v=ZrXksBKRW1A

Key words

Control, coordination, sensory, motor, stimulus

What we have learnt

1. The nervous system and hormones in our body are mainly responsible for control and coordination.
2. The exchange of information in the body occurs by electrochemical or simply chemical means.
3. Reflex actions are controlled by the spinal cord. Brain does not have a major role. Information of the action is usually transmitted from spinal cord to the brain.
4. Chemical means of control are found in plants.
5. Hormones are chemical substances responsible for control and coordination.

Exercise

1. Choose the right option-

(i) Which of the following is a plant hormone?

(a) Insulin (b) Thyroxine

(c) Estrogen (d) Cytokinin

(ii) his is not a part of the structure of a nerve cell-

(a) dendrite (b) nucleus

(c) axon (d) cellulosic cell wall

(iii) A gland present in our brain that controls hormonal secretions of several other glands in our body.

(a) Pituitary (b) liver

(c) adrenal (d) pineal

(iv) A hormone from this gland controls the level of sugar in blood-

(a) Parathyroid (b) Pancreas

(c) Adrenal (d) Pineal

(v) When we asleep at night and are bit by a mosquito, we often try to kill the mosquito. This action is controlled by-

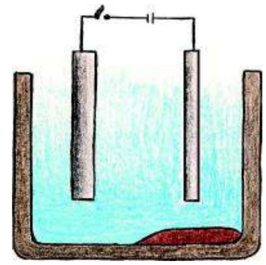
(a) Pituitary gland (b) spinal cord and brain

(c) hormones (d) pineal gland

2. Make schematic line diagrams and describe a reflex action of our body.
3. Write a note on the role of spinal cord and brain on reflex action.
4. 'There is a coordination between the secretion of hormones and the nervous system', justify the statement.
5. Illustrate a nerve cell with a neat and labeled drawing and describe it.
6. How are involuntary actions controlled in our body, explain with a diagram?
7. Write an example of chemical control in plants.
8. Explain the need of control and coordination in any living organism with examples.
9. 'Plants are sensitive to light' cite an experiment to justify this statement.
10. Give examples to show how plants respond to stimuli.

CHAPTER 9

METALS AND METALLURGY



Substances are classified as pure substances and mixtures. We also know that pure substances can either be elements or compounds. Elements (which number more than 100) combine with each other to form all the materials found around us. Elements can be further classified into metals and non-metals. But, is it easy to distinguish between metals and non-metals? In this chapter, we will study some characteristics of elements that help us identify them as metals.

9.1 Some physical properties of metals?

We have already read about the physical properties of metals in previous classes. We know that metals have luster. They can be beaten into thin sheets or foils and even be drawn into thin wires. Metals are conductors of heat and electricity. When we strike a piece of metals, a sonorous sound is produced and usually metals melt at very high temperatures.

Let us do an activity to understand the physical properties of metals in some detail.

Activity-1

From your surroundings, collect samples of some metals, for example - iron, aluminium, copper, zinc. Observe these metals and answer:

- Do all metals have luster?
- Can all metals be beaten into thin sheets or foils?

*(**Note**- Be careful while choosing your samples that you select metals and not alloys).*

We find that these two properties are similar but not identical in metals. Ponder on the following questions about some other properties of metals:

- The wires in different electrical appliances are made of which metal or metals?
- Which metal is used in household wiring?
- Which metal is used to make high tension wires?
- Which metals are used to make cooking utensils and why?

We find that a specific metal is used for a specific purpose. Why don't we use the same metal to solve all our purposes? You must be thinking that there may be more than one reason for selecting a particular metal for a specific task. For example, silver is the best conductor of electricity but due to economic (cost) factors it is not used for wiring in instruments or buildings.

We know that metals are malleable, ductile, conductors of heat and electricity, have high melting and boiling points and produce a sonorous sound. But some of these characteristics are also found in some non-metals, for example- diamond, an allotrope of carbon, has shine and is also a thermal conductor. Another allotrope of carbon, graphite, is grey in colour and a conductor of electricity. Iodine is a non-metal but has shiny crystals. Therefore, it is not right to classify an element as metal or non-metal based on any one physical property.

9.2 Chemical properties of metals

We have seen that there are many similarities, but also some differences, in the physical properties of metals. Do you think that we will see something similar in the chemical properties of metals? We learn a little more about the reactivity of metals by looking at their historical development. Through this study, we try to understand for how long human beings have been using metals and their ease of availability.

Because of differences in the chemical properties of metals, the era when humans were able to obtain them in pure forms is also different (table-1). Let us try to understand what we mean by this statement.

Table-1: Historical background of obtaining metals

Element	Obtained in	Availability in the earth's crust
Gold	6000 BC	0-00000031%
Copper	4200 BC	0-0068%
Silver	4000 BC	0-0000079%
Lead	3500 BC	0-00099%
Tin	3000 BC	0-00022%
Zinc	2000 BC	0-0078%
Iron	1500 BC	6-3%
Mercury	750 BC	0-0000067%
Platinum	1735	0-0000037%
Cobalt	1739	0-003%
Nickel	1751	0-0089%
Tungsten	1783	0-00011%
Potassium	1807	1-5%
Sodium	1807	2-3%
Calcium	1808	5%
Magnesium	1808	2-9%
Aluminium	1825	8-1%

In previous classes, we studied displacement reactions. Can you tell why copper is displaced when we add zinc pieces to copper sulphate solution but zinc is not displaced when we add copper turnings to zinc sulphate solution? We will need to look at some more displacement reactions before we can answer this question.

Activity-2

*(**Note for teachers:-** In a beaker, make a solutions of 2g of copper sulphate in 100 mL water. Similarly, in different beakers make solutions of zinc sulphate, iron sulphate and sodium chloride. The following activity should be carried out in small groups.)*

- Each group of students should take six test tubes and label them as ´A´,´B´,´C´,´D´,´E´, and ´F´.
- In test tubes ´A´ and ´B´ each, take 5 mL copper sulphate solution, in test tubes ´C´ and ´D´ take 5 mL of zinc sulphate solution and in test tubes ´E´ and ´F´ take 5 mL of iron sulphate solution and sodium chloride solution respectively.
- In test tube ´A´ add 2-3 iron nails or awl-pins, in test tube ´B´ add zinc granules, in test tube ´C´ add copper turnings, in test tube ´D´ add a piece of magnesium ribbon and in test tubes ´E´ and´F´ add zinc granules (figure-1).

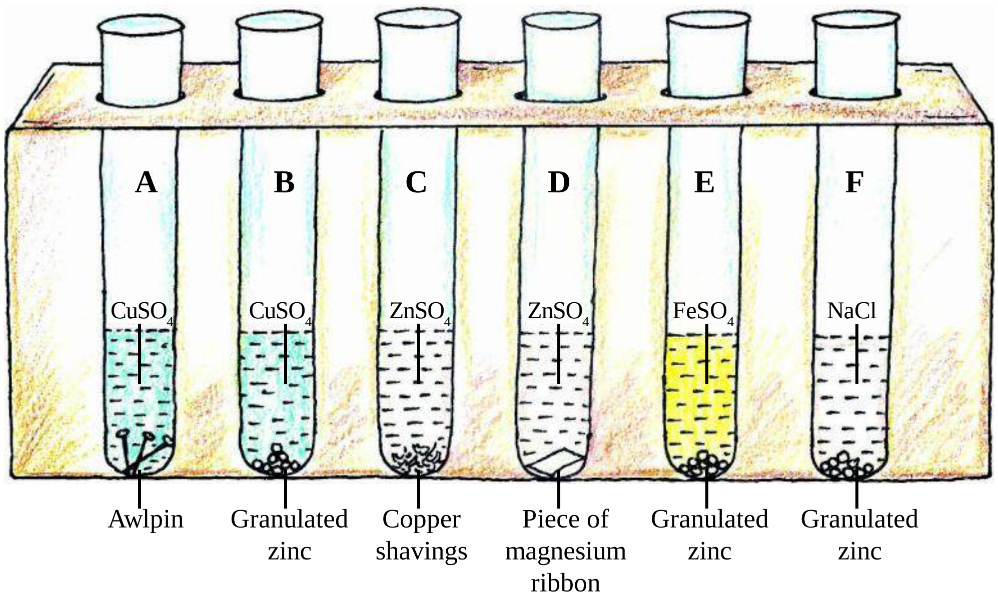


Figure-1: Comparision of reactivity of metals using displacement reaction

- Observe all the test tubes after 5-10 minutes.
  - o Did you notice any change in the appearance of the metals or the solutions.
  - o Is any precipitate being formed?
  - o Can you tell which metal is displacing another metal from its salt solution?

We find that in test tube ´A´, iron is displacing copper from copper sulphate solution, in test tube ´B´, zinc is displacing copper from copper sulphate solution, in test tube ´D´, magnesium is displacing zinc from zinc sulphate solution and in test tube ´E´, zinc is displacing iron from iron sulphate solution.Whereas in test tube ´C´, copper is not displacing zinc from zinc sulphate solution and in test tube ´F´, zinc is not displacing sodium from sodium chloride solution.

Therefore, that metal that displaces another metal from its salt solution is called more reactive of the two. The series obtained when we place metals in descending order of reactivity is known as the activity series. The reactivity of some metals is shown in table-2.

Table-2 tells us that lithium is the most reactive metal and platinum is the least reactive metal. It also helps us in comparing two metals, for example, it shows that iron being higher can displace silver from a silver salt solution but silver cannot displace iron from solution of an iron salt. The metals that occur above hydrogen in the activity series can displace hydrogen gas from dilute acids.

Table-2 : Activity series

Li	Lithium (most reactive)	Decreasing reactivity ↓
K	Potassium	
Na	Sodium	
Ca	Calcium	
Mg	Magnesium	
Al	Aluminium	
Zn	Zinc	
Cr	Chromium	
Fe	Iron	
Sn	Tin	
Pb	Lead	
H	Hydrogen	
Cu	Copper	
Hg	Mercury	
Ag	Silver	
Au	Gold	
Pt	Platinum (least reactive)	

If we compare the metals seen in the reactivity series (table-2) with when they were obtained in the pure form (table-1), we realize that the most reactive metals such as sodium, potassium and calcium were obtained in pure form only about 200 years ago whereas the less reactive metals such as gold were known even in the times of ancient civilizations. The reason these metals were used is that they are found in the elemental (pure) form in nature. Very high temperatures are required to obtain pure iron from its ores (hematite and magnetite) and this could happen only after coal and coke replaced wood as fuels. This is why, even though iron is abundantly available in the earth's crust, it was obtained in the pure form only about thirty five hundred years ago.

Mercury, zinc and tin are metals that can be obtained simply by heating their ores. Metals such sodium and potassium, which are above iron, occur as compounds that cannot be reduced to metals by chemical methods.

Let us see how the activity series helps us in understanding the chemical reactions of metals.

9.2.1 What happens when metals are burnt in air?

The more reactive metals - sodium, potassium and lithium - react rapidly with oxygen. When kept in the open, they quickly react with the oxygen present in air to give oxides. Therefore, they are kept under kerosene to prevent them from coming into contact with air. The oxides of sodium and potassium dissolve in water to gives alkalis.

$$4Na + O_2 \longrightarrow 2Na_2O$$

$$Na_2O(s) + H_2O(l) \longrightarrow 2NaOH(aq)$$

Write the balanced equation of the reaction taking place with potassium.

We know that some relatively less reactive metals - for example, magnesium - react slowly with the oxygen present in air but burn rapidly with a white flame when heated. This property of magnesium makes it useful in manufacture of fire-crackers.

Activity-3

***Note:-** The bright flame produced during combustion of magnesium ribbon can harm your eyes so be careful.*

- Take a 3-4 inch long piece of magnesium ribbon.
- If there is a white layer on the ribbon then soak it in dilute hydrochloric acid to remove the layer f magnesium oxide.
- Be careful that you do not soak the ribbon in acid for very long or the magnesium will also start reacting with the acid.
- After soaking, carefully blot the ribbon with filter paper and then heat it over a spirit lamp (figure-2).

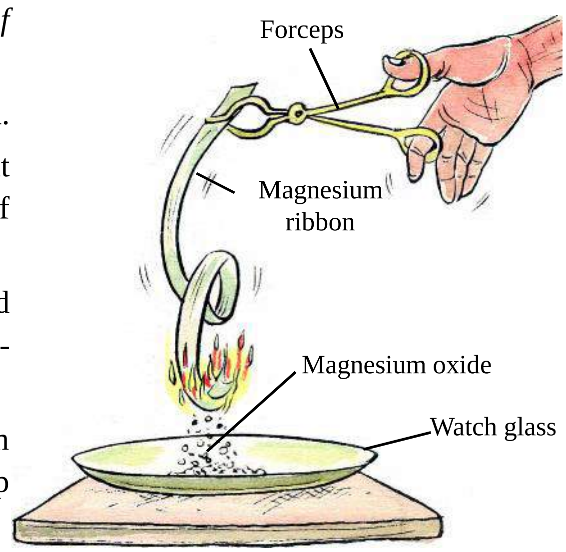


Figure-2: Combustion of magnesium

- Place a moist litmus paper (blue and red separately) near the white smoke seen on burning the ribbon and test its nature.

  The white smoke is of magnesium oxide. Is it acidic or basic?

At room temperature, zinc, lead and aluminium metals also react with the oxygen present in air to give their oxides that are deposited as thin layers on the surface of these metals. Once the layer is formed, it prevents further oxidation of the metal.

$$2Zn + O_2 \longrightarrow 2ZnO$$

$$4Al + 3O_2 \longrightarrow 2Al_2O_3$$

Most metal oxides are basic in nature but some of them such as zinc oxide and aluminium oxide are amphoteric. These oxides react with both acid and bases to give salt and water.

$$Al_2O_3 + 6HCl \longrightarrow 2AlCl_3 + 3H_2O$$

$$Al_2O_3 + 2NaOH \longrightarrow \underset{\text{Sodium aluminate}}{2NaAlO_2} + H_2O$$

Copper does not undergo combustion but a black layer of copper oxide gets deposited on the metal. Silver and gold metals do not react with oxygen even at high temperatures.

Questions

1. Why do metals lose theirlusterwhen left in the open?
2. Why are gold and silver used in making ornaments and jewelry?
3. Write the balanced chemical equations of the reactions of lead, magnesium, aluminium metals with oxygen?

We saw that potassium, sodium and lithium metals are very reactive. Magnesium reacts more slowly. Let us study some more reactions to understand the reactivity of other metals.

9.2.2 What happens when metals react with water?

Very reactive metals - sodium, potassium and lithium - react with cold water to give metal hydroxide, hydrogen gas and a high amount of heat, therefore, the reactions between these metals and water are exothermic.

$$\underset{\text{Sodium}}{2Na(s)} + \underset{\text{water}}{2H_2O(l)} \longrightarrow \underset{\text{sodium hydroxide}}{2NaOH(aq)} + \underset{\text{hydrogen}}{H_2\uparrow} + \text{heat}$$

Less reactive metals like magnesium react feebly with cold water but react rapidly with steam or hot water to give magnesium hydroxide and hydrogen gas. The hydrogen gas bubbles formed stich to the surface of the unreacted remaining metal which as a result starts floating on the surface.

$$Mg(s) + 2H_2O(l) \longrightarrow Mg(OH)_2(aq) + H_2\uparrow$$

Metals such as aluminium, zinc and lead react neither with cold water nor with hot water. However, they react with steam to five metal oxide and hydrogen.

$$2Al(s) + 3H_2O(g) \longrightarrow Al_2O_3(s) + 3H_2\uparrow$$

$$2Fe(s) + 3H_2O(g) \longrightarrow Fe_2O_3(s) + 3H_2\uparrow$$

Metals such as gold, silver and copper do not react with water at normal temperature.

9.2.3 What happens when metals react with acids?

We know that metals react with dilute acids to give the corresponding salt and hydrogen gas. Write the balanced chemical equations for reactions of magnesium, zinc and iron with dilute hydrochloric acid.

Do all metals react in this manner? Reactivity towards acids decreases as we go down the activity series from the most reactive metal to the least reactive. Less reactive metals like gold and platinum do not react with dilute acids.

Copper reacts with concentrated nitric acid to give copper nitrate, nitrogen dioxide gas and water.

$$Cu(s) + 4HNO_3(aq) \longrightarrow Cu(NO_3)_2(aq) + 2NO_2(g) + 2H_2O(l)$$

Gold and platinum react only with aqua regia (3 parts concentrated hydrochloric acid and 1 part concentrated nitric acid).

Questions

1. Write the balanced chemical equations for the given reactions:
   (a) Reaction of calcium with water
   (b) Reaction of iron with steam
2. What gas is formed when aluminium metal reacts with dilute hydrochloric acid? Write the equation for the reaction.
3. What is aqua regia?

Now we will see how different metals are obtained, how they can be protected from environmental factors, and how they can be mixed with other metals to increase their usefulness.

9.3 Occurrence of metals

Metals are usually found in the earth's crust. Some metals occur in the free state and others in the combined state. Generally, metals which lie low in the reactivity series - such as gold and platinum - are found in free form whereas, the more reactive metals react with other elements to form compounds and are found in combined form. Solid inorganic substances which occur naturally in the earth's crust, whose chemical composition is fixed and whose physical properties can be estimated, are known as minerals.Metals are extracted from these minerals. Minerals which contain a very highpercentage of a particular metal (and low percentage of impurities) and from which the metal can be easily and profitably extracted, are called ores.Usually, minerals are found in different types of rocks. All ores are minerals but all minerals are not ores.

Table-3: Ores of metals

S.No.	Type of ore	Name of ore	Formula of ore
1	Oxide	Hematite	Fe_2O_3
		Magnetite	Fe_3O_4
		Bauxite	$Al_2O_3.2H_2O$
		Cassiterite	SnO_2
2	Carbonate	Dolomite	$MgCO_3.CaCO_3$
		Limestone	$CaCO_3$
		Calamine	$ZnCO_3$
3	Sulphide	Iron pyrite	FeS_2
		Copper pyrite	$CuFeS_2$
4	Sulphate	Gypsum	$CaSO_4.2H_2O$

9.3.1 Important minerals and their distribution in Chhattisgarh

Chhattisgarh is rich in minerals and holds an important place in our nation's mineral pro duction. In all, 28 different types of minerals are found in Chhattisgarh. It is the only state in India where tin, which is a strategically important mineral, is found. The important minerals found in Chhattisgarh are shown in table-4.

Table-4: Important minerals found in Chhattisgarh

S.No	Name of mineral	Districts where minerals are found
1.	Hematite	Dantewada, Bastar, Kanker, Narayanpur, Raipur, Kabirdham
2.	Bauxite	Sarguja, Korba, Jashpur, Kanker, Bastar, Kabirdham
3.	Limestone	Raipur, raigarh, Janjipur - Champa, Kabirdham, Bastar, Bilaspur, Durg, Rajnandgaon
4.	Dolomite	Durg, Kabirdham, Bilaspur, Janjipur - Champa
5.	Alexandrite (Chyrsoberyl)	Raipur (Devbhog)
6.	Cassiterite	Dantewada, Bastar
7.	Corundum	Dantewada
8.	Gold	Raipur, Kanker, Raigarh, Mahasamund, Bastar
9.	Asbestos	Raipur, Bastar, Sarguja, Jashpur

9.4 Metallurgy

The process of obtaining metals from ores is known as extraction of metals or metallurgy. There are three main steps in this process:

1. Concentration of ore 2. Extraction of metal 3. Purification of metal

Depending on the type of metal and the type of ore, different techniques are used for extraction of metals. Let us study in some detail.

9.4.1 Concentration of ore

Ores obtained from mines are usually contaminated with large amountsof impurities such as soil, sand, etc., called gangue. The impurities mustbe removed from the ore prior to the extraction of the metal; this is known as concentration of ore. Let us learn about different techniques used in concentration of ores.

(1) Gravity separation method- When there is a large difference in the densities of the ore and gangue material then gravity separation method is used for concentration of ore. In this, the ore is first finely ground, then shaken under a stream of water which leads to the heavier ore particles settling down and the lighter gangue particles floating to the top. These gangue particles are either separated or get washed away by the water (Figure-3). Generally, this method is used for concentration of carbonate or oxide ores, for example, the ore hematite is concentrated using this technique.

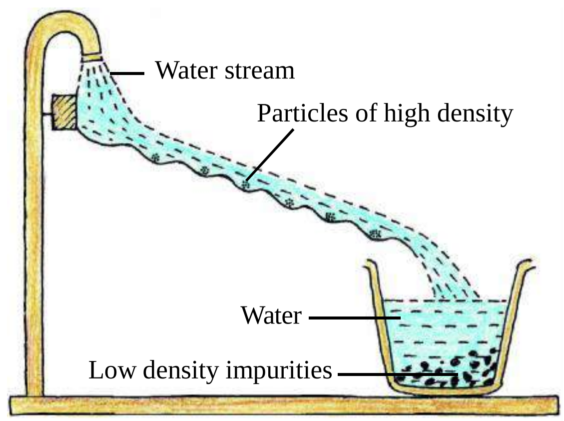


Figure-3: Gravity separation method

(2) Magnetic separation method- This method can be used if magnetic substances are present in the ore. In this method, the finely ground ore is passed over a conveyor belt which is stretched over magnetic rollers. The magnetic particles remain stuck to the belt till they are moved away from the magnetic effect of the roller whereas the non-magnetic particles fall from the belt as soon as it starts moving. In this way, two heaps are obtained; one heap is of magnetic material and the other is of non-magnetic material (Figure-4). This technique is used to separate magnetic impurities from tin ore (SnO_2).

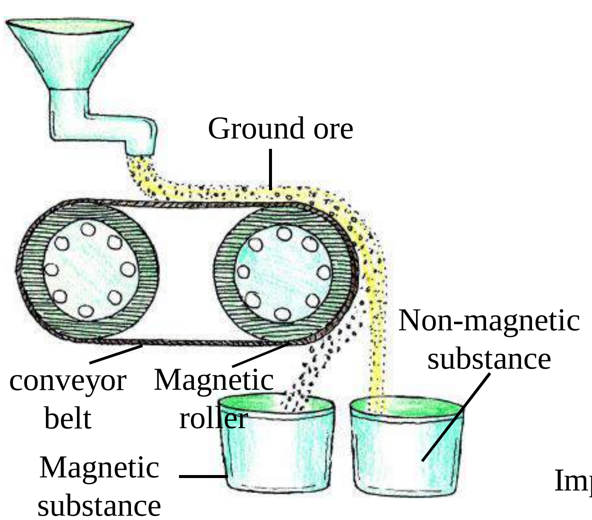


Figure-4: Magnetic separation method

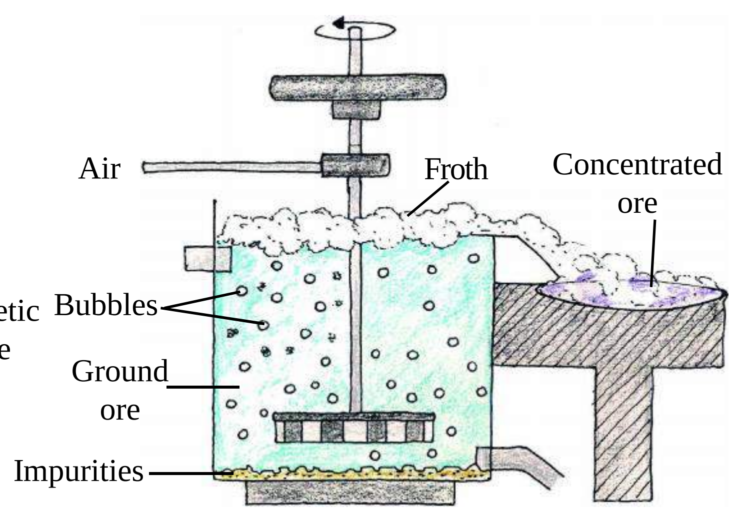
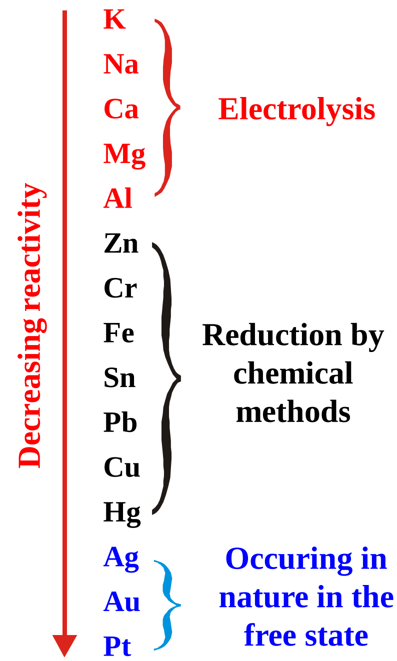


Figure-5: Froth floatation method

(3) Froth flotation process- This method is used for concentration of sulphide ores. In this method, finely ground sulphide ore is mixed with water and pine oil and compressed air is passed through the mixture causing frothing. A layer of pine oil is formed on the surface of the sulphide ore particles which causes the air bubbles to stick to them. The ore particles come to the surface with the froth while impurities like soil, pebbles, stones etc. settle down (figure-5).

Chhattisgarh has high quantities of iron ores; find out the methods used in concentration of these ores.

Table-5: Activity series and related metallurgy



9.4.2 Extraction of metal

The method used for extraction of any metal depends on its reactivity and nature of its ore.

(A) We know that it is difficult to separate the more reactive metals like sodium, potassium and calcium as elements from their compounds. When electric current is passed through these compounds, the cation dissociates from the anion and is reduced to the corresponding metal at the cathode. This process is known as electrolysis. Aluminium is also obtained by electrolysis (table-5).

(B) Medium and less reactive metals are obtained from their oxide, sulphide and carbonate ores by chemical reduction method. Some lesser or low reactive metals like mercury can be obtained simply by heating their oxides or sulphides.

For oxides, sulphides and carbonates of other metals, two steps are followed to easily reduce the metal from its ore. These steps are described below.

9.4.2.1 Converting the metal sulphide or carbonate to corresponding oxide

The method used to convert a metal sulphide or carbonate to metal oxide depends on the impurities present in the ore.

(i) The heating of concentrated sulphide ore a little below its melting point in the presence of air or oxygen is known as roasting. During roasting, the impurities are vaporized which eases the reduction of the metal compound. Roasting is usually carried out for sulphide ores.

$$2ZnS + 3O_2 \xrightarrow{\triangle} 2ZnO + 2SO_2\uparrow$$

(ii) The heating of concentrated ore a little below its melting point in the absence of oxygen is known as calcination. This method is used for carbonate ores.

$$ZnCO_3 \xrightarrow{\triangle} ZnO + CO_2\uparrow$$

On heating, carbonate ores dissociate to release carbon dioxide gas and give metal oxide.

9.4.2.2 Reduction of metal from metal oxides

Once the ores are converted to their oxides, they are then reduced to obtain the respective metals. The metal oxide is heated along with flux and reducing agent and this gives the metal in liquid form. This process is known as smelting. The flux helps in removal of hard to melt impurities. Smelting can be carried out in two ways:

(i) Carbon reduction method - roasted or calcinated ore is heated at high temperature (700°C-1800°C) with coke or carbon in a blast furnace and the oxide is reduced to liquid metal.?

$$ZnO + C \xrightarrow{\triangle} Zn + CO\uparrow$$

(ii) Chemical reduction method - Metals lower in the reactivity series can be displaced from solutions of their ionic salts by metals higher up in the reactivity series. This principle is used to separate metals using the displacement reaction. We have previously seen that copper can be displaced from copper sulphate solution by the addition or iron or zinc powder.

$$CuSO_4 + Fe \longrightarrow FeSO_4 + Cu$$
$$CuSO_4 + Zn \longrightarrow ZnSO_4 + Cu$$

Do you know the various metals which can be extracted using this method?

9.4.3 Purification of metals

The metals obtained by reduction have several impurities and is known as impure metal. The process of obtaining pure metal from impure metal is known as purification of metal. It is carried out by the following two methods:

(i) Physical methods- The two main physical techniques for purification of metals are liquefaction and zone refining (also known as fractional crystallization).

(A) Liquefaction- Metals such as tin, lead etc. that melt easily are placed over a sloping hearth in a furnace. The metal melts and flows off while the impurities are left behind.

(B) Zone refining or fractional crystallization- This method is used for refining of metals such as gold, silver and platinum. Presence of impurities lowers the melting point of a metal. Zone refining is based on the principle that impurities are more soluble in liquid state of a metal as compared to the solid state.

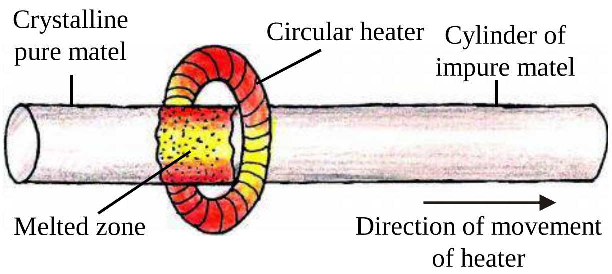


Figure-6: Zone refining

In this method, a cylinder of impure metal is placed within a circular heater till the metal starts melting. A heater is slowly moved from one end of the cylinder to the other.A narrow zone of the metal melts from the heat and the melt containing the impurities moves along with the heater to the other end of the rod while the pure metal solidifies and is left behind. Thus the impurities are concentrated towards one end of the rod and the remaining part is purified. The process is repeated several times to obtain ultra-pure metal. The part containing the impurities is cut off from the rod.

(ii) Chemical Methods- some metals are also refined using chemical methods. To obtain ultra-pure metal, electrolysis is used. A thick rod of impure metal is made the positive electrode and a thin rod of pure metal is used as the negative electrode. Solution of salt of the same metal is used as electrolyte.

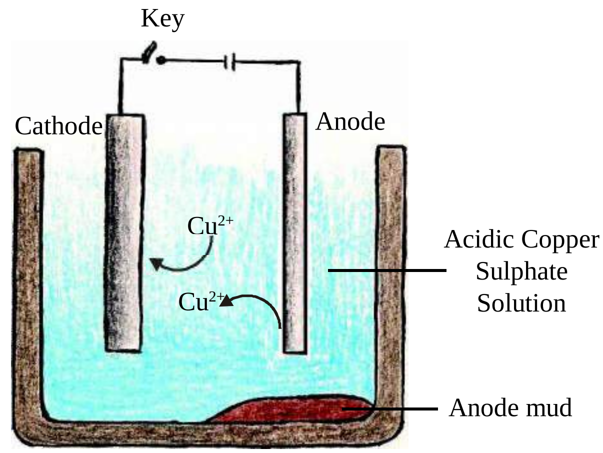
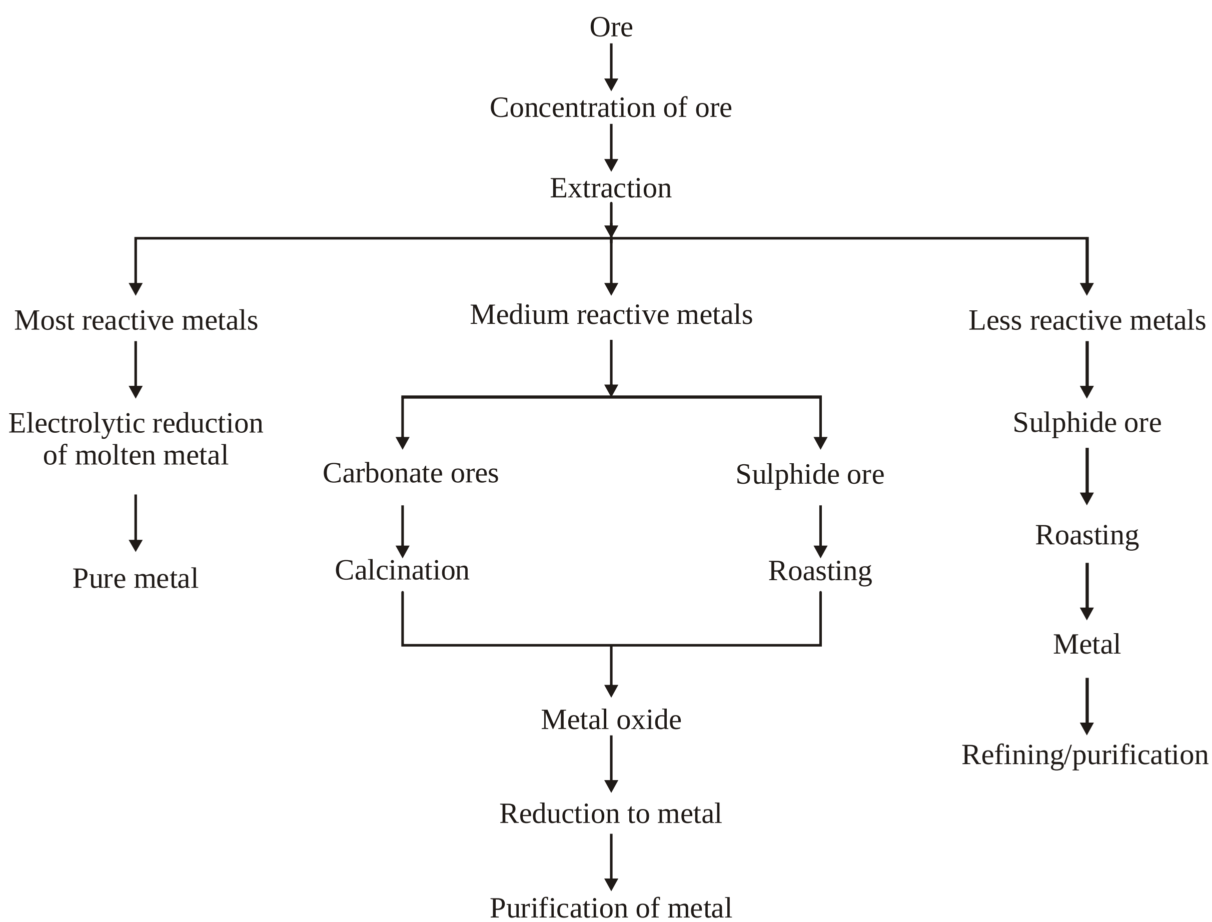


Figure-7: Electrolytic refining of metal

When electric current is passed through the electrolyte then the positive ions present in the solution (metal ions) move towards the negative electrode and are reduced to metal. At the positive electrode, the metal atoms get oxidized and dissolve in the solution. Once they dissolve in the solution these metal ions also move towards the cathode. The impurities in the metal at the anode are usually insoluble. As the metal atoms from the anode enter the solution, the substance at the anode reduces and the impurities collect below the anode. These collected impurities are called anode mud (Figure-7). This technique is used in the purification of chromium, nickel, copper, zinc etc.



Flowchart 1: Metallurgy

Activity-4

Take two copper wires of different thickness, if the wires are coated clean them with sandpaper. Connect the thicker wire to the positive end and thinner wire to the negative end of a cell. Soak both the wires in a solution of copper sulphate ensuring that the wires do not touch each other inside the solution. Observe the solution after some time and answer the following questions:

- Did the copper go from one electrode to the other?
- On which electrode did the amount of copper reduce and on which did it increase?

Similarly, when we use electrolytic refining metal is obtained on the negative electrode.

Questions

1. Write the names and chemical formulae of oxide ores of iron.
2. How are sulphide ores concentrated?
3. Na, K and Ca metals are obtained from their compounds using electrolysis, why?

9.5 Iron

Iron has played a prominent role in the human civilization and the Iron Age was the longest lasting historical era. Iron is an active metal and is found in nature in combination with other elements. Hematite (Fe_2O_3), magnetite (Fe_3O_4), siderite ($FeCO_3$) and iron pyrite (FeS_2) are the important ores of iron.

9.5.1 Metallurgy of iron

Hematite (Fe_2O_3)is the iron ore most commonly found in Chhattisgarh. Once the ore is obtained from the mines, it is crushed into a fine powder using a crusher or stamp mill which is then concentrated using gravitational separation method.

Post concentration, the ore is roasted so that impurities such as arsenic and sulphur present in the ore get converted to their gaseous oxides and are removed. The ore becomes porous facilitating metal reduction.

$$4As + 3O_2 \longrightarrow 2As_2O_3\uparrow$$

$$S + O_2 \longrightarrow SO_2\uparrow$$

Mainly sand is found as impurity in the ore which is removed with the help of calcium carbonate during smelting. The oxides of iron are reduced using carbon (coke or anthracite). The process requires high temperatures, about 1800°C. If the process is carried out with frequent breaks then a lot of energy will be wasted in heating the mixture to the required temperature. Therefore, smelting is carried out continuously in a blast furnace (Figure-8).

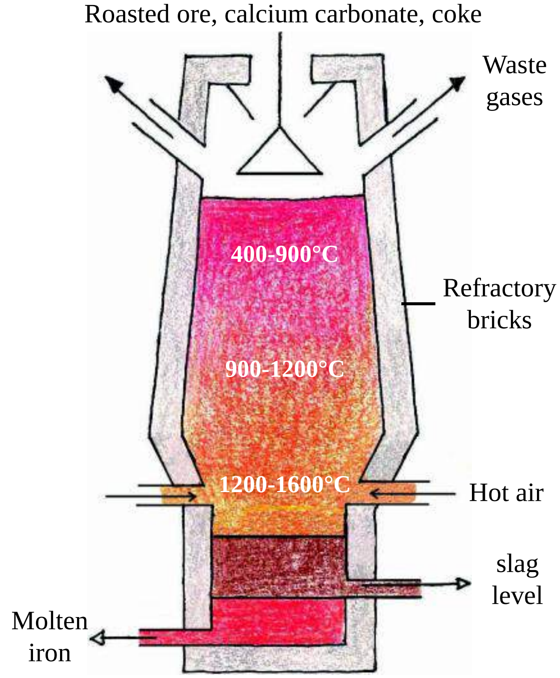


Figure-8: Blast furnace

Blast furnace is a cylindrical furnace made of steel whose insides are lined with refractory bricks. The broad portion in the middle of the furnace has inlets through which hot air (700-800°C) is blown into the furnace. The upper portion of the furnace has an outlet for gases formed in the furnace during the reaction. The lower portion has two outlets - the first higher one for slag and the second one for molten metal.

The roasted ore is mixed with lime stone and coke and fed into the blast furnace from the top and a blast of hot air is blown from the bottom. The temperature throughout the blast furnace does not remain the same so as the ore, lime stone and coke mixture comes down it has to pass through different temperature zones. The following reactions take place in a blast furnace:

Coke reacts with oxygen to form carbon dioxide gas. Since excess of coke is added, therefore the extra coke reacts with carbon dioxide gas to form carbon monoxide. Coke also reacts with insufficient oxygen to form carbon monoxide. This process ensures that high temperature (400°C-900°C) is maintained within the furnace.

$$C + O_2 \longrightarrow CO_2\uparrow$$
$$CO_2 + C \longrightarrow 2CO\uparrow$$
$$2C + O_2 \longrightarrow 2CO\uparrow$$

Oxide ores react with carbon monoxide gas to give iron and carbon dioxide. This reaction is exothermic.

$$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2\uparrow$$

Since this reaction maintains high temperature in the furnace therefore the carbon dioxide gas in not allowed to escape and again sent in to react with coke. A small amount of hematite also reacts with the coke to give iron and carbon monoxide.

$$Fe_2O_3 + 3C \longrightarrow 2Fe + 3CO\uparrow$$

At high temperature in the furnace, lime stone dissociates into calcium oxide and carbon dioxide. Since this is an endothermic reaction therefore limited quantities of lime stone are added to the furnace because excess of limestone can reduce heat and cause energy loss. The calcium oxide formed during the reaction is used to remove impurities from the ore and is known as flux. The flux reacts with silica to form calcium silicate, also known as slag.

$$CaCO_3 \xrightarrow{\triangle} CaO + CO_2$$
$$\underset{Flux}{CaO} + \underset{impurity}{SiO_2} \xrightarrow{\triangle} \underset{slag}{CaSiO_3}$$

Since the furnace temperature is kept between 1200°C and 1600°C, iron and calcium silicate remain in molten state. Their densities being different, they collect in two layers at the bottom of the furnace and are removed through outlets at two different layers.

The iron thus obtained has high quantities of coke and is known as pig-iron. Different techniques can be used to refine this iron and this gives iron of different grades such as cast iron and wrought iron.

Metal art in Chhattisgarh

Iron art and craft hold a special place in traditional art-work of Chhattisgarh. In ancient ages, iron was obtained by breaking down iron containing rocks, mixing them with coal and melting the mixture. Even today in some parts of Chhattisgarh, iron is extracted from special types of rocks and used to prepare figurines. But these days, mostly commercial iron is purchased, cut and heated to make decorative items such as knives, tongs, axes, oil-lamp holders, animal-statues, flower-vase etc. Iron art in Bastar focuses on making traditional idols of gods and goddesses for worship. Windows, doors, swings are also made in traditional iron-art.

In Dhokra metal casting art, first a wax figure is created which is then coated with clay and baked in an oven and molten metal is poured inside. The metal takes the place and shape of the wax figure. Decorative figures of bulls, gods-goddesses, horses, elephants etc. are created using this technique. Dhokra art is practiced in Raigarh, Kondagaon, Bastar etc. Door knobs and handles, animal horns, crowns etc. are also made in this art-form.

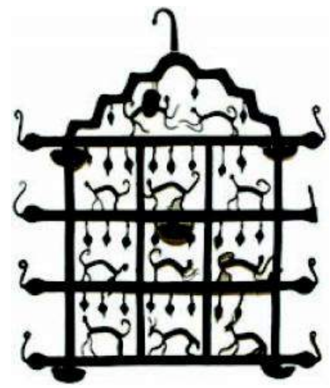


Figure - Metal art

Questions

1. Which reactions are helpful in maintaining high temperatures within the blast furnace?
2. Which compound is used as flux in the blast furnace during extraction or iron metal?

9.6 Corrosion

We know that active metals - for example, aluminium, zinc - react rapidly with oxygen and moisture and are converted into their respective compounds. This process is known as corrosion. The corrosion of iron by oxygen and water is called rusting. Next, we will discuss the process of corrosion and how to prevent it.

Activity-5

(**Note-** This activity should be carried out in summer or winter but not during the rainy season when due to high humidity it is difficult to get results).

- Take three test tubes and label them 'A', 'B' and 'C' respectively.
- Put 3-4 awl-pins in each test tube. Add enough water in test tube 'A' so that the pins are submerged.
- Moisten a piece of cotton and put it in lowest part of test tube 'B'.
- Leave awl-pins in test tube 'C' untouched.

- Now make the test tubes air-tight by placing balloons on their mouths. Put the test tubes in a test tube stand and place them in a hot place (or sunlight) for 3-4 hours (figure-9). Observe after this time. Remember that rates of reactions are slower in cold weather.
- Did rust form on the awl-pins in all three test tubes?
- Was the amount of rust formed same?
- Did you notice any change in the balloons covering the test tube mouths?

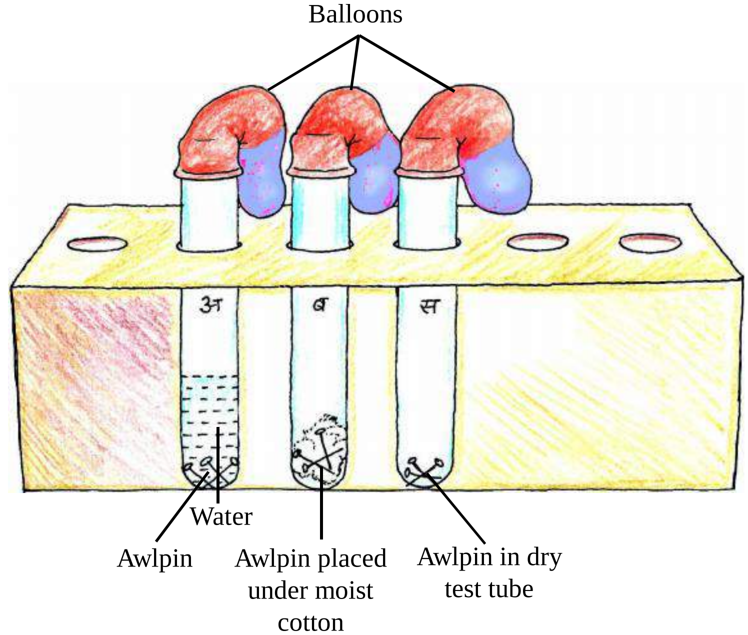


Figure-9: Effect of air and moisture on rusting process

- What could be the cause of this change? Could it be the formation or use of any gas?
- Which test tube among the three ('A', 'B' or 'C') test tubes showed more changes?

Presence of oxygen and moisture is necessary for rusting of iron but other factors such as presence of salts and acids also affect rusting. Their presence increases rate of rusting and this is why iron rusts faster in areas close to seas and oceans.

Nature of metal also affects the rate of corrosion (formation of oxide layer on metal surface). Most corrosion prevention metals try to prevent air and moisture from coming in contact with the metal. The process of applying a protective layer, usually paint or grease, on iron surface to prevent contact with atmosphere is known as barrier protection. Electroplating is used to coat the surface of iron with metals such as tin, nickel and chromium.

Activity-6

- Make a list of iron objects in your home and school and note which of them are coated with paint and which are coated with grease.
- List the basis of selection for any one of the two barriers.

Corrosion of metal can also be prevented by using a more reactive metal. This process is known as sacrificial protection. You might have heard of galvanized iron where the iron object is coated with a thin layer of zinc metal. Zinc being more reactive than iron, reacts more readily with oxygen and a thick layer of ZnO is formed which prevents the rusting of iron.

- Some metals are protected by applying a corrosion-resistant solution. In this process basic solutions of chromate or phosphate are used as corrosion resistant solutions.
- Sometimes, iron is mixed with other metals to form alloys and these do not rust at all or rust rarely.

9.6.2 Chemical principles of rusting of iron

The process of corrosion is actually an electrochemical process. When metals like iron are placed in air and humid conditions then negatively and positively charged regions develop on its surface because of which it starts behaving like an electrochemical cell.

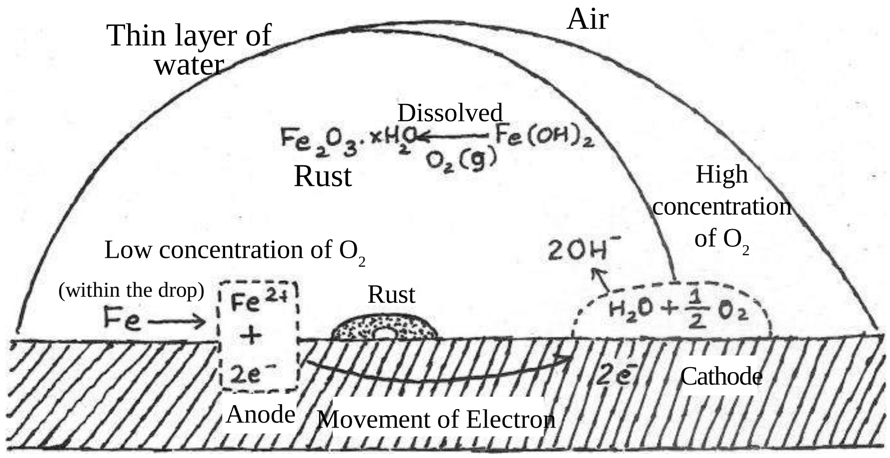


Figure-10: Chemical reactions in rusting of iron

Anode -Fe moves into the solution as Fe^{2+}

$$Fe \longrightarrow Fe^{2+} + 2e^-$$

Cathode - In the presence of oxygen, these electrons are taken up water molecules to form OH- ions.

$$2H_2O + O_2 + 4e^- \longrightarrow 4OH^-$$

The Fe^{2+} ions formed on the anode react with the OH^- to form $Fe(OH)_2(s)$. This iron hydroxide reacts with the oxygen in the atmosphere in the presence of moisture to give hydrated iron oxide.

$$2Fe(OH)_2 + ½\ O_2(g) + H_2O(l) \longrightarrow Fe_2O_3.xH_2O(s)$$

This hydrated iron oxide is known as rust.

9.7 Alloys

Alloying is a popular method of improving the properties of a metal. A homogeneous mixture in which at least one of the primary components is a metal is called an alloy. Alloys are examples of solid solutions. Human beings have been making and using alloys since prehistoric times. Alloying is done to increase hardness, improve quality or decrease melting point. Alloys can be easily cast or moulded into different shapes and find uses in many areas.

An alloy is prepared by first melting one of the metals, and then,dissolving the other metals or non-metals in it in definite proportions. The mixture is then cooledto room temperature to get alloy. While making alloys, metals (or other elements) are chosen carefully so that we can get the desired properties in the resulting alloy.

Iron isthe most widely used metal but we can't use it in its pure form because pure iron is very relatively soft. But, if a small amount of carbon is mixed in it, it becomes hard. Stainless steel is an alloy of iron where nickel and chromium are also added along with carbon. Chromium prevents iron from rusting thus increasing its usefulness.

Table-6 : Some useful alloys

S. No.	Alloy	Constituents and their percentages	Uses
1.	Brass	Cu - 60-80%, Zn - 40-20%	Utensils and household objects
2.	Bronze	Cu - 75- 90%, Sn - 25-10%	Coins, utensils, statues
3.	German Silver	Cu - 50%, Zn- 25%, Ni - 25%	Coins, utensils, and ornaments
4.	Magnalium	Mg - 5% , Al - 95%	Structural framework of aircrafts
5.	Bell metal	Cu - 80% , Sn - 20%	For making bells
6.	Gun metal	Cu - 87% , Zn - 3%, Sn -10%	For making material used in Engineering
7.	Solder	Sn - 50%-75%, Pb - 50-25%	For joining together metal wires
8.	Duralumin	Al-95%, Cu-4%, Mg-0.5% Mn-0.5%	Manufacture of aircrafts, helicopters, jet planes etc
9.	Stainless steel	Cr-11.5%, Ni- 2 %, C- trace amount, remaining -Fe	Manufacturing knives, cooking utensils etc.
10.	Alnico	Al-12 %, Co-5 %, Ni-20%, Fe	Making permanent magnets

Activity-7

- Make a list of all objects made of metal that are used in your schools or at home.
- Note which of the objects is made of pure metals and which is made of alloys. Think: what could be the reason for using pure metal or alloy while making a particular object.

Chhattisgarh is a primary site for iron ore and also has many steel production plants. Chhattisgarh has a long history of working with iron and different areas follow different traditions of iron craftsmanship. Our ancestors not only discovered techniques of iron extraction but also prepared many different alloys by mixing iron with other metals.

Questions

1. How will the rate of corrosion be affected in water that has a high concentration of salts?
2. Why do we make alloys?
3. What is galvanization?

Keywords

Mineral, ores, metallurgy, extraction, roasting, calcination, gravity separation method, froth floatation method, magnetic separation method, liquefaction, smelting, flux, blast furnace, refining, corrosion, barrier protection, sacrificial protection, alloys

What we have learnt

- Metals have metallic luster, ductility, malleability, sonority and they are good conductors of heat and electricity.
- When metals are arranged in descending order of their reactivity, we get the reactivity series.
- More reactive metals can displace less reactive metals from the latter's salt solutions.
- Metals react with oxygen to form metal oxides which can be basic or amphoteric in nature.
- Metals react with water to release hydrogen gas.
- Metals react with acids to give the corresponding salt and hydrogen gas.
- Metals are present in nature in both free and combined forms.
- The process of separating metals from their ores is known as metallurgy. Metallurgy has three main steps - (1) concentration of ore (2) extraction of metal and (3) purification of metal.
- The method of concentration depends on the nature of the metal ore.
- Concentration of ore is done mainly using three methods - gravity separation method, froth floatation method and magnetic separation method.
- The heating of concentrated sulphide ore a little below its melting point in the presence of air or oxygen is known as roasting.The heating of concentrated ore a little below its melting point in the absence of oxygen is known as calcination.
- Reduction of metal from its metal oxide is done mainly using coke or charcoal.
- Flux is the substance added to remove molten impurities from an ore. Flux reacts with the impurities to form slag.
- Reactive metals react with oxygen and moisture and convert into their compounds (usually oxides); this process is known as corrosion.
- Metals are mixed with other metals and non-metals to make alloys.

Exercises

1. Choose the correct option–

   (i) Which among the following metals is most reactive–

   (a) Mg (b) Al

   (c) Na (d) Zn

   (ii) The formula of bauxite ore is–

   (a) $MgCO_3$ (b) $Al_2O_3.2H_2O$

   (c) Fe_2O_3 (d) SnO_2

   (iii) Which method among the following is used in concentration of iron pyrite–

   (a) Magnetic separation (b) Gravity separation

   (c) Froth floatation (d) Electrolysis

   (iv) Calcium silicate is–

   (a) Alloy (b) Gangue (c) Slag (d) Flux

   (v) The constituent metals in stainless steel are–

   (a) Copper, zinc and tin (b) Iron, chromium and nickel

   (c) Copper, iron and zinc (d) Iron, tin and aluminium

2. Fill in the blanks

   (i) The process of removal of a less active metal from its salt solution by a more reactive metal is known as …………….. (displacement/precipitation) reaction.

   (ii) The primary iron ore found in Chhattisgarh is ……………….. (hematite/magnetite).

   (iii) Alloys are a …………………….(homogeneous/heterogeneous) mixture of two or more metal or metals and non-metals.

   (iv) The process of heating an ore at a temperature a little below its melting point in the absence of oxygen is called …………………… (roasting/ calcination).

3. Explain the following

   (i) Ore (ii) mineral (iii) slag (iv) flux

4. Write the balance chemical equations for the given reactions:

   (i) Reaction of aluminium metal with steam.

   (ii) Reaction of zinc oxide with sodium hydroxide.

   (iii) Reaction when calcium carbonate is heated.

   (iv) Reaction of oxygen with sodium.

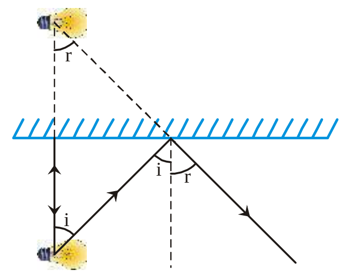
5. Explain the process of reduction of metal from a metal oxide.

6. Discuss the different methods used to prevent corrosion.

7. In the purification of a metal (M), what all will act as anode, cathode and electrolyte. Explain with an example.
8. Explain the following techniques used in concentration of ore:
   (i) Gravity separation method
   (ii) Froth flotation method
   (iii) Magnetic separation method
9. Discuss the extraction of iron from hematite as per the following steps:
   (i) Concentration of ore
   (ii) Reduction of oxide to metal (along with chemical equation)
   (iii) Diagram of blast furnace
10. Explain the electrochemical principle behind corrosion.
11. Give reasons for:
   (i) Gold, silver and platinum are used in making jewelry
   (ii) Sodium, potassium and lithium metals are stored under kerosene
   (iii) Although aluminium is an active metal it is still used to prepare cooking utensils
   (iv) Carbonate and sulphide ores are converted into their oxides for extraction of metal

Chapter 10

Light: Reflection And Refraction From Plane Surface



In class VII you have done several experiments using a light source, mirror(s) and black paper. All those experiments were done with light rays. You would have observed that an object casts a shadow when it blocks the path of the light ray. The properties of the shadow depend on the opacity of the object. Transparent objects do not cast shadows. However, in reality, most of the object are neither truly transparent nor truly opaque. When light falls on an object, some of the light gets reflected and some of it is refracted while the remaining is absorbed by the object.

You have also observed by doing experiments, that light travels in simple straight path. Is this the reason why we cannot see an object placed in the other room?

In this chapter, we will learn about reflection and refraction of light at plane surfaces. We will represent a light ray with a simple line and study the formation of shadows and images after reflection and refraction of light. We shall use geometry to find the position, shape and nature of the image. But, before that, let's do a simple experiment about the formation of shadow.

Activity-1

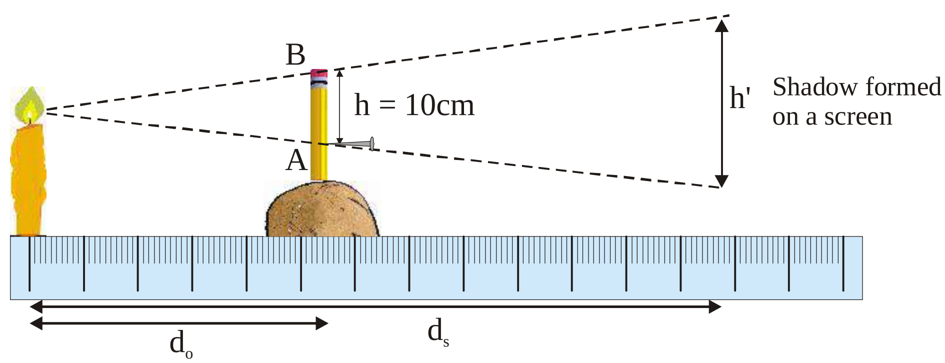


Figure-1

To measure the length of shadow of a pencil, insert the pencil perpendicular in a piece of potato. Insert a pin at a height 10 cm below the head of pencil as shown in the diagram. The pin should be attached perpendicular using glue or wax. Now, observe the change in the shadow varying the distance of light source and the screen from the pencil. What do you see?

- If we decrease the distance between the light source and the pencil or we increase the distance between the screen and pencil, then we will observe that the size of the shadow increases and vice versa.
- On keeping the pencil and screen fixed fixed and bringing the source near it, we will find that the shadow length increases.
- If we keep the pencil and source fixed, and move the screen away then the size of the shadow increases and it decreases when we move the screen close to the pencil.

The ratio between the size of the shadow and the distance between the shadow and source is equal to ratio of the size of the object and distance between the object and source.

i.e;

$$\frac{\text{Length of the object}}{\text{Distance between object and source}} = \frac{\text{Length of the shadow}}{\text{Distance between image and source}}$$

$$\frac{h}{d_o} = \frac{h'}{d_s} \Rightarrow h' = \frac{h\,d_s}{d_o}$$

Use the above activity to fill the following table - Size of object (h) = 10 cm

Formula for calculating size of shadow: $h' = \frac{h\,d_s}{d_o} = 10 \times \frac{d_s}{d_o} = 10 * (d_s/d_o)$

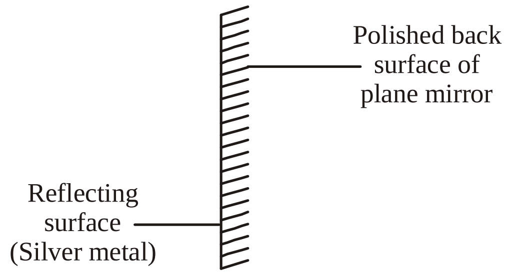
S. No.	**Distance between object and source(d_0)**	**Distance between object and screen(d_s)**	**Size of shadow of object (h')**	**Size of shadow using formula**
1.	20 cm.	10 cm.		
2.	20 cm.	20 cm.		
3.	30 cm.	10 cm.		
4.	30 cm.	20 cm.		
5.	40 cm.	10 cm.		
6.	40 cm.	20 cm.		

Did you verify the formula?

Now you can predict the size of shadow in any case.

10.1 Image formation on plane mirror by reflection

Any plain and shiny surface works as a plane mirror. A Plain mirror consists of a thin layer of silver sandwiched between a transparent glass on one side and a protective paint coating on the other side. Silver is a very good reflector of light. So, it acts as a reflecting surface in the mirror.



According to laws of reflection-

1. Angle of incidence is always equal to the angle of reflection.
2. Incident ray, normal and the reflected ray lie in the same plane.

Let's understand these laws through some activities.

10.1.1 Study of laws of reflection

1. Angle of incidence is always equal to the angle of reflection.

To understand this law, we will do practical number 1 given on at the end of the book.

2. Incident ray, normal and the reflected ray lie in the same plane.

The point, at which incident ray falls on the mirror is called the Incidence Point, where a line can be drawn perpendicular to the surface of the mirror. This line is known as a normal line. Reflected ray lies in the same plane as the incident ray and normal (in this case the plane of paper). This is the second law of reflection. In the figure given below, mirror is fixed vertically. Incident ray is shown in the red colour and the normal plane is shown in the yellow colour. According to the second law of reflection reflected ray (yellow colour) would also lie in the same plane.

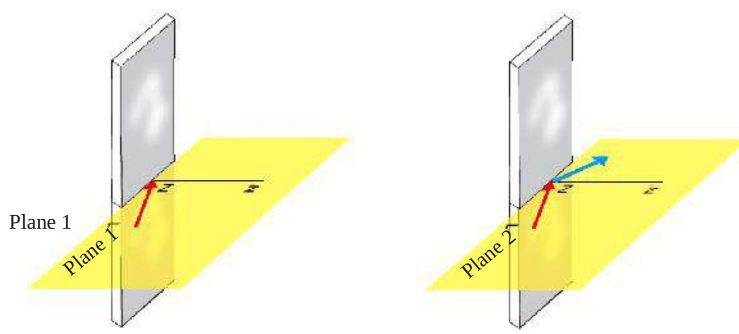


Figure-3 (a)

If we rotate the mirror as shown below then what would be its effect on the normal line?

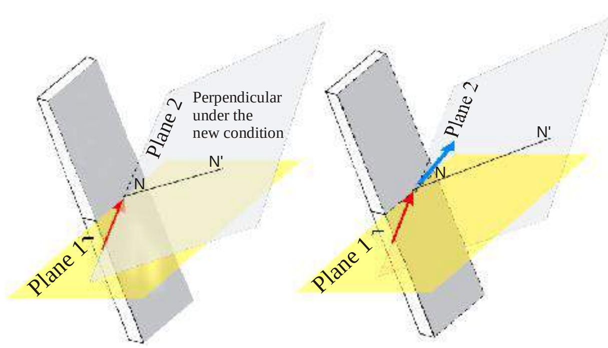


Figure-3 (b)

In order to understand the direction of the normal glue a matchstick to a plane mirror. Now rotate the mirror and observe the change in the direction of the matchstick.

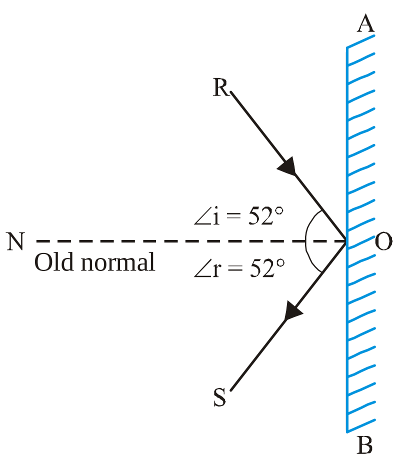
10.1.2 Effect of rotation of plane mirror on reflected rays

If we rotate the plane mirror by 35° then what would be the direction of normal on mirror? By how much angle reflected ray will rotate?

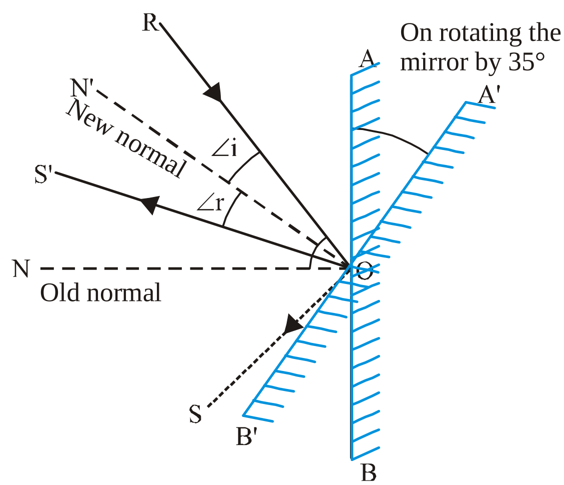
Question 1: A light ray falls on a plane mirror making an angle of 52° with normal AB. Now, keeping incident ray fixed, rotate the plane mirror byθ =35° at the point of incidence. The normal also gets rotated by an angle θ from its original direction at the point of incidence.

New position of mirror and normal will be A'B' and ON' respectively. As we can see, the angle of incidence decreases with respect to the initial condition.

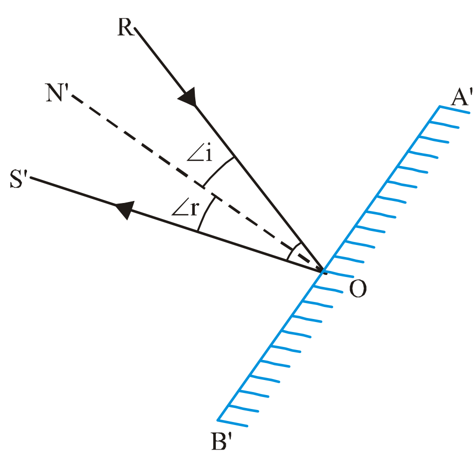
Now can you tell, what will be the angle of reflection?



(a) Old condition



(b) New condition



(c) On moving by ¯ = 35°

ON = Old normal

ON' = New normal

RO = incident ray

OS = Old reflected ray

OS' = New reflected ray

Figure-4

Solution: Angle of incidence from new normal = ∠i – 35° = 52° – 35° = 17°

According to law of reflection, ∠i = ∠r

So, angle of reflection from new normal = 17°

Difference between (∠SON) and (∠S'ON') = 52 + 35 – 17 = 70°

i.e; our new angle of reflection = 70° = 2 × 35°

Therefore, when the plane mirror is rotated by an angle θ, the reflected ray gets rotated by an angle of 2θ°.

Activity-2

S.No.	Angle of incidence	Rotating the mirror by ¯°	Reflected angle in new condition

10.2 Formation of image of point object by plane mirror

Consider a point object O placed infront of a plane mirror. Light rays from the object are being reflected at the mirror. When we look through a mirror it appears as if the reflected rays are coming from the point I. Therefore, point I is the reflection of point O. Such images are called virtual image.

Virtual image can be drawn by producing the reflected rays in backward direction till these rays meet at a point.

The reflected rays reaching our eyes appear to emerge from a point behind the mirror. The image I is formed at the same distance as the object 'O' from the mirror. We will prove this using geometry.

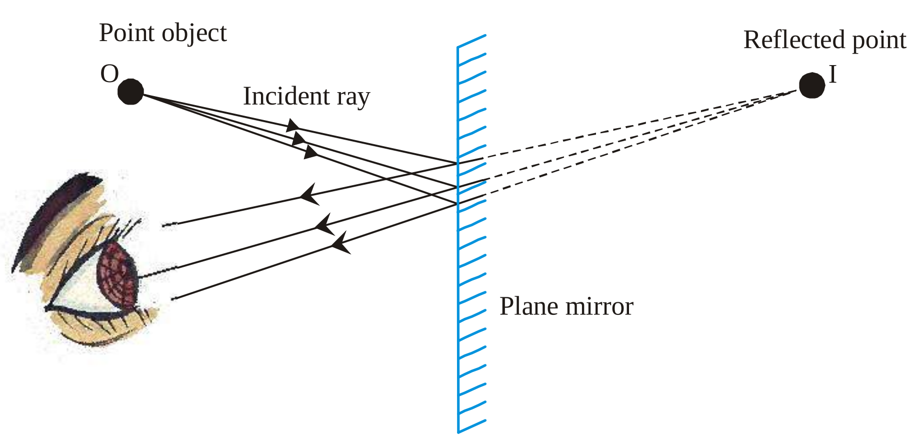


Figure-5: Point formed by plance mirror is virtual image of the objcts

10.2.1 Distance of image formed by plane mirror

If you stand in front of a plane mirror, then you will observe that your image is formed at same distance behind the mirror as you are from the mirror. To see this, place a meter scale between you and the mirror. At what distance from the meter scale is your image formed? When you move towards the mirror where does your image move? What happens when you move away from the mirror?

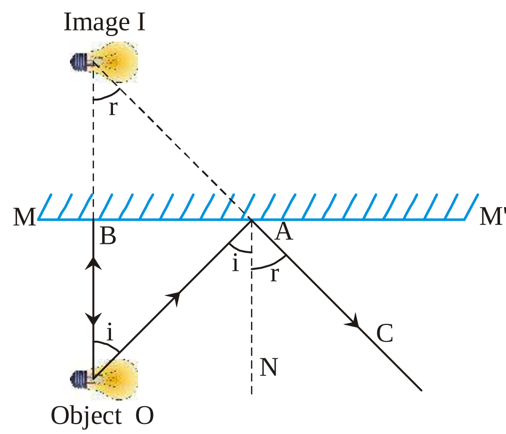


Figure-6

Consider an object, at a distance OB from the plane mirror MM'. AN is normal to the mirror.According to the law of reflection, light ray OA falls on the mirror and gets reflected in the direction AC. Another ray OB, falls normally on the mirror and after reflection it comes back in the same direction. If we produce the rays AC & OB backward behind the mirror, then they will meet at a point I. Therefore, the virtual image of O is formed at I.

According to the figure,

If angle of incidence is $\angle OAN = (\angle i)$

then $(\angle BOA) = (\angle i)$ (alternate interior angle) ....(1)

and if angle of reflection is $(NAC) = (\angle r)$

then $(\angle BIA) = (\angle r)$ (corresponding angles) ....(2)

according to law of reflection $(\angle i) = (\angle r)$ ......(3)

therefore from equation (1),(2) and (3)

in ΔBOA and ΔBIA

$(\angle BOA) = (\angle BIA)$ $[(\angle i) = (\angle r)]$

$(\angle OBA) = (\angle IBA)$ (90° formed by normal)

AB = AB (common side)

$(\angle OAB) = (\angle IAB)$ (since sum of all angles in a triangle is 180°)

so $(\angle OAB) \equiv (\angle IAB)$ and by theorem, corresponding parts of congruent triangles are congruent (CPCTC)

Therefore, OB = BI

Therefore, the distance of image from the plane mirror is same as the distance of object from the mirror.

Question 2: If an object is placed at a distance of 30 cm from a plane mirror. Then find the total distance between object and image formed by the plane mirror.

Solution: Distance of object from plane mirror = 30cm

Object after reflection from plane mirror forms image at a distance same as the distance between object and mirror from the mirror

So, the distance of image from the mirror = the distance of object from the mirror.

Distance between the object and the image: = 30 cm + 30 cm = 60 cm

Therefore, the total distance between the object and the image is 60 cm.

10.3 Image of Extended object at plane Mirror

Consider an object OO' placed in front of a mirror. According to the laws of reflection, incident and reflected rays would be as shown in the figure.

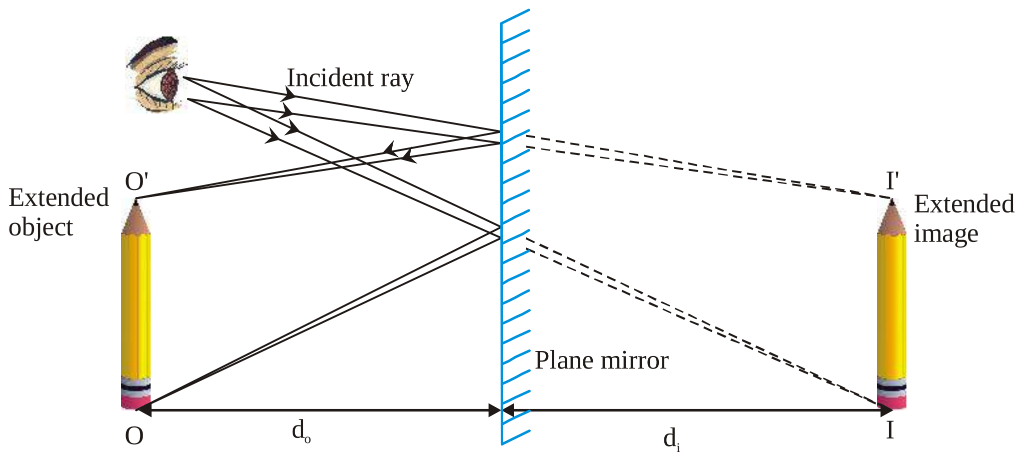


Figure-7: Virtual image I I' of object O O' formed by plane mirror

Light coming from O and O' gets reflected from the mirror and appears as if they are coming from I and I'. That means I is the image of O and I' is the image of O'. All the points between the O and O' will also form their image between I and I'.

When you look yourself in the mirror, do you see any difference in the size of the image and yourself? Is the height of the image same as your height?

Hold a pencil in your hand and look at the image in the mirror. Now move the pencil away from the mirror towards your eye. Now, can you see any difference in the size of the image?

In order to understand this let's consider an example.

An observer is standing at a point O and is looking at two trees of same height.

The Tree closer to the observer will look bigger than the one away from him. This is because the light from far away tree will make a smaller angle than the one closer to the observer. Our eyes determine the size of the object based on the angle made by the light from the object.

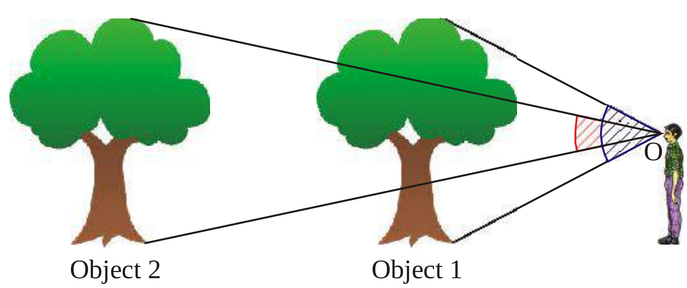


Figure-8 (a): The view angle in cross on coming closer to the object

Therefore, when we bring the pencil closer to us, its image is formed further behind the mirror. Because of this, distance between the image and our eye increases, which leads to decrease in the angle made by the image with our eye. This result is that the object looks smaller.

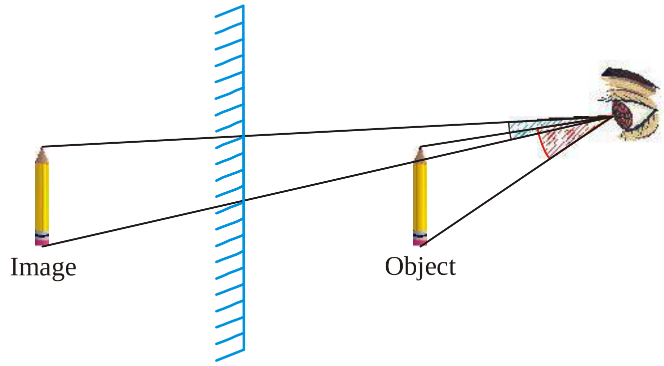


Figure-8 (b)

10.3.1 What is the Minimum Size of Mirror required to view a full Image?

In the given figure, we can see that PQ part of the mirror MM' is sufficient to show our full image if it is kept at a height of QM'.

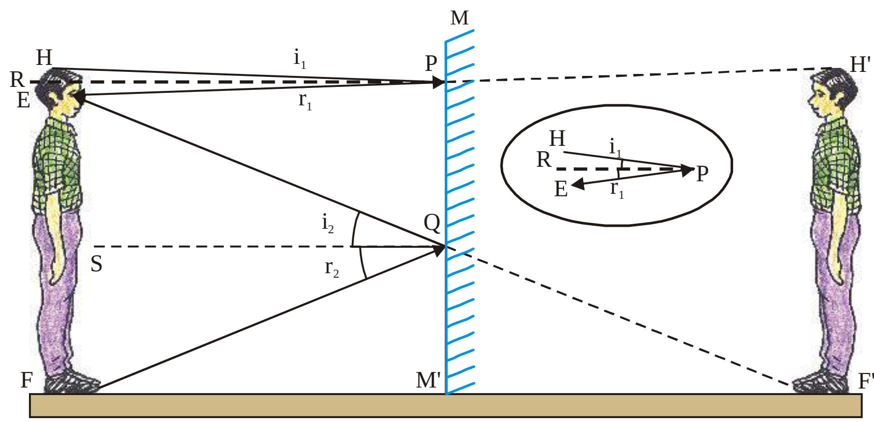


Figure-9

Observe ΔHPE and ΔEQF.

Light ray coming from our head H gets reflected at P and enters our eye E. We see the image of our head at H' behind the mirror. In the same manner, light coming from our leg F gets reflected at Q returns to our eye E and we see the image at F'. So, we can see, that in order to form our complete image, only PQ part of the mirror is used.

In (ΔHPE) and (ΔEQF) draw normal PR and QS on HF :

Since, $(\Delta\, i_1) = (\Delta\, r_1)$

And $(\Delta\, i_2) = (\Delta\, r_2)$ (according to laws of reflection)

Hence, $HR = RE = \dfrac{HE}{2}$ …(1)

And $SF = SE = \dfrac{EF}{2}$ …(2)

Now PQ = RS,

PQ = RE + ES

$$PQ = \frac{HE}{2} + \frac{EF}{2}$$

$$PQ = \frac{1}{2} [HE + EF]$$

$$= \frac{1}{2} [HF]$$

So, the useful part of the mirror is half the height of person who is standing infront of the mirror.

And since QM' = SF

$$QM' = \frac{EF}{2}$$

Therefore, the mirror needs to be placed at the level, half the level of eye.

Discussion:

Discuss the properties of image formed by a plane mirror.

Question 3: A person is 160 cm tall. What would be the length of mirror if he/she wants to see his/her full image.

Solution: Height of person = 160cm

As we have discussed earlier if a person wants to see his /her full image then the length of mirror will be half of the height of a person.

So, length of mirror $= \frac{1}{2}$ height of a person

$$= \frac{1}{2} \times 160$$

= 80 cm

Therefore, a person whose height is 160 cm needs a mirror of 80 cm to see his/her full image.

10.4 Multiple reflections

We know that a single plane mirror can make only one image. What will happen if we combine two plane mirrors?

Place two mirrors at right angle to each other. Place a coin between these mirrors and see how many images are formed?

As shown in the figure, image of object O is formed at O_1 due to mirror 1. In the same way mirror 2 forms the image of O at O_2.

Mirror 2 gets reflected from mirror 1 and forms its image behind mirror 1. This is a virtual image of mirror 2. This virtual mirror will inturn reflect the image at O_1 to O_3. In the same manner virtual image of mirror 1, formed from mirror 2, will act as a virtual mirror and will reflect the virtual image O_2 to O_3.

Hence, virtual image of any object can act like a virtual object and can give virtual reflection. Kaleidoscope works on a similar principle.

Now arrange the mirror so that they form angles 30°, 45°, 60°, 120°, 180° etc. with each other. In each case, how many images are formed? How many are formed when mirrors are parallel to each other?

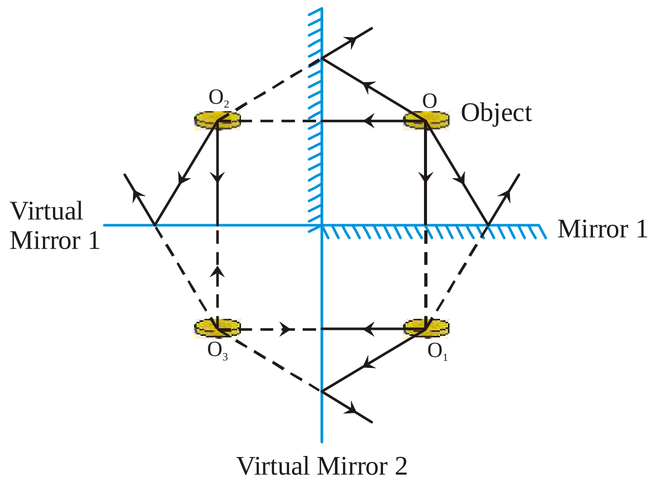


Figure-10

You will find in your observation that the number of reflections depends on the angle between the mirror.

$$\text{Number of Images} = \frac{360}{\theta} - 1$$

If the angle between both mirrors is 90° then $\frac{360}{90} - 1 = 1 = 4 - 1 = 3$ Images will be formed.

10.5 Refraction of light from plane surface.

In daily life, you must have seen many examples of refraction.

You have seen that the base of a vessel filled with water seems to be upraised. Do you know why this happens?

If, instead of water, we use another fluid like kerosene oil or turpentine oil, will the base of vessel seems to be upraised by same height as water?

Insert a pencil or spoon in a glass filled with water. Pencil appears to be bend. We will study the concept behind this by doing an activity.

Activity - 2

Put a bowl on a table. Put a coin on bottom of bowl. Ask your friend to stand near the table and watch the bowl. Now ask her to move away from the table so that the coin disappears, and stand at that point.

Now, pour water in the bowl without disturbing the coin.

Is your friend able to see the coin from that place now? How's that possible?

Due to refraction of light in water the coin seems to be upraised from its real position. Actually, a virtual image of the coin is seen by your friend.

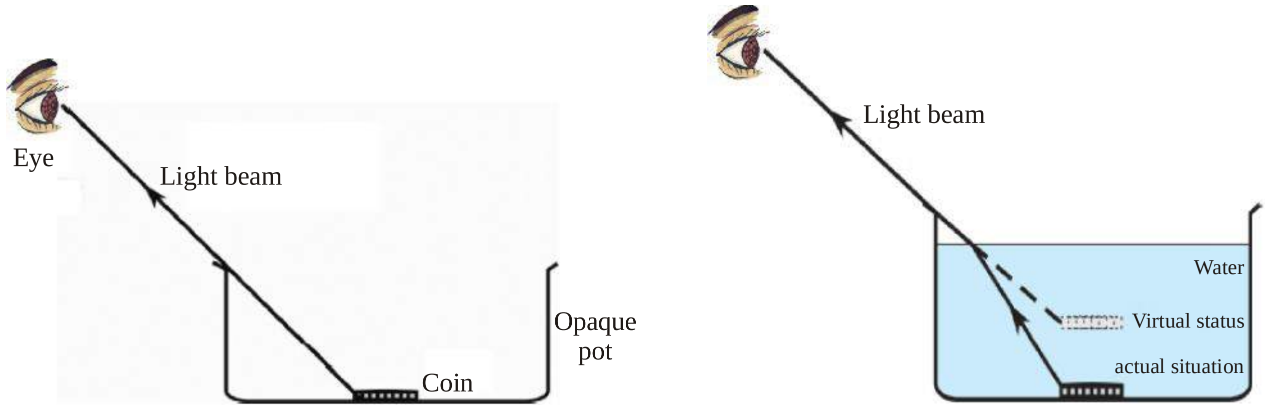


Figure-11: Coin appears upraised due to refraction of light

When light ray moves in a medium, it follows a straight line path. But what happens when light passes from one medium to another? What happens to the straight line path at the surface of two me diums? It seems that upon entering the second medium with some inclination, light changes its direction of propagation.

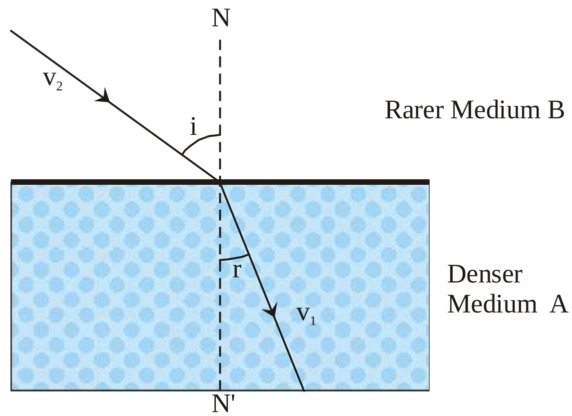


Figure-12 (a): Refracted ray bends towards normal on going from lighter to denser medium

Light ray changes its velocity at the boundary of two medium and bends from the straight line path. This is known as refraction of light. If light is incident normal to the surface, then there is no change after refraction.

When light ray passes from Optically rarer medium to Optically denser medium, then light bends towards the normal to the boundary of the media.

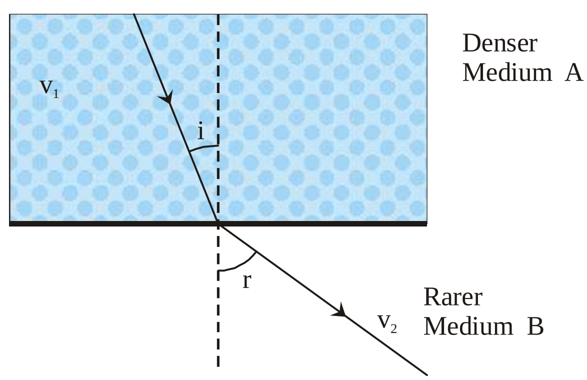


Figure-12 (b): Refracted ray bends way from the normal on going from denser to rarer medium

Can you tell which side the refracted ray will bend, towards the normal or away from the normal, going from denser to rarer medium? Tell by observing the given figure and discus the reason behind it.

The angle of incidence ($\angle$i) is defined as the angle between the incident ray and normal, the angle between normal and the refracted ray is called angle of refraction ($\angle$r).

In this section we will are using "rarer medium" and "denser medium". This has reference to optical density. Optical is different from mass density. A medium of high refractive index has more optical density.

Can you tell while going from denser medium to rarer medium which angle will be greater ($\angle$i) or ($\angle$r) fig. 12(b).

Figure-12(a) Medium A is denser than medium B then speed of light in medium B (v_2) will be greater than speed of light in medium A (v_1).

10.5.1 Refractive index

We have seen that the speed of light is different in different transparent mediums. In a vacuum the speed of light is 3×10^8 m/s, which is greater than that in any other medium. In the air, the speed of light is little less than that in vacuum.

If the speed of light is 'v' in a medium and 'c' in vacuum, then, the ratio of the speed of light in vacuum to speed of light in the medium is called 'absolute refractive index' of that medium. We denote this by 'n'.

$$\text{Absolute refractive index} = \frac{\text{speed of light in vacuum}}{\text{speed of light in medium}}$$

ie. n =c/v

Question 4: If the absolute refractive index of water is $\frac{4}{3}$, then find the speed of light in water?

Solution: Refractive index of water = $\frac{4}{3}$

Speed of light in vacuum c = 3×10^8 m/sec

Speed of light in water v = ?

We know that-

$$\text{Refractive index of medium} = \frac{\text{speed of light in vacuum}}{\text{speed of light in water}}$$

$$n_w = \frac{c}{v_w}$$

$$\frac{4}{3} = \frac{3\times10^8 m/s}{v_w}$$

$$v_w = \frac{3\times3\times10^8 m/s}{4}$$

$$v_w = \frac{9\times10^8 m/s}{4}$$

$$= 2.25\times10^8 \text{ m/s}$$

so speed of light in water will be 2.25×10^8 m/sec.

Refractive index of a material gives us the idea of how fast or slow the light is moving in that material. Speed of light will be less in the material of higher refractive index.

In the following table, the refractive index and the absolute density of different materials are given. Using $n = \frac{c}{v}$ we can calculate the speed of light in different mediums. Complete the table:

Table 1: refractive index and absolute density of some materials

S. No.	Material (medium)	Refractive index	Absolute density	Speed of light
1	Diamond	2.42	3.52	1.24×10^8 m/s
2	Pliant glass	1.64	2.9–4.5	1.83×10^8 m/s
3	Crown glass	1.52	2.5–2.7	……………………..
4	Simple glass	1.50	2.5	……………………..
5	water	1.33	1.00	……………………..
6	ice	1.31	0.92	……………………..

10.5.2 Relative refractive index

The ratio of speed of light in the first medium and speed of light in the second medium is called relative refractive index. We denote this by ${}_1\mu_2$ or n_{21}.

$$n_{21} = \frac{\text{speed of light in first medium}}{\text{speed of light in second medium}} \qquad ....(1)$$

$$n_{21} = \frac{v_1}{v_2} \qquad \text{Eq. (2)}$$

Where v_1 is speed of light in the first medium and v_2 is the speed of light in the second medium.

If we divide by c in eq. (2) in denominator and numerator

$$n_{21} = \frac{v_1/c}{v_2/c}$$

$$= \frac{v_1}{c} \times \frac{c}{v_2}$$

$$= \frac{1}{n_1} \times n_2$$

$$= \frac{n_2}{n_1}$$

Thus, relative refractive index (n_{21}) = $\dfrac{\text{refractive index of second medium}}{\text{refractive index of first medium}} \; \dfrac{(n_2)}{(n_1)}$

$$n_{21} = \frac{n_2}{n_1} \qquad \text{Eq. (3)}$$

Think

Does refractive index depend on the angle of incidence?

Question 5: If the refractive index of water is 1.33 and refractive index of glass is 1.5 then find ($_wn_g$) refractive index of glass with respect to water?

$$= \frac{n_g}{n_w} = \frac{1.5}{1.33} = 1.13$$

And refractive index of water with respect to glass $_gn_w = \frac{n_w}{n_g} = \frac{1.33}{1.5} = 0.89$ (approximately)

Remark: We can see above that;

$$\frac{n_g}{n_w} \times \frac{n_w}{n_g} = 1$$

$_gn_w \times {}_wn_g = 1$ or $_1n_2 \times {}_2n_1 = 1$

therefore,

$$_1n_2 = \frac{1}{_2n_1}$$

Remember:

- Absolute refractive index of a medium is always greater than one because speed of light in vacuum is greater than speed of light in any other medium.
- Refractive index of air is 1.003 but for simplicity we take it as 1.

10.5.3 Refraction rules

Experiment: To determine relation between angle of incidence and angle of refraction.

Materials required: Drawing board, white chart sheet, drawing pins, pins, rectangular glass slab, pencil, scale, and protractor.

Procedure: Take white chart sheet and fix it on drawing board using drawing pins. Place the rectangular glass slab over the chart sheet in the middle.

Using pencil draw outline of the glass slab and label it as ABCD. Remove the glass slab and draw normal MN on AB. Draw a line such that it makes some angle with the normal MN as in figure 13. Now place 2 pins vertically on the drawn line and mark them as E and F respectively. Put the glass slab again on the drawn outline, look at the images of E and F through the opposite edge and fix the other 2 pins at point say G, H such that all four of them lie in a same line. What do you observe on removing the glass slab? Remove all 4 pins and draw small circle at the position of tip of pins.

Join the positions of tip of pin E and F and produce it to AB using pencil and scale. Let EF meet AB at point O. similarly, do it for points G and H and produce it to edge CD. Let GH meet CD at O'. Now join the points O and O'. Draw normal M'N' at point O'.

You can see that at point O and O' light ray has changed its direction and both points O and O' lie on the surface separating two transparent media.

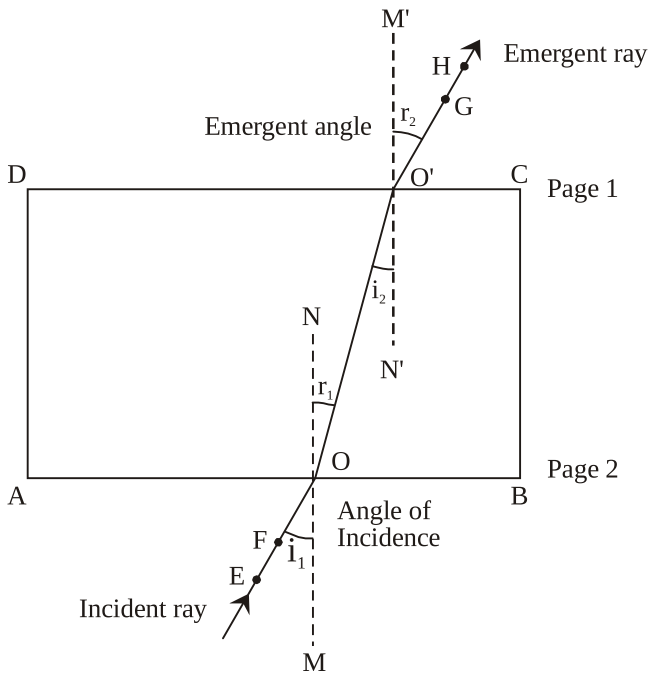


Figure-13: Refraction through the two faces of a rectangular slab

Use the data obtained to fill the given table by changing the angle of incident ray in the above experiment.

Table -2

	Surface 1		**Surface 2**	
S.No.	**Angle of incidence (i_1)**	**Angle of refraction (r_1)**	**Angle of incidence (i_2)**	**Angle of refraction (r_2)**

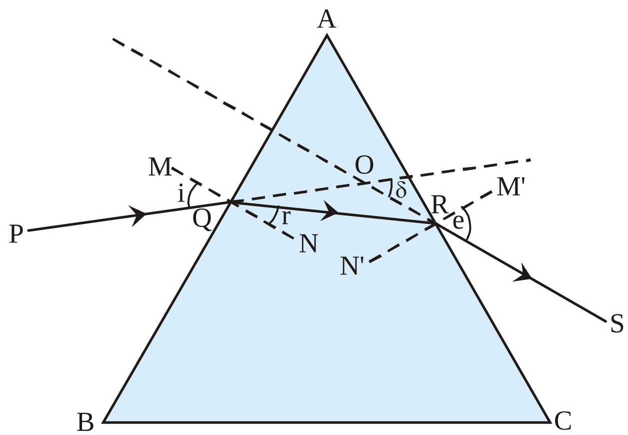
Compare the angle of incidence and angle of refraction at both refractive surfaces.

By looking at the figure you can easily see that the ray coming out of the slab GH has direction similar to the incident ray EF. The angle of incidence is same as the angle that the ray coming out of slab makes with normal O' for all cases. Which means the extent of bending of light ray at the opposite parallel face of rectangular slab is equal and opposite.

Thus shows that refraction of light follows certain laws, you can read about the laws in the practicals section of this textbook.

10.6 Refraction of light through prism

So far we have studied refraction of light through glass slab, water and through other different medium. In all those activities both refractive surfaces were at same angle. What would happen if both refractive surfaces were placed in such a manner that they are making angle with each other? Here we will study about refraction of light when light is incident on the refractive surface which is making an angle with the other refractive surface.



PQ = Incident ray
QR = Refracted ray
RS = Emergent ray
∠δ = Angle of deviation
∠i = Angle of incidence
∠r = Angle of refraction
∠e = Emergent angle

Figure-14:

According to the figure, a light ray PQ is incident on surface AB of a prism and I is the angle of incidence. After refraction from surface AB, the light travels in the QR direction. This ray act as incident ray for surface AC, which after refraction from AC surface comes out of prism and travels in RS direction. If we extend our incident ray PQ in forward direction and ray RS in backward direction they will meet at some point. Call that point as O. Due to refraction of light inside the prism there is some change or deviation in the direction of light. The Angle QOR is known as the angle of deviation.

10.7 Actual and virtual depth

Previously we have done an experiment with a coin in beaker full of water where we have used the term virtual image, now can you tell how that happened?

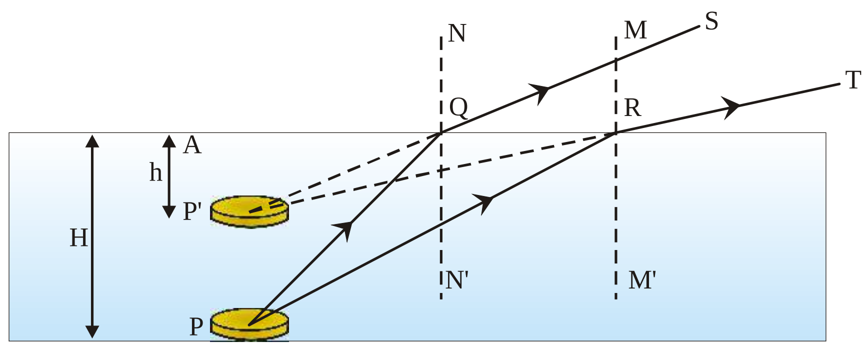


Figure-15

Suppose that a coin is at depth AP =H inside water. At point Q, light rays travel from denser medium (water) to rarer medium (air) and hence are refracted away from normal NN'. It seems that the light ray is coming from P'. Therefore, image of P forms at P'. This is the reason why the virtual depth of coin AP' = h is lower than the actual depth and why the coin seem to be upraised.

$$\text{Refractive Index} = \frac{\text{actual depth}}{\text{virtual depth}} = \frac{H}{h}$$

10.8 Principle of reversibility of Path of light

So far, with the help of several activities, we have seen that when light travels from one medium to another it gets refracted in a certain path. Have you ever thought what would be its direction if the direction of ray is changed? To understand the principle of reversibility of light, let us consider a compound plate having water as media and rectangular glass slab with one face coinciding (according to the figure). Let it be held in air medium.

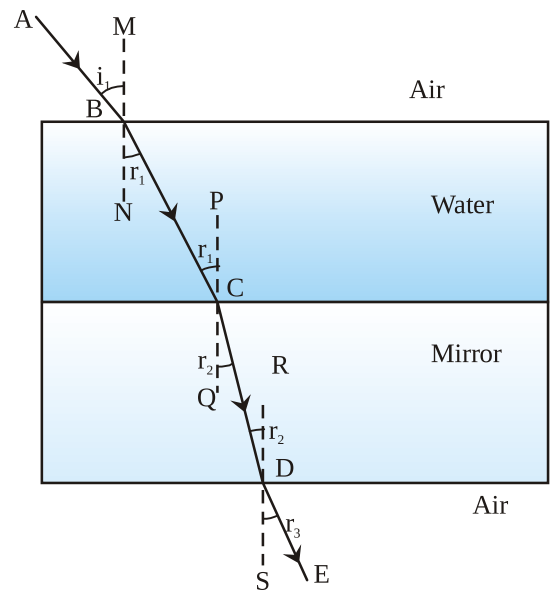


Figure-16

When light ray AB moves from air to water (rarer to denser) at point B refraction occurs, ray AB bend towards the normal MN and follows path BC. At point C when light ray BC enters glass medium from liquid medium again refraction occurs and light ray bend towards the normal PQ. At point D when ray comes out from glass medium again refraction takes place and light ray bends away from normal RS. In this way when light travels from air - liquid - glass - air ABCDE will be the path of light ray. Similarly, if we move from air - glass - liquid - air, according to the laws of refraction EDCBA will be the path along which the light ray will travel. From this, we can conclude that on traveling between different medium, if at a fixed point the direction of ray is reversed then reversibility is seen in the direction of propagation of ray.

10.9 Critical angle and Total internal reflection

Like the last activity, we will take a thick glass slab and use laser light to study refraction of light and other phenomena. When light passes through the glass slab and reaches air, then light ray refracts from dense to light medium. We will first incident the light at an angle of 0° (degree) from the normal in the glass slab. Now, let's think about the following points.

- Can you see the refracted ray?
- Is there any deviation in the path of the light while it passes from glass to air?

Do the above activity for the incident angles 5°, 10°, 15° etc. and observe the angle of refraction.

For a particular value of incident angle, emergent refracted ray will graze through the surface separating both mediums. This angle is known as critical angle of that material.

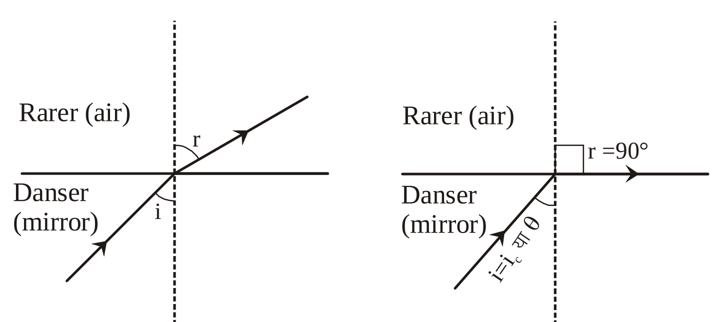


Figure-17

When light passes from dense medium like glass to rarer medium like air, it moves away from the normal. In this situation angle of refraction r is more than angle of incidence i. ($\angle r > \angle i$)

As the angle of incidence "i" is increased, the value of angle of refraction r also increases. At some stage, angle of incidence value will be such that the value of angle of refraction would be $\angle r = 90°$. In this situation, refracted ray will pass touching the surface separating both the mediums. At this situation, the measure of angle of incidence is called as "critical angle". This is represented by I_c or θ_c.

Therefore,critical angle is that value of incident angle in the denser medium for which angle of refraction is 90° in the rarer medium.

10.9.1 Total Internal Reflection

If the incident angle in the denser medium is more than the critical angle then the angle of refraction would be more than 90 degree i.e. light will, instead of passing through the rarer medium (air), pass through the denser medium (glass).This is a situation of reflection and not refraction. Hence, when light passes from denser medium to rarer medium and the incident angle is more than the critical angle then light gets internally reflected in the denser medium. This is known as Total Internal Reflection.

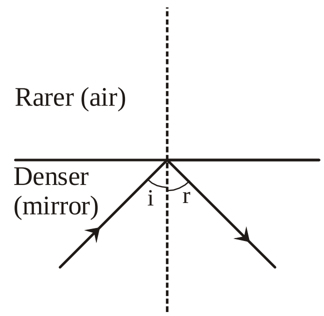


Figure-18

Necessary conditions for total internal reflection:-

1. Light should pass from denser medium to rarer medium.
2. Incident angle should be more than critical angle.

10.9.2 Examples of total internal reflection.

1. An empty test tube (air medium) inclined at some angle is immersed in beaker filled with water, when it is observed from top, the upper part of test tube looks shiny as it has been painted. The reason behind this is that when light ray travelling through water incident on test tube, the rays travels from rarer to denser medium. This is followed by light travelling from the glass wall of test tube towards glass-air boundary, in which some of the rays have angle of incidence greater than critical angle. Therefore, these rays reach eyes after total reflection and hence the upper part of test tube looks as shiny as silver. The shininess disappears as the test tube is filled with water.

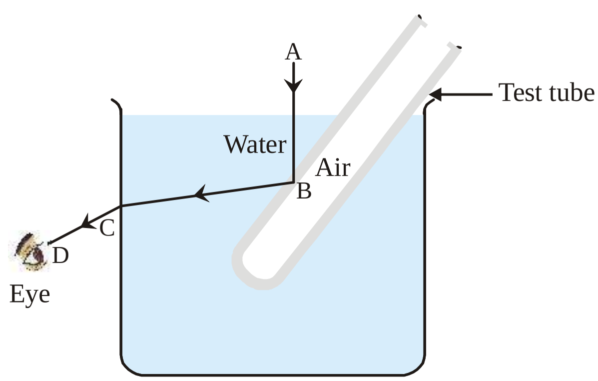


Figure-19

2. Mirage- During hot days in the deserts, people see an inverted reflection of a distant pine tree which make them believe that there is pool of water around the tree. However, when they reach there they find that there is no water. This illusion is known as mirage.

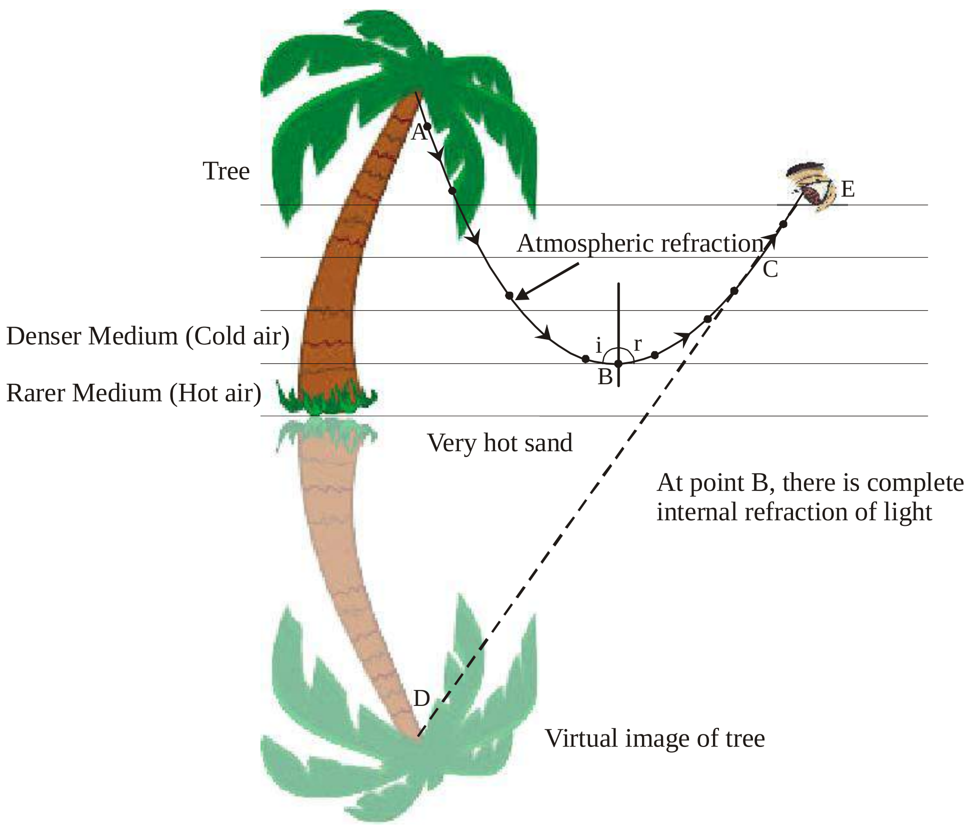


Figure-20

The air near the land surface is hotter and optically rarer while that on a more height is cooler and optically denser.

Light from top parts of a tree travels down towards the land but due to continually changing optical density, it gets refracted. When the angle of incidence becomes more than the critical angle, the light coming from top of the tree gets reflected and starts travelling in the direction away from the land (as shown in the figure). We see this internally reflected light and to us it seems like the light is coming from the direction of land. Hence, it appears as if there is a reflection of the tree on the surface because of a water body, while really there is no water body.

Figure-21

Similarly, Concrete Roads provide an example of Mirage. Discuss with your friends how this can happen?

Key Words:

Reflection, Normal, Incident ray, Reflected ray, Refracted ray, Emergent ray, Angle of Incidence, Angle of Reflection, Angle of Refraction, angle of Deviation, Emergent angle, Real image, Virtual image, Refraction, Refractive index, Prism, Reversibility principle, Critical angle, Total internal reflection, Real depth, Apparent depth.

What we have learnt

- Light ray travels in a straight path.
- When light ray is incident on an opaque object, then the image formation takes place on screen behind the object.
- Angle of incidence is always equal to the angle of reflection.
- Incident ray, reflected ray and normal all lie on same plane.
- Plane mirror always forms virtual, erected image of same size as object.
- By rotating the plane mirror by an angle θ, the reflected ray gets rotated by an angle 2θ.
- To see the full image of person, the height of plane mirror should be at least half the height of person.
- If two plane mirrors are at θ angle, then $\frac{360}{\theta} - 1$ images will be formed by them.
- When light travels from one medium to another medium then it gets deviated from its path, it is called Refraction of light
- Speed of light in vacuum is 3×10^8 m/s .
- When light travels from denser to rarer medium then it bends away from normal.
- When light travels from rarer to denser medium then it bends towards normal.
- The refractive index of a transparent medium is the ratio of speed of light in vacuum to the speed of light in the medium. It is called Absolute refractive index.
- From principle of reversibility ${}_2\mu_1 = \frac{1}{{}_1\mu_2}$.
- First law of refraction says the incident ray, refracted ray and normal to the point of incidence on the plane dividing the two mediums lie in the same plane.
- According to second law of refraction, ${}_1\mu_2 = \frac{\sin i}{\sin r}$, this is known as Snell's law.
- In prism, the angle between the incident ray and emergent ray is called angle of deviation.

Exercise

1. Choose the correct answer–

   (i) If we rotate a plane mirror by 2θ, then the reflected ray will rotate by–

   (a) 2θ (b) 3θ (c) 4θ (d) θ

   (ii) What should be the minimum length of the plane mirror if a person wants to see his full image?

   (a) One fourth of the person's height (b) One third of the person's height

   (c) equal to the person's height (d) One half of the person's height

   (iii) How many images will be formed of an object kept between two mirrors making 45° with eachother?

   (a) 5 (b) 6 (c) 7 (d) 8

   (iv) If an object is placed at a distance of 3 cm from the mirror, then the distance between the image and the object will be–

   (a) 4 cm (b) 6 cm (c) 3 cm (d) 12 cm

2. Fill in the blanks

   (i) Image formed by a plane mirror is erect, virtual and..

   (ii) Second law of refraction is also known as..

   (iii) Light ray falls normally on plane mirror; the angle of reflection will be...................

   (iv) For................................light should travel from denser medium to rarer medium.

3. What are the laws of reflection?

4. What are the laws of refraction?

5. The refractive indices of medium A and B are n_A and n_B respectively. Total internal reflection is possible on going form which medium to which medium given that $n_A > n_B$.

6. What is total internal refraction and what are the necessary conditions for it to take place?

7. Give two examples where refraction is seen in daily life.

8. What do you understand by critical angle?

9. Light travels from air to glass slab having refractive index of 1.50. What will be the speed of light in glass? Speed of light in vacuum is 3×10^8 m/s. (ans- 2×10^8 m/s)

10. Refractive index of diamond is 2.42. Explain this statement.

11. A light ray travelling in the air enters the Ice. Will the light ray move away from the normal or towards the normal? Why?

12. If we increase the distance between the mirror the object then what would be the effect on the distance between the image and the object?

13. What is the difference between virtual image and real image?

14. What is the difference between absolute refractive index of a medium and the relative refractive index of two mediums? What is the relation between them?

15. What is the principal of reversibility?

16. State the reasons for following: -

    (i) The position of fish in a pond is not same as it is observed from outside.

    (ii) A Bubble of air shines in water.

    (iii) Mirage is an illusion.

17. Prove that the length of the mirror required to view the complete image of an object is half of the height of the object.

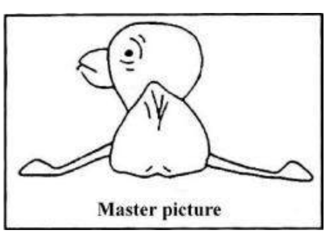
18. What do you mean by refraction of light? How is it different from reflection of light?

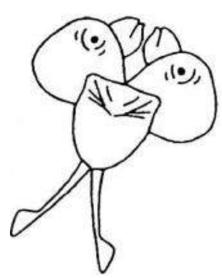
19. If the absolute refractive index of glass is 3/2 and that of water is 5/4, then find the ratio of speed of light in water and to that in glass. Ans. (1.2)

20 A fish seems to be at a depth of 75cm from the surface. What is the actual distance from the surface? (Refractive index of water is 1.33). (Ans - 100 cm)

Ask a mirror

You have been given a master picture and some more pictures. Place a plane mirror around the master picture and see the image formed. The image and master together form a new picture. Use your mirror and master picture to figure out how?





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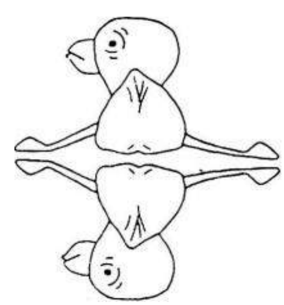

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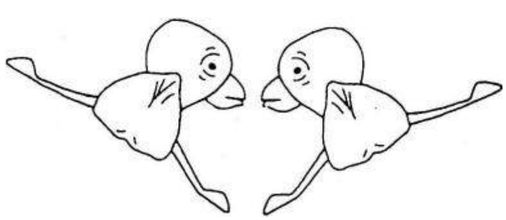

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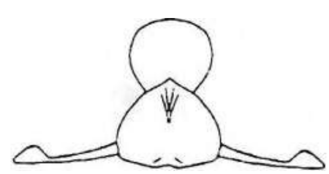

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CHAPTER 11

CHEMISTRY OF NON-METALS

In the chapters on periodic table and metals and metallurgy, we read that most of the elements are metals. If non-metals are so few in number why do we give them so much importance? To understand this, let us think about the following questions:

- Water is made of two elements. Are these elements metals or non-metals?
- Is the gas which is essential to maintain life on earth a metal or non-metal?

In this chapter, we will learn which elements are non-metals and the criteria for placing them in this category. We will also study in detail three non-metals - hydrogen, oxygen and nitrogen - which are important for sustaining life one earth.

11.1 Physical properties of non-metals

You are familiar with some non-metals like hydrogen, oxygen and nitrogen. Can you tell how you determined that these elements are non-metals, not metals?

We know that metals have certain defining characteristics, for example, under normal emperature and pressure most metals are solids. If an element is gas at normal temperature and pressure then we can easily say that it is not a metal and is a non-metal. But not all non-metals are gases. Different non-metals are found in different states, for example, bromine is the only non-metal found in the liquid state and non-metals like carbon, iodine, phosphorous, sulphur, selenium etc. are found in the solid state. In fact, the hardest element is diamond, which is one of the allotropes of carbon.

Allotropy

You may be aware that both graphite and diamond are forms of carbon. Both are solely made of carbon atoms. Think - how is it possible that two substances that look so different are actually forms of same substance, carbon?

Not just carbon but many other elements are found in more than one form in the same state. This property of elements is known as allotropy and the different forms are known as allotropes. The bonding between atoms in different allotropes is different leading to difference in some physical properties.

Since the atoms of different allotropes of an element are identical therefore the chemical reactions shown by them are same. For example, both graphite and diamond give carbon dioxide on combustion. Oxygen, phosphorous and sulphur are some other non-metals that exhibit allotropy.

It is possible to differentiate whether a solid element is metal or non-metal; this is because most non-metals are brittle. In other ways also solid metals and solid non-metals are different from each other. Non-metals do not display ductility or malleability nor do they produce a metallic sound. Further, apart from graphite which is an allotrope of carbon, all other non-metals are poor electrical conductors or insulators. Similarly, except diamond, all other non-metals are poor thermal conductors.

Questions

1. The physical properties of four different elements are shown in the given table. Can you tell:

   (a) which of the elements are metals and which are non-metals

   (b) the criteria for deciding whether element 'D' is metal or non-metal?

Element	State	Ductile	Conducts electricity
A	Solid	No	No
B	Solid	Yes	Yes
C	Gas	No	No
D	Solid	No	yes

2. Which of the following exhibit allotropy?

   C, CO_2, SO_2, S, C_4H_{10}, CH_4

11.2 Where do non-metals lie in the periodic table?

Can you tell whether an element is a metal or non-metal by looking at its position in the periodic table? We know that as we move from left to right in a periodic table, there is a decrease in metallic character, that is, as the group number increases the metallic character decreases. If we look at the elements of the first group then we find that all its elements except hydrogen are metals but we will not find a single metal in the elements of group 18. If we look at the elements in a particular group then there is an increase in the metallic character as we go down the group, for example, if we take group 15 then the first two elements (nitrogen, phosphorous) are non-metals. The fourth and fifth elements (arsenic, antimony respectively) of group 15 show some metallic character but are not completely metal. However, the last member (Bismuth) of the same group is a metal.

There are some properties that are exhibited only by metals while there are other properties that are shown only by non-metals. However, we also find some elements that show some properties of metals and others of non-metals, that is, their properties lie somewhere in the middle. In the periodic table, these elements are located between metals and non-metals. That is why we don't see a sudden change in metallic group as we move from one group to the next, the change is step-wise. This behavior is seen in elements situated along a zig-zag diagonal line in the periodic table. The elements are counted among metals but they are called metalloids or semi-metals. Metalloids include boron, silicon, germanium, arsenic, antimony, tellurium and polonium. Just like metals the metalloids are also found as solids. Boron and silicon are poor conductors of electricity but addition of impurities leads to electrical conductivity. All elements that do not belong to metals and metalloids groups are called non-metals.

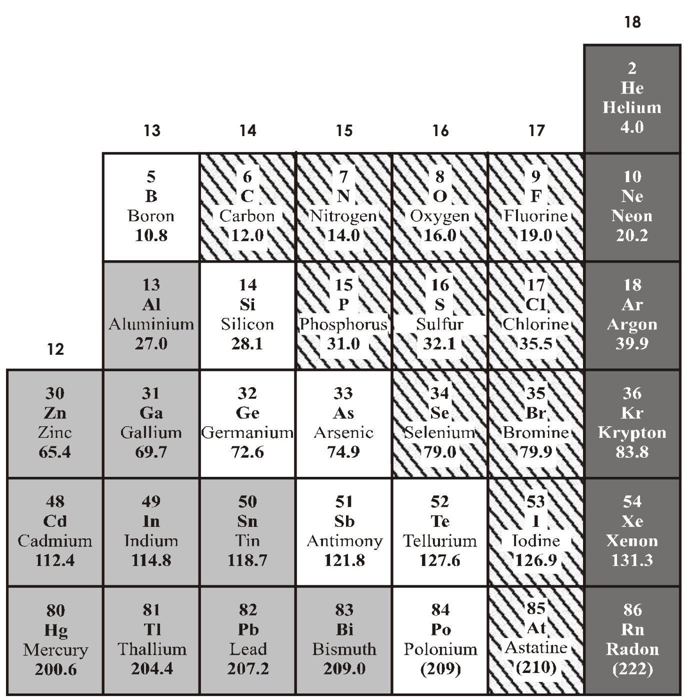


Figure-1: Non-metals in the periodic table

Non-metals include one member (carbon) of group 14, two members (nitrogen and phosphorous) of group 15 and three members (oxygen, sulphur and selenium) of group 16. Group 17 is known as the halogen group and five of its members - fluorine, chlorine, iodine, bromine and astatine - are non-metals. Since halogens require only one electron to complete their octet therefore they are very reactive. They are not found in the free-state in nature and were recognized only near the end of the 18th century. Group 18 consisting of noble gases is a big group of non-metals. It includes the colourless gases helium, neon, krypton, argon, xenon and radon. Since the outermost shells of noble gases have 8 electrons therefore they do not normally take part in chemical reactions. They are also known as inert gases due to this lack of reactivity. Since they are found in trace amounts in the atmosphere they are called rare gases as well.

Can you think of any element which is a non-metal but which has been placed on the left side in the periodic table? Before we study more about non-metals let us read a little bit about their history.

11.3 How and when were non-metals discovered?

Carbon and sulphur are two non-metals that were known even in ancient times. In fact, they were discovered so long ago that we don't know the exact dates or the names of the persons who discovered them.

In nature, carbon is found as diamond and graphite and these two forms have been mentioned in various ancient documents. However, at that time graphite and diamond were regarded as two separate substances. It was only with the development of modern chemistry that we understood that diamond, graphite etc. all are actually carbon which give carbon dioxide on burning. Lavoisier carried out combustion of carbon and diamond to prove that both are actually the element carbon. Thus, he called it carbon and gave it a place in his list of elements published in the year 1789. Similarly, sulphur was also known from ancient times and again it was Lavoisier who proved that sulphur is an element. Phosphorous was discovered in the middle-ages (1669) by Hennig Brand, a merchant from Hamburg, Germany.

Till the middle-ages very little was known about gaseous substances. Since most non-metals are found as gases in nature therefore they were discovered only after techniques to produce and collect gases had been refined. Before this, due to lack of knowledge about gaseous state, role of gases in chemical reactions and their formation as chemical products was not understood. Thus, it was long time before we could completely understand the nature of several chemical reactions, especially combustion.

In mid-eighteenth century, a device called pneumatic trough was developed by Hales. Pneumatic troughs made it possible to collect gases produced during combustion and other chemical reactions. With the help of this apparatus other scientists were able to separate and study many gases and it led to the discovery of gaseous non-metals.

With this, there was an increase in discovery of non-metals. Fluorine was discovered in 1771 and chlorine in 1774 by the Swedish chemist Scheele. Slowly, other non-metals were also discovered.

Inert gases are found in the free state in nature but only in trace amounts therefore, their discovery also took some time. In 1785, Cavendish carried out some experiments with air in which he separated nitrogen gas and oxygen gas from it. He was left with bubbles of some unknown gas, possibly argon, but he was unable to identify it. It was more than 100 years before these bubbles were identified as a new element. In 1894, two scientists called Ramsay and Raleigh found that the density of nitrogen gas obtained from air is more than that of pure nitrogen from which they concluded that another gas was present in air. They separated the gas and called it argon. Ramsay also included other inert gases like helium, neon, krypton and xenon. In this way, most of the non-metals had been discovered by the end of 19th century.

Questions

1. What are metalloids? Give any two examples.
2. Give reasons why gaseous elements were discovered quite late as compared to solid elements.
3. The elements of group 18 do not normally take part in chemical reactions, why?

11.4 Chemistry of non-metals

Non-metals, except hydrogen, are found between groups 14 to 18 in the periodic table which means that they have 4 to 8 electrons in their outermost shell. Since non-metals have a tendency to gain electrons therefore they are electronegative in nature. We know that non-metals are more electronegative than metals but the electronegativity of each non-metal is not same. The value of electronegativity for non-metals ranges from 2.01 to 4.1.

In the chapter on periodic table, we saw that electronegativity decreases on going down a group and increases on moving from left to right in a period. This means that the elements of group 17 are most electronegative. Fluorine has the highest electronegativity value and that for oxygen and chlorine is also quite close. The value of electronegativity determines how a non-metal will react with metals or other non-metals.

All non-metals, except those in group 18, form negative ions or covalent bonds during chemical reactions. Let us now study about some common chemical reactions shown by different non-metals.

11.4.1 Reaction between metal and non-metal

We have previously read about the reactions between metals and non-metals. Let us review some of them -

$$2Mg(s) + O_2(g) \longrightarrow 2MgO(s)$$

$$2Cu(s) + O_2(g) \longrightarrow 2CuO(s)$$

$$Fe(s) + S(s) \longrightarrow FeS(s)$$

$$3Mg(s) + N_2(g) \longrightarrow Mg_3N_2(s)$$

Magnesium nitride

$$2Na(s) + Cl_2(g) \longrightarrow 2NaCl(s)$$

$$6Ca(s) + P_4(s) \longrightarrow 2Ca_3P_2(s)$$

Calcium phosphide

Metals and non-metals react with one-another to form ionic compounds. Here, the metal is oxidized and the non-metal is reduced.

11.4.2 Reactions between non-metals

We know that covalent bonds are formed when non-metals react with one another. Many covalent compounds can be formed but here we will concentrate on chlorides and oxides, that is, compounds of oxygen and chlorine.

(A) Reaction of non-metals with chlorine - non-metals react with chlorine to form chlorides.

$$C(s) + 2Cl_2(g) \longrightarrow CCl_4(l)$$
$$H_2(g) + Cl_2(g) \longrightarrow 2HCl(g)$$
$$P_4(s) + 6Cl_2(g) \longrightarrow 4PCl_3(l)$$

Phosphorous chloride

(B) Reaction of non-metals with oxygen - non-metals react with oxygen to form oxides.

$$C(s) + O_2(g) \longrightarrow CO_2(g)$$
$$S(s) + O_2(g) \longrightarrow SO_2(g)$$
$$P_4(s) + 5O_2(g) \longrightarrow P_4O_{10}(s)$$

Remember that while writing the chemical formula of compounds keep the less electronegative element before the more electronegative element. Since the electronegativity of both oxygen and chlorine is more as compared to other elements therefore they are written last in chemical formulae of compounds.

11.4.3 Nature of oxides of non-metals

Activity-1

- Take some sulphur powder in a deflagrating spoon and heat it.
- When sulphur starts burning, put the spoon in a gas-jar or covered glass so that the gas being formed collects in it (Figure-2).
- After some time remove the spoon, add a little water to it and immediately cover it again.
- Now shake the jar and test the solution formed with blue and red litmus paper.

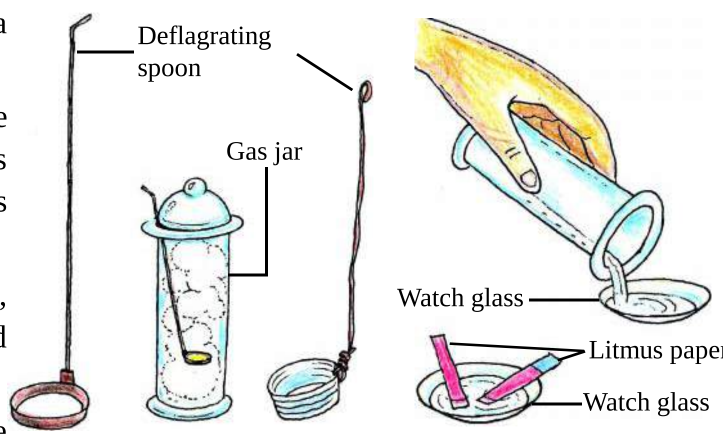


Figure-2: Testing the nature of non-metal oxide

- Did you observe any change in colour of litmus paper?

Precaution: *Since sulphur dioxide gas being formed can harm us therefore carry out the experiment in a well-ventilated area.*

Sulphur reacts with oxygen to form sulphur dioxide. In activity-1, you may have observed that the solution of sulphur dioxide in water is acidic in nature.

$$SO_2 + H_2O \longrightarrow H_2SO_3$$

In the same way, the solutions of most non-metal oxides in water are acidic, for example,

$$CO_2 + H_2O \longrightarrow H_2CO_3$$

But, not all non-metal oxides are acidic. We know that water is an oxide of hydrogen but it is neutral.

Questions

1. Look up the names of different acids used in the laboratory and find out the non-metals that make them up.
2. Non-metals are electronegative, why?
3. You are given an element; how will you identify whether it is a metal or non-metal? Give three means.

Some important non-metals

Consider the names hydrogen, oxygen and nitrogen. Do you notice any similarities in the names? All of them end in -gen. Actually, the suffix -gen is derived from the Greek word genes which means 'one which produces'. For example, hydrogen is combination of hydro, which means water and -gen and thus, the word hydrogen means 'one which forms or produces water'. When oxygen was discovered it was believed that this element was needed to form acids (oxy-) and thus the name oxygen was given.

Nearly 70% of the earth's surface is water which is a compound of hydrogen and oxygen. The air around us is about 78% nitrogen and 21% oxygen. This is the reason why these three are also known as elements of air and water. Along with oxygen, these three non-metals form many compounds, such as protein, that are vital and fundamental to life.

11.5 Hydrogen

Usually, we say that an element has been discovered only when it has been isolated in the pure form and its physical and chemical properties have been studied. In 1671, the British scientist observed that a highly inflammable gas is produced in the reaction between iron and hydrochloric acid but he did not study it systematically or identify it as a new element. Other scientists also saw that many metals are soluble in acids producing an inflammable gas but it was Cavendish who in 1776 first proved that this gas was different from other gases. Therefore, he is credited with the discovery of hydrogen. He also produced water from hydrogen and oxygen and on the basis of this reaction Lavoisier named the new gas hydrogen.

93% of the universe is hydrogen. Hydrogen is present around us as diatomic molecule (H2). On earth we rarely find pure hydrogen molecules and it is usually found as a compound. Hydrogen is a colourless, odorless, tasteless gas which is extremely inflammable. In previous classes, you have read about isotopes. Hydrogen has three isotopes called protium, deuterium (heavy water) and tritium. The atomic number of hydrogen and the relative atomic weight is also 1.

Henry Cavendish

British physicist and chemist Henry Cavendish (1731-1810) obtained hydrogen by the reaction between hydrochloric acid and different metals like tin, zinc and iron. He characterized the properties of this gas and found that hydrogen was extremely light and had the lowest density among the known elements. After studying the gas, he named it flammable air. Along with discovery of hydrogen he studied atmospheric composition, properties of different gases, determined the composition of water and measured the density of earth based on different experiments. Cavendish is famous for rigour and accuracy in his experiments.

11.5.1 Laboratory preparation of hydrogen

1. In the laboratory, hydrogen gas (H2) is prepared by the reaction between hydrochloric acid and granulated zinc. In the chapter on acids and bases you read about the preparation of hydrogen using this method. Write the balanced chemical equation for this reaction.

Activity-2

- Take some granulated zinc in a Wolf bottle.
- Place a thistle funnel on one opening and a bent glass tube on the other opening of the bottle (figure-3).
- Attach a rubber tube to the other end of the glass tube and place the tube in a filled water-trough.
- To collect the gas produced, place a test-tube or gas jar filled with water over the rubber tube in the trough.

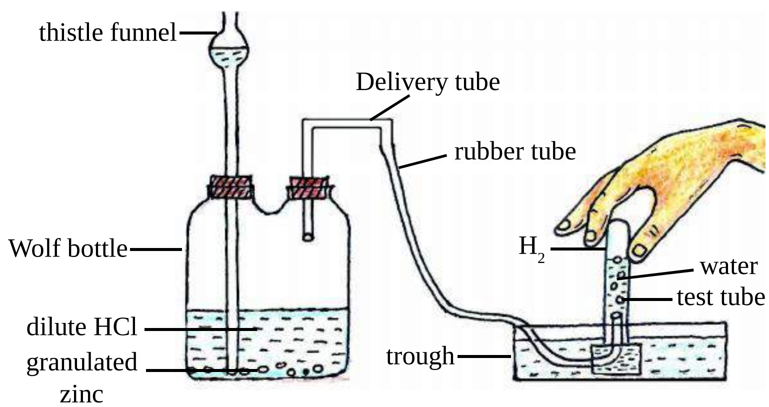


Figure-3: Laboratory method for hydrogen preparation

- Using the thistle funnel keep adding dilute hydrochloric acid to the bottle till the lower end of the funnel is submerged. After some time you should observe some bubbles in the water in the trough.
- How will you test that the gas collected by the displacement of water is hydrogen?

2. The reaction of granulated zinc with a base also produces hydrogen gas.

$$Zn(s) + 2NaOH(aq) \longrightarrow \underset{\textit{Sodium zincate}}{Na_2ZnO_2(aq)} + H_2\uparrow$$

Precautions: *While collecting hydrogen gas, if it is contaminated by air then the mixture will explode as soon as it comes in contact with a flame. Therefore, collect the gas carefully and for testing the gas don't put the lighted matchstick inside the test-tube, merely take it close to the mouth of the test tube.*

11.5.2 Chemical properties of hydrogen

Hydrogen atom has one electron present in its K-shell. Hydrogen, similar to elements of group 1, can lose one electron to form H^+ ion (hydrogen ion). It is also possible for hydrogen to gain an electron and form negatively charged H^- ion (hydride ion) and in this respect it is similar to the elements of halogen group. Thus, hydrogen can be placed either in group-1 or group-17 in the periodic table. Since, in the modern periodic table, elements have been placed in increasing order of their atomic number therefore hydrogen is palced in the first position in group-1.

1. Reaction with metals- the electronegativity of hydrogen as compared to hydrogen so hydrogen reacts with metals to give the corresponding hydride.

$$2Na + H_2 \longrightarrow 2NaH$$

$$Mg + H_2 \longrightarrow MgH_2$$

2. Reaction with halogens- halogen halides are obtained when hydrogen reacts with halogens.

$$H_2(g) + X_2(g) \longrightarrow 2HX(g) \quad \text{Where } X = F, Cl, Br, I$$

On this basis, complete the following equations and balance them-

$$H_2(\ \ ) + Br_2(\ \ ) \longrightarrow ?$$

$$H_2(\ \ ) + F_2(\ \ ) \longrightarrow ?$$

3. Reduction reaction- hydrogen reacts with hot metal oxides and reduces them to the corresponding metal.

$$CuO(s) + H_2(g) \xrightarrow{200°C} Cu(s) + H_2O(g)$$

$$Fe_3O_4(s) + 4H_2(g) \longrightarrow 3Fe(s) + 4H_2O(g)$$

The reduction of metal halides is also possible using hydrogen.

$$2AgCl + H_2 \longrightarrow 2Ag + 2HCl$$

11.5.3 Uses of hydrogen

1. In metallurgy, a stream of hot hydrogen gas is passed over metal oxides to get metals. Hydrogen is used in extracting tungsten and molybdenum metals.
2. Hydrogen is used in industrial preparation of ammonia, hydrochloric acid etc.
3. Hydrogen is also essential in manufacture of carbonic compounds. For example, hydrogen is used in large scale preparation of methanol.
4. Production of vegetable fat by hydrogenation of vegetable oils- Double bonds between carbon atoms are found in the carbonic compounds present in vegetable oils which react with hydrogen and are converted to single-bonded vegetable fats.
5. Dissociation of hydrogen molecules in fuel cells produces electrical energy and then heat is produced in the reaction between hydrogen and oxygen. It causes less pollution as compared to fossil fuels.

11.6 Nitrogen

The atomic number of nitrogen is 7 and its electronic configuration is 2,5. Under normal temperature and pressure conditions nitrogen is found in the gaseous state. It is the first element of group 15 in the periodic table.

Nitrogen is the most abundant element in the atmosphere. At one point of time in the past it was believed that air was an element. British scientist Black (1728-99) demonstrated through some experiments that when a candle is burnt in a closed jar or beaker it extinguishes after some time and we can conclude that the air left inside the beaker no longer supports combustion. When he removed the gas formed during combustion of candle from the beaker he found that there was another gas left behind in the beaker. This gas also did not support combustion. But he could not explain his observations. Ultimately, one of his students Daniel Rutherford (1749-1819) was able to characterize the properties of the gas and therefore he is credited with the discovery of nitrogen.

11.6.1 Laboratory method of nitrogen preparation

In the laboratory, nitrogen gas is obtained by heating a solution of ammonium chloride and sodium nitride.

$$NH_4Cl(aq) + NaNO_2(aq) \xrightarrow{\text{Heat}} NaCl(aq) + 2H_2O(l) + N_2(g)$$

Activity-3

- Take equal amounts (25 g) of ammonium chloride and sodium nitride in a round bottom flask.
- Add 100 mL water to the flask and shake it so that the ammonium chloride and sodium nitride dissolve in the water.
- Take a glass tube, boiling tube, water-trough and test tube and arrange it as shown in figure-4.
- Now heat the flask and use displacement of water to collect the gas formed.

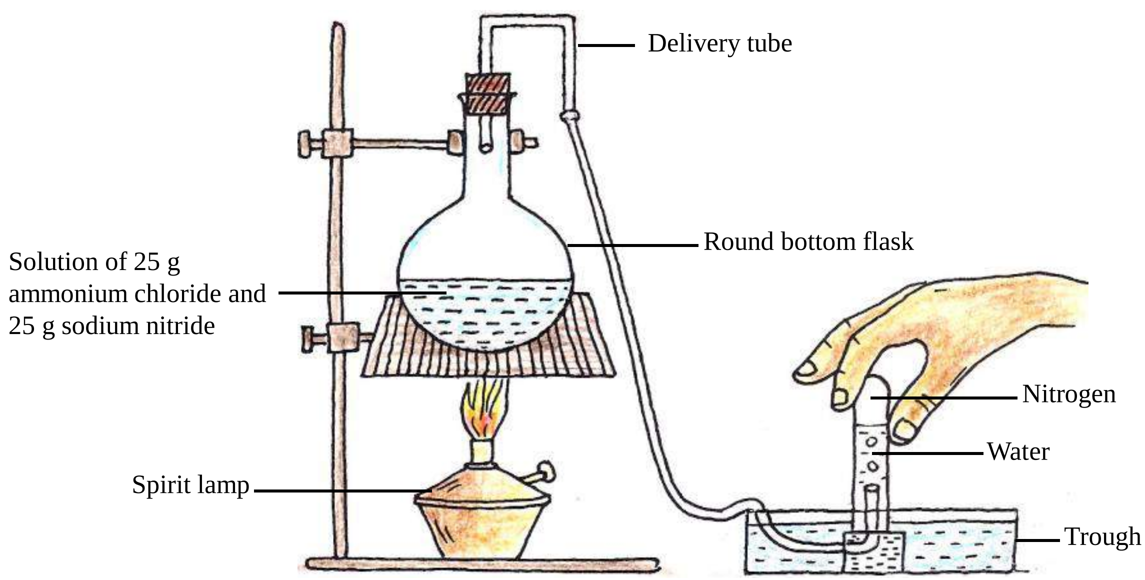


Figure-4: Laboratory method of nitrogen preparation

11.6.2 Chemical properties of nitrogen

We know that a molecule of nitrogen has two nitrogen atoms joined together by a triple bond. Therefore, nitrogen is a diatomic molecule and takes part in chemical reactions as N_2.

1. **Reaction with oxygen -** Nitrogen reacts with oxygen at extremely high temperatures (2000°C) to form nitric oxide.

$$N_2(g) + O_2(g) \xrightarrow{2000\ K} 2NO(g)$$

2. **Reaction with metals -** Nitrogen reacts with metals at high temperatures to form metal nitrides.

$$6Li + N_2 \xrightarrow{Heat} \underset{\textit{Lithium nitride}}{2Li_3N}$$

3. **Reaction with hydrogen -** At high temperature (450-500°C) and under high pressure (200 atm), in the presence of Fe catalyst and Mo promoter, nitrogen and hydrogen react with one another to form ammonia. (Catalysts increase the rate of reactions without taking part in it. Here, the catalyst Fe increases the rate of reaction and the promoter Mo increase the efficiency of the catalyst). This method of ammonia production is known as the Haber's process.

$$N_2(g) + 3H_2(g) \underset{200\ atm}{\overset{450\text{-}500°C}{\rightleftharpoons}} 2NH_3(g)$$

11.6.3 Uses of nitrogen

1. Proteins found in living organisms are compounds of nitrogen and some other elements (C,H,O,S).
2. It is used in the industrial manufacture of ammonia and nitric acid.
3. To create and inert atmosphere in packaged foods, chips' packets etc.
4. Manufacture of useful fertilizers like urea in agricultural field.
5. Liquid nitrogen rapidly absorbs heat therefore it is used to freeze and preserve tissue samples, blood samples etc.

11.7 Oxygen

Oxygen is the first element of group 16 in the periodic table. Oxygen is most abundant element in the earth's crust. It is second only to nitrogen in abundance in the atmosphere.

The atomic number of oxygen is 8 and its electronic configuration is 2,6. Two isotopes of oxygen, O_2 and O_3 are found in nature. Most of the oxygen around us is in the form of diatomic molecule, O_2.

11.7.1 Laboratory method of oxygen preparation

In the laboratory method, oxygen is prepared by heating potassium permanganate.

$$2KMnO_4 \xrightarrow{\triangle} \underset{\textit{Potassium manganate}}{K_2MnO_4} + MnO_2 + O_2\uparrow$$

Activity-4

- Take 2-3 g of potassium permanganate in a glass boiling tube and set-up your apparatus as shown in figure-5.
- Now heat the boiling tube and collect the gas formed in an upside down test tube or gas jar filled with water and kept in a trough.
- When the test tube is filled completely with the gas then place your thumb over its mouth and carefully remove it from water.

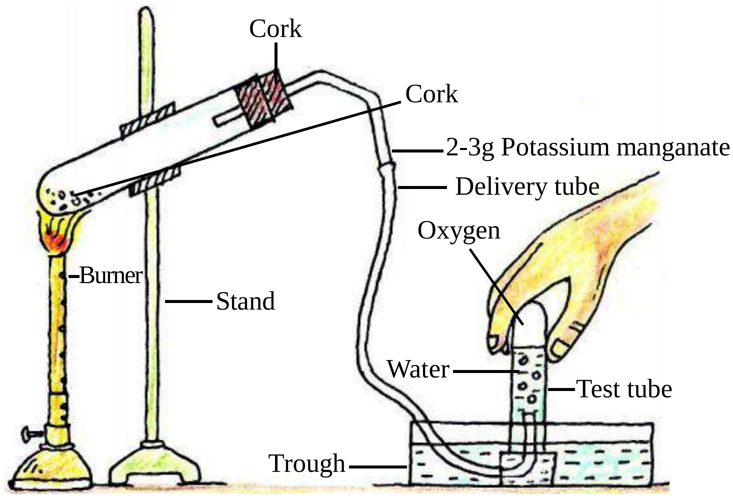


Figure-5: Laboratory method of making oxygen gas

- How will you test whether the collected gas is oxygen?

11.7.2 Chemical properties of oxygen

Although oxygen gas itself does not burn but it supports combustion. After fluorine, it is the most electronegative element.

1. Reaction of oxygen with metals and with non-metals - Oxygen reacts with metals and non-metals to form the respective oxides.

$$4Na + O_2 \longrightarrow 2Na_2O$$
$$N_2 + O_2 \longrightarrow 2NO\uparrow$$

2. Reaction with hydrogen - On passing an electric spark through a mixture of oxygen and hydrogen, water is obtained.

$$2H_2 + O_2 \xrightarrow{\text{Electric spark}} 2H_2O$$

3. Reaction with compounds - Oxygen reacts with ammonia to form water and nitrogen gas.

$$4NH_3 + 3O_2 \longrightarrow 2N_2 + 6H_2O$$

4. Reaction with hydrogen chloride gas - In the presence of copper chloride catalyst, oxygen oxidizes hydrogen chloride gas into chlorine gas.

$$4HCl + O_2 \xrightarrow{\text{Catalyst } 400°C} 2H_2O + 2Cl_2\uparrow$$

11.7.3 Uses of oxygen

1. Oxygen is necessary for essential processes like respiration and combustion. The energy produced during these reactions is used to sustain life and in daily processes.
2. Proteins, carbohydrate and fats which are fundamental molecules of life are also compounds of oxygen.

3. Oxygen is used in the industrial preparation of several chemicals like nitric acid, sulphuric acid, ozone etc.
4. Liquid oxygen is used as component of liquid fuel in rockets.
5. Oxy-hydrogen flames (which is produced as a result of combustion of a mixture of hydrogen and oxygen) and oxy-acetylene flames (which is produced as a result of combustion of a mixture of acetylene and oxygen) are used for cutting, joing and welding metals.

Questions

1. Write the balanced chemical equations for reactions of calcium, lithium and aluminium with hydrogen.
2. Which gas is used in packaged foods and why?
3. In laboratories, oxygen is collected in an upturned, water-filled test tube or gas jar, why?

Keywords

Metalloid, catalyst, promoter, halogen, allotropy, electronegativity, noble gas, oxide, fluoride, nitride

What we have learnt

- Elements can be classified as metals, non-metals and metalloids.
- Different Non-metals are found in all three states - solids, liquids and gaseous.
- The electronegativity of non-metals is more than that of metals.
- Different forms of the same element that exhibit different physical properties are known as allotropes. Thus, the occurrence of an element in a particular state in different forms is known as allotropy.
- Except graphite, which is an allotrope of carbon, all other non-metals are electrical insulators.
- Non-metals react with oxygen to give oxides which are mostly acidic in nature.
- Hydrogen, nitrogen and oxygen are found in nature as diatomic molecules.
- Ionic compounds are formed by reactions between metals and non-metals gives.
- Non-metals react with each-other to give covalent compounds.
- Hydrogen atom can lose one electron to form H^+ ion (similar to elements of the first group) and can gain one electron to form H^- ion (similar to elements of group 17).
- Hydrogen reduces metal oxides to corresponding metals.
- At 450-500°C and under 200 atm, in the presence of iron catalyst and molybdenum promoter, nitrogen and hydrogen react with one another to form ammonia.

Exercises

1. Choose the correct option -

   (i) The solution in water of which of the following will be acidic

   (a) Na_2O (b) CO_2

   (c) MgO (d) H_2O

   (ii) Which of the following elements does not exhibit allotropy

   (a) Sodium (b) Oxygen

   (c) sulphur (d) phosphorus

   (iii) Which among the following is a metalloid

   (a) oxygen (b) helium

   (c) magnesium (d) arsenic

   (iv) Noble gases do not react with other elements because

   (a) They are monoatomic gases (b) Their atomic size is small

   (c) Their outermost shell is full (d) They are found in abundant amounts

   (v) The gas obtained on heating potassium permanganate is

   (a) nitrogen (b) oxygen

   (c) hydrogen (d) helium

2. Fill in the blanks

   (i) The most electronegative element is …………….. (chlorine/ fluorine).

   (ii) Carbon is ………… (more/less) reactive as compared to oxygen.

   (iii) Non-metals are found at the …………….(right/ left) side of the periodic table.

   (iv) ……………….. (hydrogen/ nitrogen) gas is obtained when granulated zinc is reacted with dilute acid or alkali.

3. Compare the physical properties of metals and non-metals.

4. Write the balanced chemical equations for formation of chlorides and oxides of the following elements - hydrogen, phosphorous, sodium and magnesium.

5. Write the equation and corresponding conditions for reaction between nitrogen and hydrogen.

6. "Hydrogen can be placed either in group 1 or in group 17". Do you agree with this statement or disagree? Give reasons.

7. Why are helium, neon, krypton, argon, xenon and radon known as inert gases?

8. Explain the following industrial uses of hydrogen-
   (a) Heat production on combustion
   (b) Reaction with vegetable oils in the presence of a catalyst
9. What happens when potassium permanganate is heated? Explain giving balanced equation.
10. Gas 'A' is formed when granulated zinc reacts with dilute hydrochloric acid. It reacts with oxide 'B' and reduces it to copper metal. Write the names of 'A' and 'B' and also give the equations for the described reactions.
11. Sevati took sulphur powder in deflagrating spoon, heated it and collected the gas formed in a test tube. What will happen when moist red and blue litmus papers are taken near the mouth of the test tube and why? Write the chemical equations for the reactions taking place.
12. The processes described below are due to which property of hydrogen-

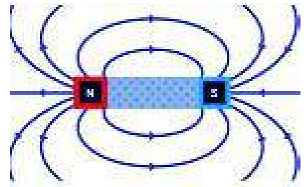
a. A hydrogen filled balloon floats in air.

b. A 'pop' sound is heard when a lighted matchstick is taken near the mouth of a hydrogen filled gas jar.

13. Compound X, which is used for drinking, has pH value 7. Electrolysis of an acidic solution of X gives gases Y and Z. The volume of Y is twice that of Z. Y burns rapidly while Z supports burning. Identify X, Y and Z and write the equations for the described reactions.

CHAPTER 12

MAGNETIC EFFECTS OF ELECTRIC CURRENT



You have studied about electricity and magnetism in your previous classes. You would be surprised to know that both of them are effects produced by a single phenomenon, i.e. wherever an electric charge is active, it produces a magnetic effect. Also, wherever a magnetic field exists, electric charge in some form of other will be preswent. You are familiar with magnets and the magnetic compass.

You have studied about the various properties of a magnet in previous classes. List the various properties that a magnet exhibits.

12.1 Magnetic field and magnetic lines of force

Place a small magnetic compass near a bar magnet. The compass needle is deflected and becomes stationary pointing in a particular direction. This shows that a force has acted upon the compass needle, due to which it moved in a particular direction before coming to a stop.

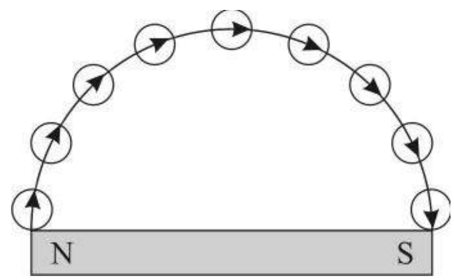


Figure-1: magnetic lines of force

The area surrounding a magnet, in which a force is exerted on the magnetic compass due to which it turns and stops in a particular direction, is known as the magnetic field. The magnetic field of a magnet is shown by imaginary magnetic lines of force surrounding it.

In a magnetic field, the direction of magnetic compass needle changes its constantly on moving it from one point to another. When the compass is moved from the magnet's North Pole towards its South Pole, it forms a curved path, which is known as magnetic lines of force.

At any point on this curved line of force, if a line tangential to that point is drawn, it will indicate the direction of the magnetic line of force at that point.

Magnetic lines of force have the following properties:

1. They originate at the North Pole and travel to the South Pole in the area surrounding the magnet.
2. They continue from the South Pole to the North Pole inside the magnet.
3. They form a closed loop.
4. The lines of force do not cross each other at any point.
5. Magnetic lines of force are concentrated at the poles and spaced apart at other sections of the field, which indicates that field intensity is strongest at the poles.

You can observe the magnetic field by conducting the following activity.

Activity-1

Items required: Drawing board, white paper, drawing pins, bar magnet, iron filings (or powder).

Method:
1. Fix a white paper on the drawing boards using the pin.
2. Place a bar magnet at the centre of this paper.
3. Now sprinkle the iron-filings evenly around the magnet.
4. Now gently tap the drawing board with your fingers. Note your observations.

You will observe that the magnet exerts a force on the iron filings which then arrange themselves in a particular shape, as shown in figure-2.

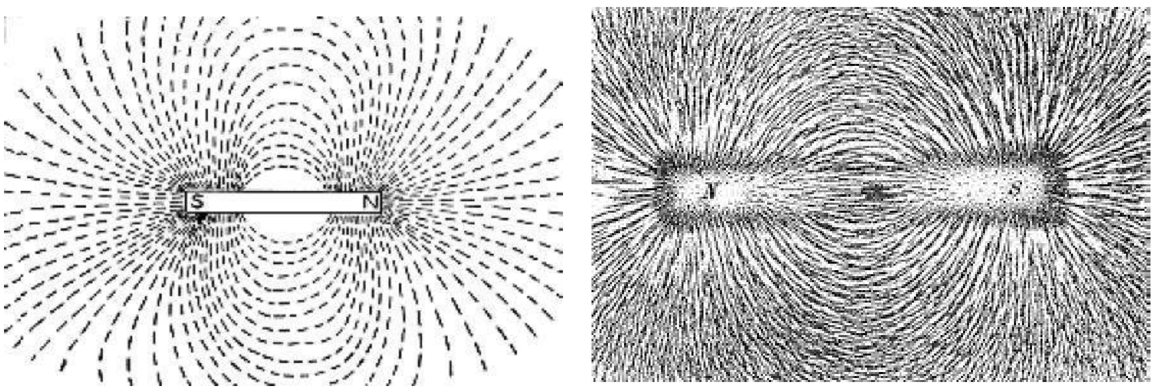


Figure-2: Magnetic fields

The area surrounding a magnet where the magnetic force is observable is known as the magnetic field of the magnet. The iron filings arrange themselves in a particular pattern, and these are known as magnetic lines of force. Let us draw the magnetic lines of force by using a compass by performing the following activity.

Activity -2

To draw the magnetic lines of force when the North Pole of the magnet is aligned with the geographic North.

Items required: Drawing board, white paper, pins, magnetic compass, bar magnet, iron filings etc.

Process:
1. Keep the drawing board on a table.
2. Fix a white paper on the board with pins, or cello-tape.
3. Remove any magnetic materials nearby.
4. Draw a line at the centre of the paper along its length and place a small compass on it. Now move the board till the compass needle aligns itself straight along the drawn line. Now, this line is aligned with the earth's North-South direction. Write N and S at the ends of the line.

5. Place a bar magnet straight on the line so that the line passes through the magnet centre, as shown in figure-3(a). Now the North Pole of the magnet is facing the geographic North. Draw an outline of the magnet.

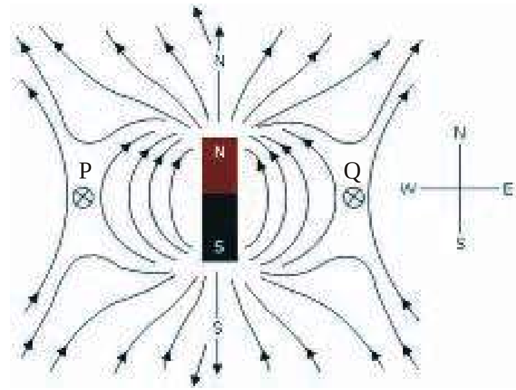


Figure-3(a): Drawing magnetic lines when the North

6. Draw a point near the magnet's North Pole, from where you shall start drawing the lines of force. Place the compass on this point in such a way that the South end of the compass needle lies in a straight line with this point. Now draw another point with the pencil at the other (North) end of the compass needle. Repeat the above by again placing the south end of the compass needle at the second point and draw another point at the other needle end. In this way, move the compress forward to draw the various points, till you reach the South Pole of the magnet.
7. Now draw a thin line through all the points mapped from the magnet's North Pole to the South Pole.
8. Mark direction arrows along the line pointing towards the South Pole. This is a magnetic line of force.
9. Similarly, draw other lines of force, starting from various points near the magnet's North Pole and ending at the South Pole. These lines of force will look like those shown in figure-3(a).

We observe that the lines of force from a curved square shape around points P and Q. When we place the magnetic compass in this square and bring an iron nail near it, the compass needle is attracted towards the nail. On removing the nail, if the compass needle stays stationary in the same position, this, indicates the absence of any magnetic field. This is known as a neutral point of the field.

Neutral point

We know that the earth acts like a magnet and therefore, it also has a magnetic flux area. When a magnet is placed anywhere, the area around it has two magnetic fields. First is the magnet's own magnetic field and second is the earth's magnetic field. The magnetic lines of force in this area are a resultant of the two fields. Any point in this area, where the magnet's line of force a equal and opposite to the earth's magnetic lines of force will be a neutral point. Point P and Q in figure 3(a), are two such point.

The magnetic force lines of various states of a magnet are shown in figure-3(b), 4(a), 4(b), 4(c) and 4 (d).

Magnetic lines of force are a vector quantity and their direction is taken the same as that a unipolar North Pole will follow in the magnetic field. Therefore, the magnetic lines of force appear at the North Pole and enter into the south. Inside the magnet, they go from south towards north. Hence, it forms a closed loop.

These lines of force do not cross or intersect each other, because if they did it would result in the campus needle pointing in two directions simultaneously at the intersection point, which is not possible.

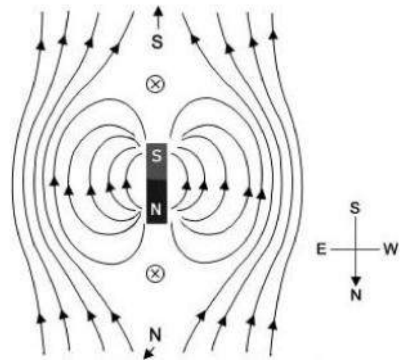
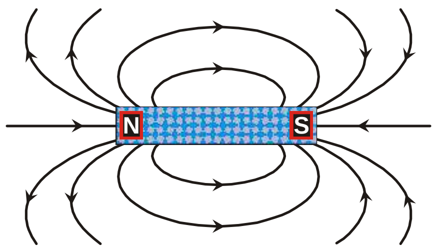
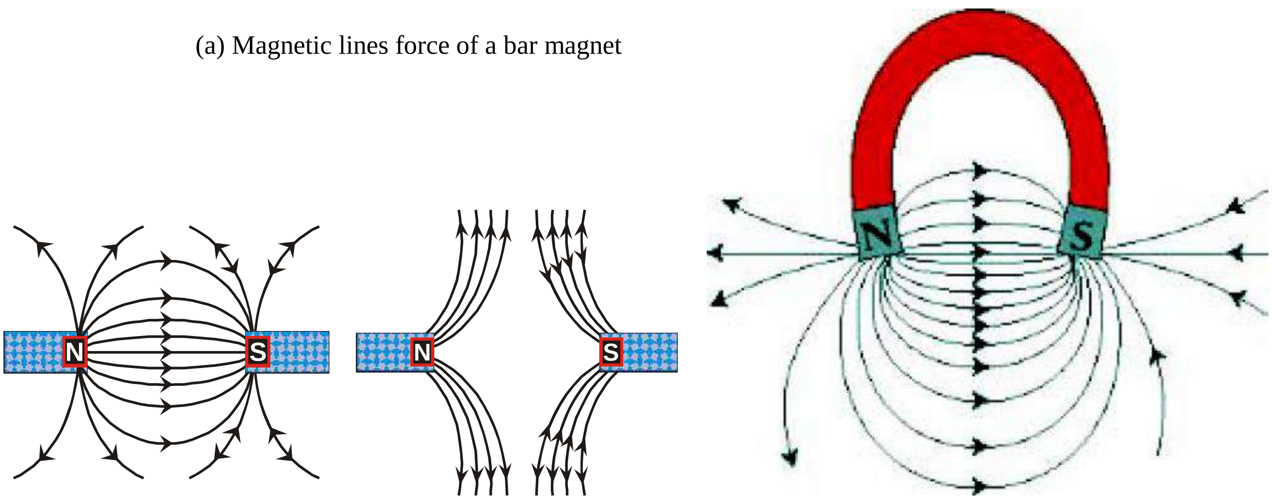


Figure-3(b): Magnetic lines of force when magnetic North Pole is aligned to geographical South



(a) Magnetic lines force of a bar magnet



(b) field lines when opposite poles of two magnets face each other

(c) field lines when similar poles of two magnets face each other

(d) field lines of horseshoe type magnet

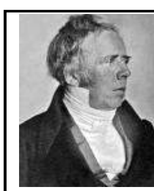
Figure-4 (a), (b), (c), (d): Magnetic lines of force

Questions

1. What are magnetic lines of force?
2. Write the properties of magnetic lines of force

12.2 Magnetic Field Due To Current Carrying Conductor

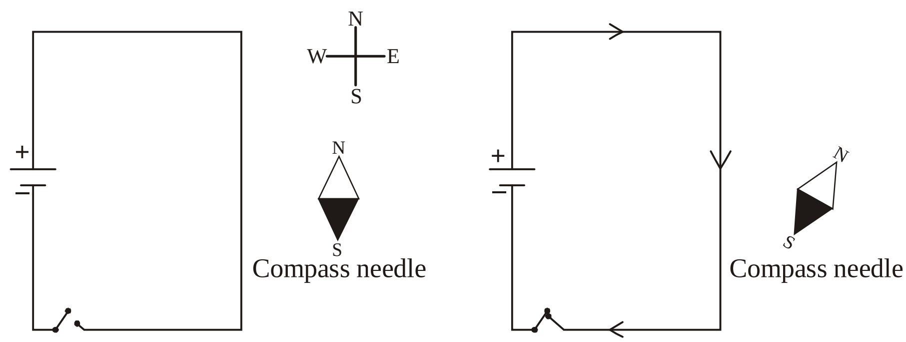
When electric current flows in a conducting wire, a magnetic field is produced around it. To observe this phenomenon, take a conducting wire (copper, aluminium etc.). Join the two ends of the wire to the terminals of a battery. Place a compass near and parallel to this wire (figure-5a). On switching on the circuit, current starts flowing in the wire and the compass needle gets deflected. This shows that a magnetic field is produced when current flows in a



Hans christian orsted

Electro-magnetic effects were first observed by Danish scientist H.C. Orsted in 1810.

conductor. The needle deflection intensifies with increase in the current and the direction of the magnetic lines of force gets reversed if the direction of current flow in the circuit is changed. If the current is switched off, the magnetic field also disappears (becomes null). Therefore, the magnetic field around the conductor is the result of the flow of current.



(a) No deflection when current is off (b) Needle deflects when current flows

Fig 5: Deflection of the compass needle due to flow of current

12.3 Magnetic Field Produced in a linear current carrying Wire

When a current carrying wire produces a magnetic field around itself, how is the shape of the magnetic field determined? Does the shape of the magnetic field depend upon the shape of the conductor? To test this, let us do the following activity.

Activity-3

Material required one 6V battery, one way key/switch, rectangular cardboard piece, 1 piece of straight thick copper wire, iron filings, etc.

Method:

1. Take the piece of cardboard.
2. Pierce the copper wire, vertically through the centre of the cardboard, so that the cardboard remains fixed in a flat horizontal position.
3. Connect the wire to a battery and key as shown in figure-6.
4. Sprinkle iron filings around the wire and place a small compass on the edge of the cardboard.
5. Now, switch on the current by closing the circuit, and gently tap the cardboard. You will observe that the iron filings arrange themselves in a particular shape and the compass needle gets deflected in a particular direction.

The iron filings arrange themselves around the wire in concentric circles. You can draw the lines of force and mark the direction of the field with arrows. Now, repeat this activity by changing the direction of current flow in the wire. What do you observe?

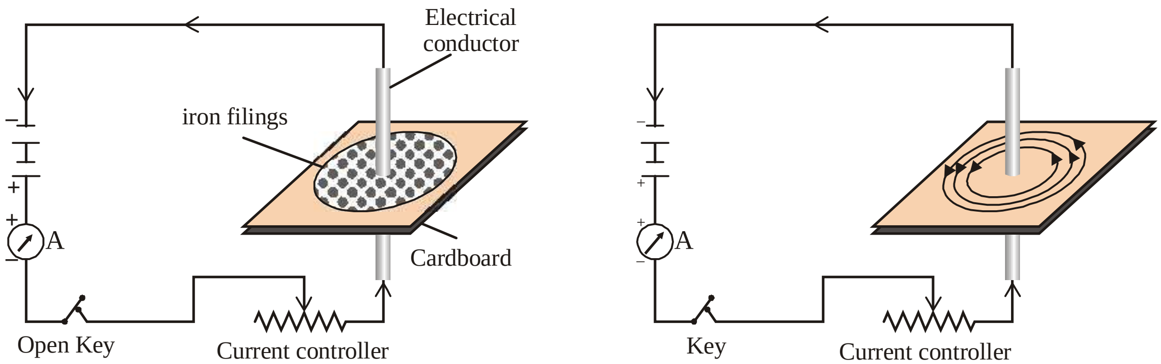


Figure-6: Magnetic field of a straight wire conductor

Now add a current controller and ammeter to the circuit as shown in figure-6. Change the amount of current flowing in the circuit and observe the effects on the magnetic field by placing the compass at various points on the cardboard. You shall observe that the needle deflection increases in intensity when the current flowing in the conductor increases. If the current flow is kept constant, but the compass is brought nearer to the conductor, the deflection in the compass needle becomes more pronounced, indicating higher field intensity. You will observe that the distance between the concentric lines of force is shorter near the conductor and the circles grow further apart and more dispersed as the distance from the conducting wire increases. Therefore, the magnetic field intensity is inversely proportional to the distance from the current carrying conductor.

12.4 Right Hand Rule For Diretion Of Magnetic Field

The direction of the magnetic lines of force of a magnetic field produced by a straight current carrying conductor can be determined easily, by the right hand rule. Imagine that you place your right hand around the conductor in such a way that the thumb points towards the direction of current flow, then the fingers bent around the conductor will point in the direction of the lines of force, as shown in figure-7.

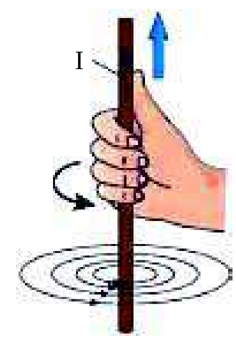


Figure-7: Right hand rule

Questions

1. Draw the magnetic lines of force produced by a linear conductor, carrying electric current.
2. If in a conducting wire, current is flowing from east to west, what would be the direction of the lines of force at a point, vertically below the wire and at a point above that wire?

12.5 Magnetic Field Due To Circular Current Carrying Conductor

We have seen the shape of the magnetic field produced by a straight current carrying conductor. Imagine that the straight wire is now bent into a circular coil, and current flows through it. What would be the shape of the magnetic field produced?

Let us fix a circular coil on a cardboard sheet as shown in figure-8. When current starts flowing in the coil, sprinkle the iron filings on the cardboard. We can observe that the iron filings get arranged in concentric circles around the two strands of the loop figure-8. As we move away from the wire, the circles get larger in diameter and spaced further more apart.

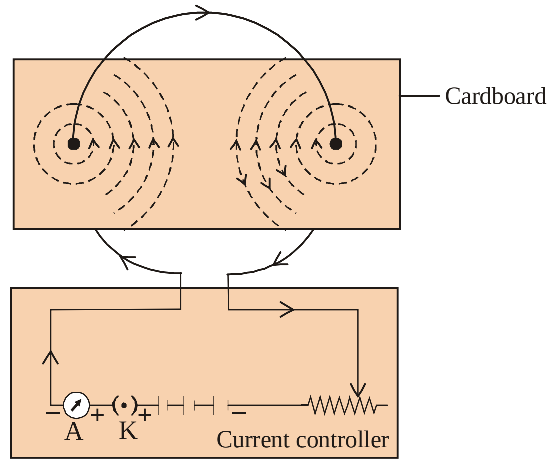


Figure-8: Magnetic field due to circular current carrying conduct

As the distance increases, the lines appear almost straight due to the large diameter.

By using the right hand rule, we can observe that the circular wire produces a magnetic field which has the lines of force in the same direction at every section of the circular coil, and therefore, the intensity of the magnetic field gets magnified. Let us perform an activity to observe this phenomenon.

Activity-4

Materials required- circular cardboard piece, insulated copper wire coiled into about 50 loops, current controller, battery (6V), switch, ammeter, etc.

Method:

1. Take the circular cardboard and make two holes in it.
2. Now pierce the copper wire coil through the holes in such a manner that the card-board lies horizontally on the vertically held loop.
3. Join the battery, current controller, ammeter, and switch in series in this circuit as shown in figure-8.
4. Sprinkle iron fillings uniformly on the cardboard
5. Switch on the current.
6. Gently tap the cardboard to enable the iron filings to arrange themselves in a particular shape and study the pattern formed.

We have learnt that the intensity of the magnetic field produced by a current carrying conductor is directly proportional to the amount of current flowing in the conductor. If we have a wire coil of n circular loops, then the magnetic field intensity would be n times that produced by a single coil. This is due to the fact that the direction of the current flowing in each loop is same.

Now repeat the above activity by reducing the diameter of the wire loop. The coil acts as the thin disc magnet, where one plane of the disc acts as a North Pole and the other plane as the South Pole of the magnet.

12.6 Magnetic Field Due To A Solenoid

A solenoid is a cylindrical shaped tube formed by tight coils of conducting copper wires. Figure-9 shows a solenoid whose two ends are joined to a battery. When current flows in the solenoid, a magnetic field is produced around the solenoid. Compare the pattern of magnetic field in figure-9 to the magnetic field shape shown in figure-4 (a).

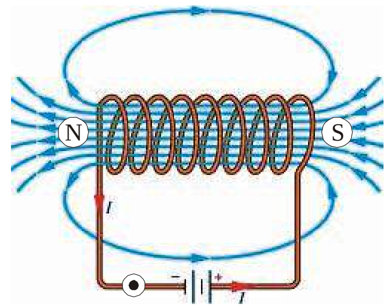


Figure-9: Magnetic field of a current carrying solenoid

In both the figures, the magnetic line of force appear as similar in shape and pattern and thus, the magnetic field produced by a solenoid is similar to that of the bar magnet, and one end of it acts as a North Pole while the other end acts like a South Pole. The magnetic lines of force inside the solenoid are parallel lines which show that the magnetic field inside the solenoid is uniform. The magnetic field produced inside the solenoid can be used to produce a magnet by placing a piece of magnetic material like iron, inside the solenoid, as in figure-10 (a).

This type of magnet produced is known as electromagnet.

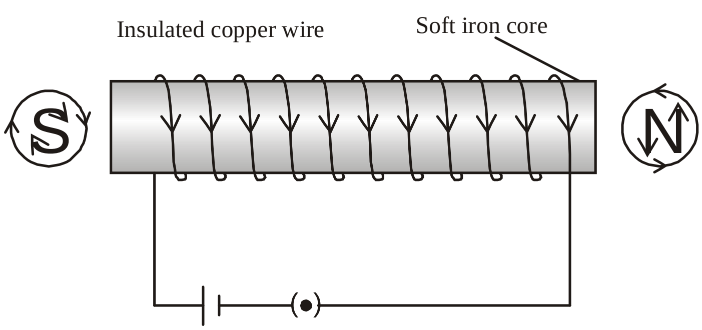


Figure-10 (a): electromagnet

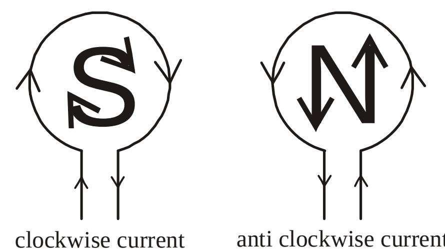


Figure-10 (b): electromagnet

The circular shape formed by bending a conducting wire is called a loop or coil. The coil end where the current direction is clockwise acts as a South Pole, and the other end where the current direction is anticlockwise acts as the North Pole.

Questions

1. Imagine a circular loop of wire placed on a table. If a clockwise current is flowing in the loop, find the direction of the magnetic lines of force inside the loop and outside the loop.
2. Draw an example of magnetic field where the lines of force are uniform.

12.7 Force On Current Carrying Conductor In A Magnetic Field

We learnt that when electric current flows in any conductor, it produces a magnetic field around the conductor, and when a compass is placed in this field, the compass needle experiences a force. Similarly, the compass will produce an equal but opposite force on the conductor.

To study the force affecting a current carrying conductor due to presence of a magnetic field, let us conduct the following activity-

Activity-5

Materials required: small aluminium rod AB, joining wires, horse shoe magnet, battery, switch, wooden stand.

Method: Fix the aluminium rod on the wooden stand with the help of joint wire as shown in figure-11. Place a strong horse shoe magnet in such a way that the aluminium rod lies centrally and horizontally between the two poles of the magnet. The North Pole of the magnet should be at the front of the rod and South Pole in the back. Due to this, the direction of the magnetic field lines is from left to right of the rod.

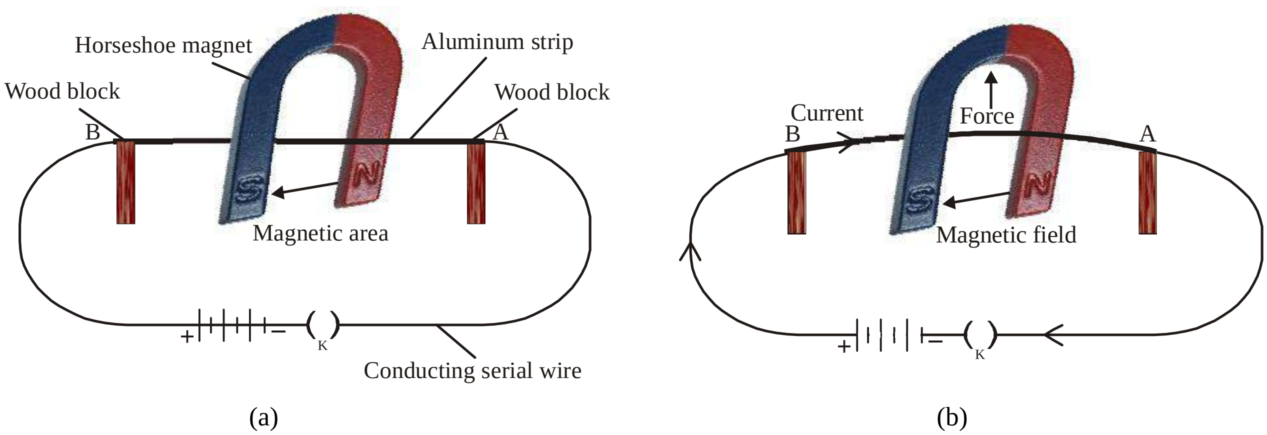


Figure-11 (a), (b): Force on current carrying wire

- Now switch on the current in the aluminium rod (B to A)
- What do you observe when the current flows?
- We observe that the rod turns left.
- Now change the direction of current flow and write your observations.

The motion of the conductor in this activity shows that a force is exerted on the current carrying conductor when placed in a magnetic field. The direction of this force changes on changing of the current direction.

Now change the position of the magnetic poles in the above activity and observe whether the direction of the force also changes. We observe that the force direction changes on changing the direction of the magnetic field. This shows that the direction of the force exerted on the conductor depends both on the direction of the magnetic lines of force as well as the direction of the current flowing in it.

In this activity, we kept the current direction and magnetic lines of force perpendicular to each other and observed that the direction of force produced is also perpendicular to both of them. To indicate this, Fleming gave the left hand rule.

12.8 Fleming's Left Hand Rule

When a current carrying conductor is placed in a magnetic field the conductor experiences a force. Fleming gave the left hand rule, to determine the direction of the force experienced by a conductor when placed in a magnetic field. A left hand can be held as shown in figure 12, where the thumb, the first finger and middle finger are held perpendicular to each other. The thumb represents the direction of motion resulting from the force, experienced by the conductor II the first finger represents the direction of the magnetic field, then the middle finger represents the direction of current.

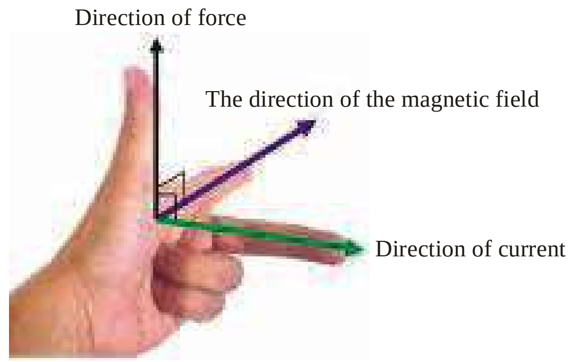


Figure-12: Fleming's Left Hand Rule

Electric motors and electric generators are some of equipments, which make use of magnetic field of a current carrying conductor.

Questions

1. In activity-5, how will the motion of aluminium rod AB be affected when,
   (a) The magnitude current in the rod is increased.
   (b) A more powerful horse shoe magnet is used.
   (c) The length of the rod is reduced.

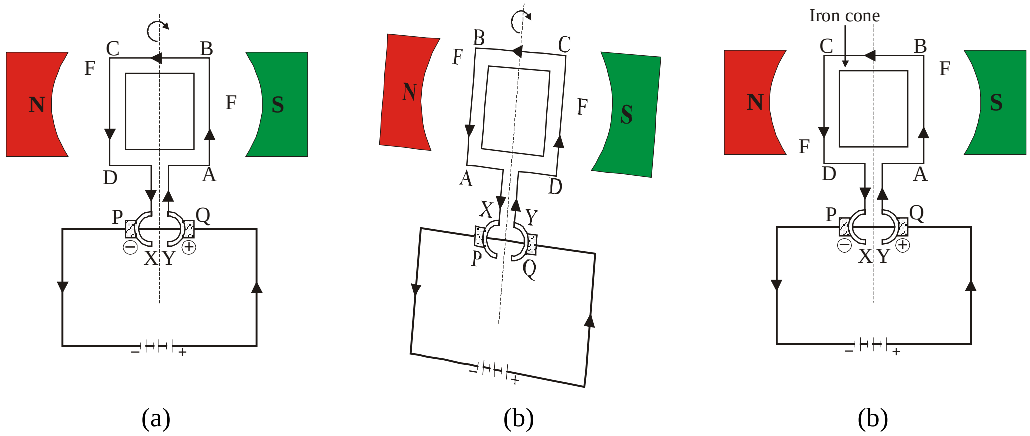
12.9 Electric Motor

An electric motor is a device which converts electrical energy into mechanical energy. They are used in numerous appliances and machines like electric fans, refrigerators, washing machines, water pumps etc. Electric motors can be powered by direct current (D.C.) power sources such as batteries, rectifiers etc. or by alternating current (A.C.) sources such as power supply grids, generators, etc.

Principle: when a circular coil is placed inside a magnetic field and current flows in the coil, then force acts on the coil, which moves (rotates) it continuously. When the coil in turn, rotates the axle (shaft) attached to it, and the axle delivers the mechanical power. In this manner, a motor converts electrical energy into mechanical energy.

Construction of motor and it working principle

In an electrical motor, as shown in figure-13, a rectangular loop (coil) of insulated copper wire ABCD, is placed between two cylindrical poles of a permanent magnet in such a way that the arms AB and CD are perpendicular to the magnetic field lines of force. The loop can be made to spin by attaching a half circle of copper, X and Y, to each end of the loop. The inside surface of the copper half circles is insulated, and fixed on the shaft (axle) of the motor and the shaft rotates along with the loop. The outer surface of the copper half circles are joined to two stationary (fixed) conducting carbon brushes P and Q, as shown in figure-13.



NS- Magnetic pole
ABCD- Conducting copper wires
XY- Insulated spheres
PQ- Carbon brush

Figure-13: Simple electric motor

Working: The current flowing from the battery enters the loop through the brush Q and flows out through the brush P to complete the circuit. Note that in loop ABCD current flows from A to B, B to C and C to D. Therefore, the current flows in opposite directions in the two arms, AB and CD. Due to this the resulting force generated, acts on AB in a downward direction and CD in an upward direction. Therefore, the loop turns or rotates in an anti-clockwise direction. After half rotation, the half circle Y comes in contact with fixed brush P, and half circle X is in contact with brush Q. thus the direction of current flowing in the loop remains the same, but gets reversed in the loop arms. The current now flows from DC to BA. This arrangement to reverse to reverse the flow of current in loop arms is known as a dual changer. The two half circles act as a dual changer. Due to this reversal, the loop continues to rotate in an anti-clockwise direction. In heavy motors, used in industries, the permanent magnets are replaced by electromagnets. Increasing the number of turns in the coil, increases the amount of current which in turn increases the power of the motor. The coil is wound tightly around a soft iron piece known as core. The coil and core assembly is known as armature.

12.10 Eletromagnetic Induction

In this chapter, we have studied that when a current carrying conductor is placed in a magnetic field, it experiences a force. This force results in the motion of the conductor. Now, imagine a situation, where if a current carrying conductor is moved through a magnetic field, an electric current is produced in the conductor. This phenomenon was first studied by Michael Faraday. Let us perform an activity to observe this.

Faraday is known for Electro-magnetic induction, force fields and laws of electro-magnetism

Michael Faraday

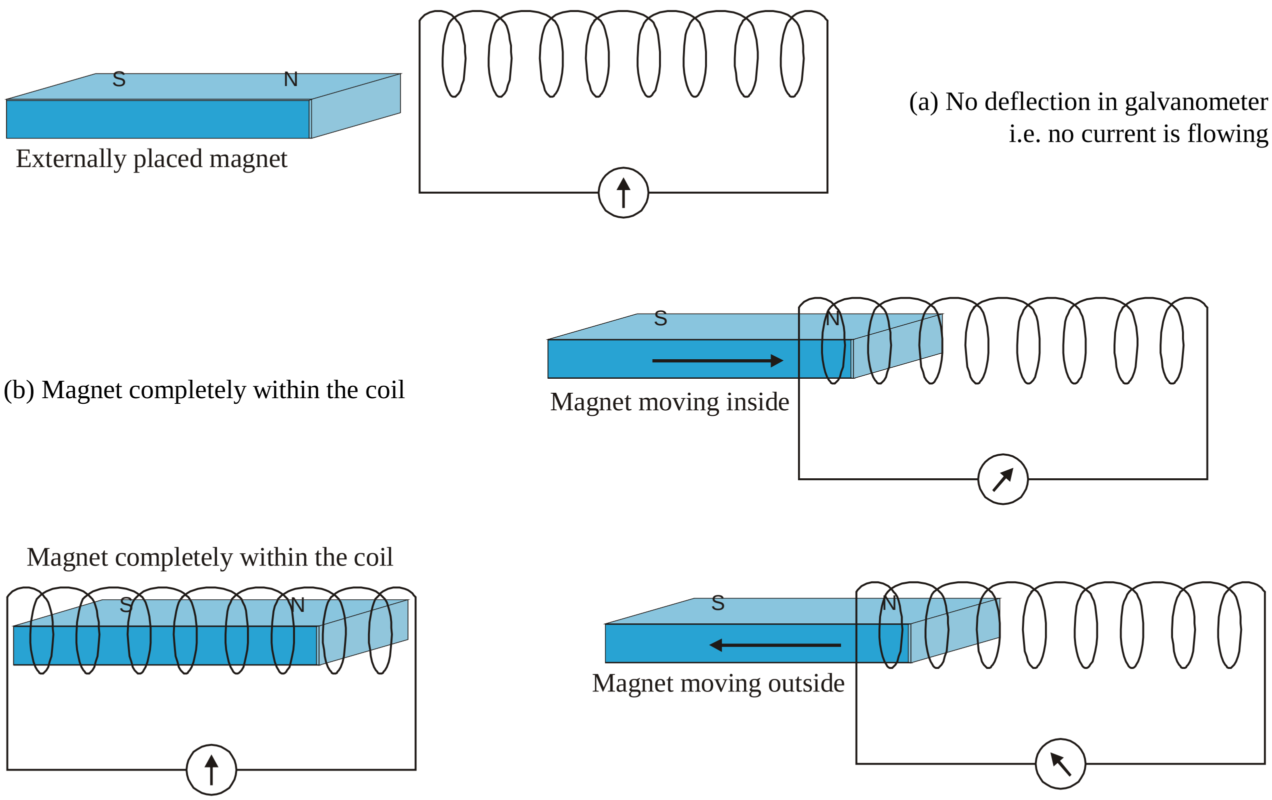
Activity-6

Materials required: a copper coil of numerous turns, galvanometer, a strong bar magnet.

Method: 1. Take a coil PQ, having numerous turns of copper wire.

2. Join the two ends of the coil to a galvanometer as shown in figure 14.

3. Take a strong bar magnet and move its north pole towards the coil end Q. do you notice ant deflection in the galvanometer needle.



(c) Magnet moving outside (d) Left deflection in galvanometer

Figure-14: Indication of electro-magnetic

4. You will notice an instant deflection in the needle of galvanometer which indicates the flow of current in coil PQ.

5. As soon as the movement of the magnet is stopped, the deflection of the needle is nil.

6. Now, move the North Pole of the magnet away from the coil Q and notice that current again flows in the coil but now the deflection of galvanometer needle is in opposite direction.

You can also observe that if the south pole of the magnet is moved towards coil end Q, the deflection of the galvanometer is in opposite direction to that when the north pole of the magnet was moved towards Q. This activity, demonstrates that when a conductor is moved in a magnetic field, or the magnet is moved, current is produced in the conductor and this is known as an induced current. This phenomenon is known as electro-magnetic induction.

Flemming's right hand rule is used to find the directijon of current in this activity.

12.11 Fleming's Right Hand Rule

According to this rule, spread the thumb, the first finger and the middle finger of the right hand in such a way that they are perpendicular to each other., as shown in figure 15.

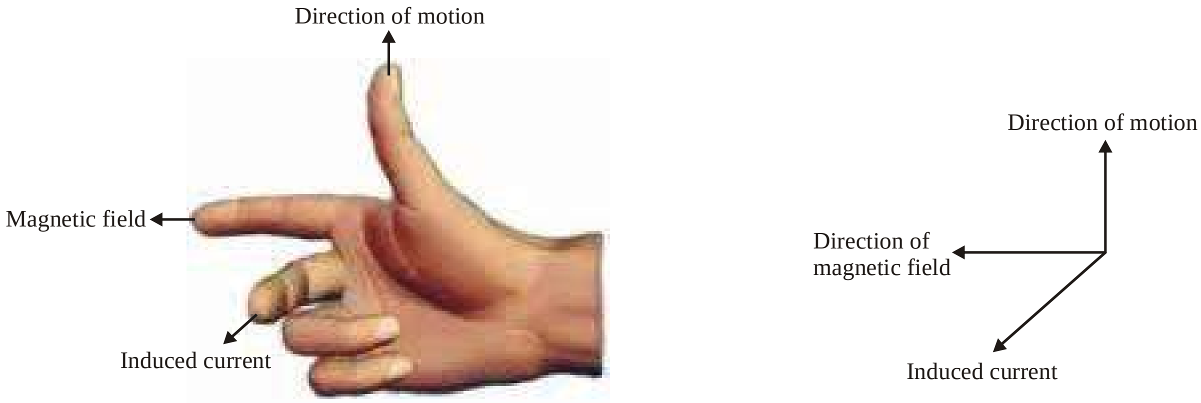


Figure-15: Fleming's right hand rule

The thumb represents the direction of motion of the conductor, first finger shows the direction of magnetic field lines of force and the middle finger points in the direction of the flow of induced current.

12.12 Dynamo Or Eletric Generator

Dynamo is an apparatus, which converts mechanical energy into electrical energy. It works on the principal of electromagnetic induction. This phenomenon is also used to generate large scale electric power by power plants for use in home and industries.

Construction:

1. Armature: for this, a rectangular coil having numerous turns of insulated copper wire is tightly wound around a soft iron core, as shown in figure-16.
2. Magnet: the armature is placed between the insides of the NS poles of a strong horse shoe magnet.

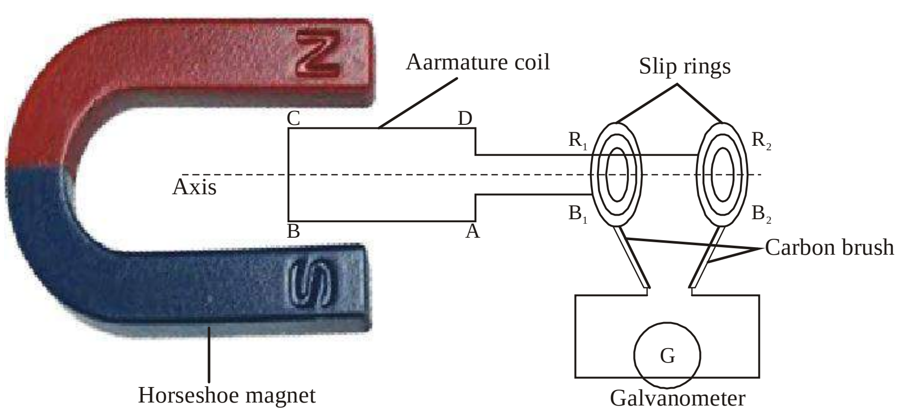


Figure-16: Electric generator

3. Circular dual changer: R_1 and R_2 are metallic half circles which are mounted on a shaft.

4. Carbon brush: fixed current conducting carbon brushes B_1 and B_2 are placed touching the half circles R_1 and R_2 respectively. The brushes are joined to a galvanometer.

Process: when the armature shaft attached to two half circles is moved in such a way that arm AB above the coil is above the arm CD, then the intensity of the magnetic lines of force passing through the loops varies and an induced current is produced in the two arms AB and CD, of the loop, as given by Fleming's left hand rule. The current generated in each coil of the armature would add up, and create a powerful current in the loop. In the external circuit, the current will flow from the brush B_1 towards B_2. After half rotation of the loop, the arm CD is now above the arm AB and the induced current will flow in the direction DCBA. The half circle R_2 is now in contact with brush B1 and therefore the current flows from B_1 towards B_2. The current in this arrangement flows in the same direction during rotation of the loop and it is known as direct current generator.

To obtain alternating current (A.C.), we use instead of half circles, a circular ring (slip ring), due to which the AB arm of the armature is always joined to brush B1 and CD arm to the brush B_2. Therefore, when the direction of the current in the loop is ABCD, then in the external circuit it flows from B_2 towards B_1 and when the direction is DCBA, then in the external circuit, it flows from B_1 towards B_2.Thus, the direction of current reverses with every half rotation of the loop. This type of current, which periodically reverses its direction, is known as alternating current or A.C. The assembly to produce such type of electricity is known as alternating current generator.

Questions

1. What is an electric generator?
2. Write the principle on which an electric generator works.
3. What is a circular dual changer?

Keywords

Dual pole magnetic compass, magnetic field, straight conductor, magnetic lines of force, solenoid, neutral point, dynamo or generator, alternating current, direct current, half circle dual changer, slip ring, Maxwell's rule, Fleming's left hand rule,Fleming's right hand rule.

What We have learnt

- Compass needle is a small magnet whose one end always points towards North direction and is known as North Pole. The other end pointing towards south is called the South Pole.
- The magnetic axis and the geographical axis of earth are bent at an angle of 17° to each other.
- The intensity of magnetic flux surrounding a magnet indicates the power of the magnet.

- The magnetic field is represented by magnetic lines of force. A line of force is a circular curve along the tangent of which an imaginary unipolar North Pole travels.
- The lines of force are concentrated where the intensity of magnetic field is high.
- Two lines of magnetic force never intersect each other.
- At the neutral point, the magnetic field of the magnet is equal but opposite to the earth's magnetic field.
- A magnetic field is associated with a current carrying conductor. The lines of force form concentric circles around the conductor and their direction is determined by the left hand rule.
- Solenoid is a coil formed by numerous turns of insulated copper wire.
- The electromagnet has a core of soft iron around which a coil of insulated wire is wound tightly.
- When a current carrying conductor is placed in a magnetic field, it experiences a force, and the direction of this force is determined by Fleming's right hand rule.
- Electric motor is a device to convert electrical energy into mechanical energy.
- Electric motor works on the principle of force created on a conductor by a magnetic field.
- Electromagnetic induction is a phenomenon where induced generated by varying the intensity of magnetic field in a conducting coil. The direction of induced current is determined by the Right hand rule of Fleming.
- Electric generator or dynamo converts mechanical energy to electrical energy.
- Dynamo works on the principle of electromagnetic induction.

Exercise

1. Choose the correct option

   (i) The magnetic lines of force determine,

   (a) shape of the magnetic field (b) direction of the field

   (c) intensity of the magnetic field (d) intensity and direction of magnetic field

   (ii) A straight current carrying conductor has a magnetic field

   (a) lines of force parallel to the conductor

   (b) lines of force perpendicular to the conductor

   (c) lines of force in concentric circles around the conductor

   (d) lines of force starting radially from the wire end

   (iii) A solenoid has a magnetic field inside it, which is

   (a) different at each point (b) same at each point

   (c) zero (d) None of the above

(iv) electromagnetic induction is a phenomenon to

(a) charge any matter (b) rotate a coil
(c) produce magnetic field in a coil
(d) to produce induced current when either coil or magnet moves.

(v) We can generate electric current using–

(a) Generator (b) Motor
(c) Galvanometer (d) Ammeter

2. Fill in the blanks

(i) That device which converts mechanical energy into electrical energy is ....

(ii) .... converts electrical energy into mechanical energy.

(iii) Fleming's left hand rule indicates the direction of ....

(iv) Fleming's right hand rule indicates the direction of .... acting on the conductor.

(v) Maxwell's left hand rule indicates the direction of ....

3. Which scientist gave the principle of electromagnetic induction?

4. A magnetic field is created around a conductor when current flows in it. Which scientist first confirmed this phenomenon?

5. List three appliances that use electric motor.

6. Write the right hand rule of Fleming.

7. List the three ways in which a magnetic field can be produced.

8. How does a solenoid act as a magnet? Can you determine its North and South poles by help of a bar magnet?

9. Write the three chief properties of a magnet.

10. What are magnetic lines of force? Write the three main properties of lines of force.

11. Why two magnetic lines of force do not intersect each other?

12. Determine the electric motor under the following headings,

(a) labelled diagram (b) working principle (c) working process

13. Describe the electric generator under the following headings,

(a) labelled diagram (b) working principle (c) working process

14. Two circular coils A and B are kept near each other. If the current flowing in coil A is varied, would a current be induced in coil B. Answer giving reasons.

15. Connect an insulated copper coil to a galvanometer. What will happen if a bar magnet is,

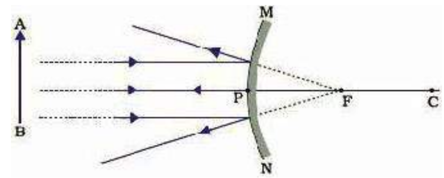
(a) moved inside the coil (b) kept stationary in the coil (c) moved outwards from inside the coil

16. Write the rule which represents the direction of magnetic lines of force produced by a straight conductor.

17. Make an electromagnet

CHAPTER 13

LIGHT: REFLECTION & REFRACTION AT SPHERICAL SURFACES



In the previous chapter, we have learnt about the laws of reflection & refraction at plane surfaces. We also did some activities to observe the phenomena of refraction. Can the same laws be applied to understand reflection & refraction from spherical surfaces?

We will try to discover the answer to the above question in this chapter. We shall also perform experiments involving spherical mirrors and lenses.

13.1 Reflection from spherical Mirrors

Recall, that in class 7th, you had learnt how polishing the inside or outside of a hollow sphere turns it into a mirror. The inner surface of a hollow sphere is called its concave side and the outer surface is called its convex side. If the inner side is polished with silver, then we get a Convex mirror. Alternatively, if the outer side of sphere is polished then we get a Concave Mirror.

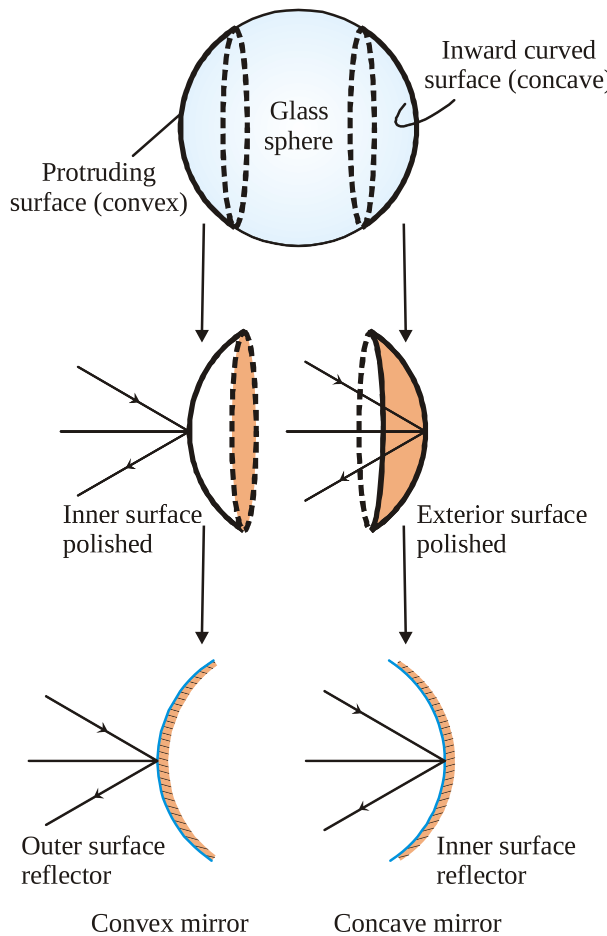


Figure-1: Spherical mirror

Activity-1

Take a serving spoon made of stainless steel. Bring the outer surface of spoon closer to your face and observe. Can you see the image of your face in the spoon? Is the image same as the one you see in a plane mirror, or is it different? Is the image inverted? Is the image bigger, smaller or of the same size as the object (your face)?

Now observe the same characteristics of the image from the inner side of the spoon. You might observe that the image is bigger and erect (not- inverted). Now slowly increase the distance of spoon from your face. May be you will now observe the that the image is inverted. You can repeat the experiment and try to observe the image formation of a Pen or pencil from the two sides of the spoon.

13.1.1 Some important definitions related to spherical Mirrors

The centre of the reflective surface of a spherical mirror is called its POLE and this point is denoted by the letter P in diagrams. Pole is situated on the surface of the hollow sphere from which the mirror has been made. As you know, a spherical mirror is a polished part of a hollow sphere, therefore the Centre of the hollow sphere is called the centre of curvature of the Mirror, and is denoted by C in diagrams. "C" is not a part of the surface of sphere, it lies outside the surface. The distance between C & P, which is also the radius of the hollow sphere is called the Radius of curvature of the spherical mirror. It is denoted by "R" in diagrams.

The line passing through the Centre of Curvature "C" and pole "P" is called the principal axis. It is perpendicular to the Pole because any line through centre of a circle is perpendicular to the circumference. The diagram represents the cross section of a spherical lens which is a circle.

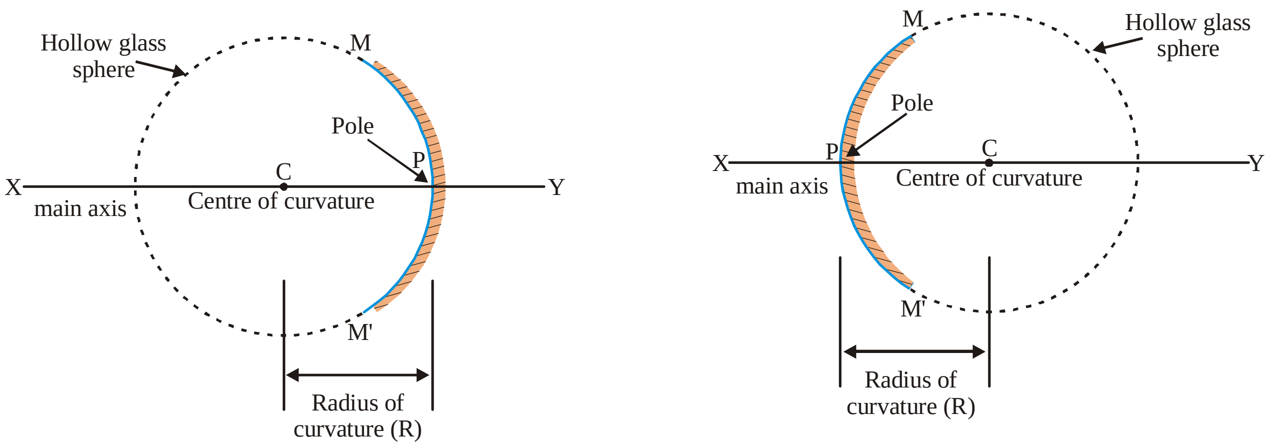


Figure-2

Another important location in the discussion of spherical mirrors is the FOCUS. To understand the concept of focus, let's perform an activity.

Activity-2

Take a concave mirror and place its so that the reflecting surface is facing towards the sun. The light coming from sun gets reflected from the mirror. We will try to obtain the reflected light on a piece of paper. Place a paper in front of mirror and adjust its position till a very sharp bright point is seen. This is the image of sun, formed from the mirror and obtained on the paper (which acts as a screen to obtain image). What will happen if this arrangement of paper and mirror is maintained for some time?

The image of the sun formed has been obtained on a screen outside mirror, so it is a Real image.

The point at which the image is obtained is called the focal point of the mirror. As you can see, the focal point lies outside the mirror. The focal point is indicated in diagrams by the letter "F".

In the case of concave mirror, light rays coming parallel to principal axis converge after reflection at the focal point F. In the case of convex mirror, Rays coming parallel to principal axis, appear to be coming from the focal point. The image formed in case of a convex mirror cannot be obtained on screen and is called a Virtual Image.

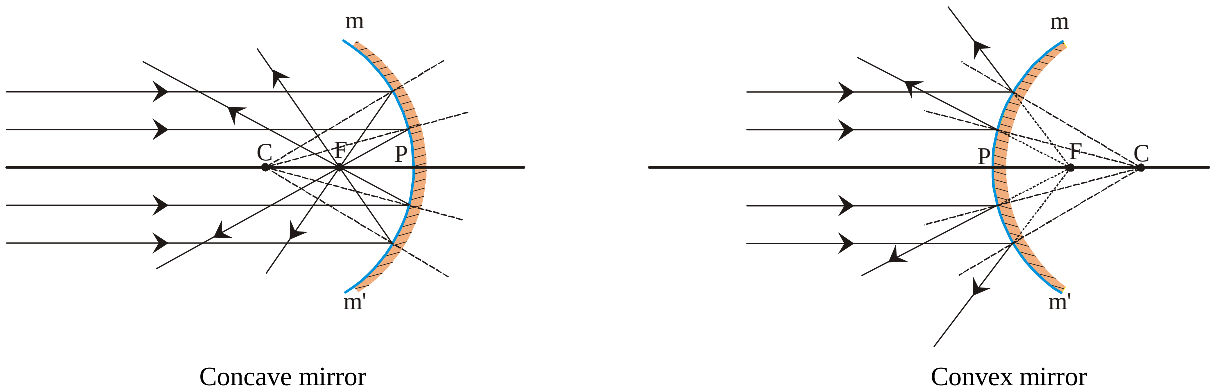


Figure-3

The distance between Pole P and focal Point (or Focus) F of a spherical mirror is called the focal length of the mirror and is denoted by "f".

The boundary of the curved surface of a spherical mirror is called its aperture. In figure-2, mm' represents the aperture of the mirror.

For mirrors with small aperture, the focal length "f" is half of the radius of curvature "R". Mathematically, $R = 2f$. In other words, (for small aperture mirrors) the focal point is the mid-point of the line joining the centre of curvature C and Pole P.

13.1.2 Laws of Reflection at Spherical Surfaces

In the previous chapter, we had learnt the laws of reflections. These laws apply uniformly to all surfaces - plane & curved. If we know the angle of incidence of a ray of light on a curved surface, then we can get information about the angle of reflection as well. The angle of incidence is the angle between the incident ray of light and the normal to the surface. To understand the concept of normal on a curved surface, Let us perform an activity.

Activity-3

Take a hollow rubber ball and cut it into two halves. As shown in the figure, put some pins on the inner and outer surfaces of the ball. All these pins are perpendicular (or Normal) to the surface of the ball on the point where they have been inserted. In the case when pins are put on the outer surface of the ball, they appear to diverge from each other, while, the pins inserted on the inner face appear to converge in the same direction.

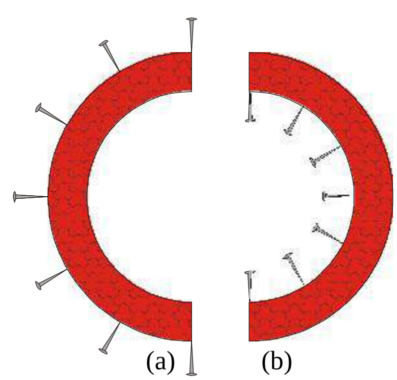


Figure-4

From this, we can get an idea of what happens to the normal on the surface of a spherical surface.

A convex mirror is like the outer surface (Figure- 4a) of the ball and a concave mirror is like the inner surface of the ball (Figure- 4b).

The point where pins appear to meet is called the Centre of curvature of concave mirror. According to geometry, any line passing through the centre of a sphere to its surface its Normal to that point on surface.

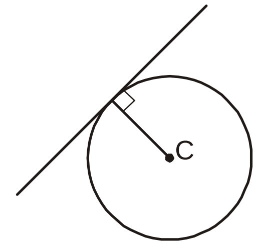


Figure-5

Discuss

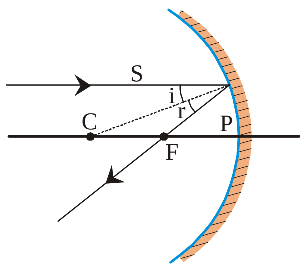


Figure-6

Why do the light rays falling on a convex mirror appear to be coming from a point while those falling on a concave mirror meet at a point.

For the light ray S, the angle of incidence is equal to the angle of reflection. $\angle i = \angle r$.

13.1.3 Sign convention for Reflection at spherical surfaces

For the study of reflection at spherical surfaces, we will follow a fixed sign convention system called the Cartesian coordinate sign convention. In this convention, we take the pole P to be the origin and the principal axis (XX') as the X axis. The following features of this convention must be kept in mind:

(i) The object is always placed towards left hand side of the mirror. This means that light from the object travels towards right and gets reflected and then travels towards left side direction again.

(ii) All measurements taken in X-direction are measured through the pole and parallel to Principal axis.

(iii) Distances measured towards right side of the pole (along +X axis) are taken to be positive and those measured towards left (along +X axis, or against the direction of travel of incident light) are taken to be negative.

(iv) The distances measured perpendicular to X-axis, in upwards direction (+Y-axis) are taken to be positive.

(v) The distances measured perpendicular to X-axis, in downwards direction (–Y-axis) are taken to be negative.

The above sign convention is represented pictorially below. This sign convention will be used in deriving the mirror formulae and in solving problems.

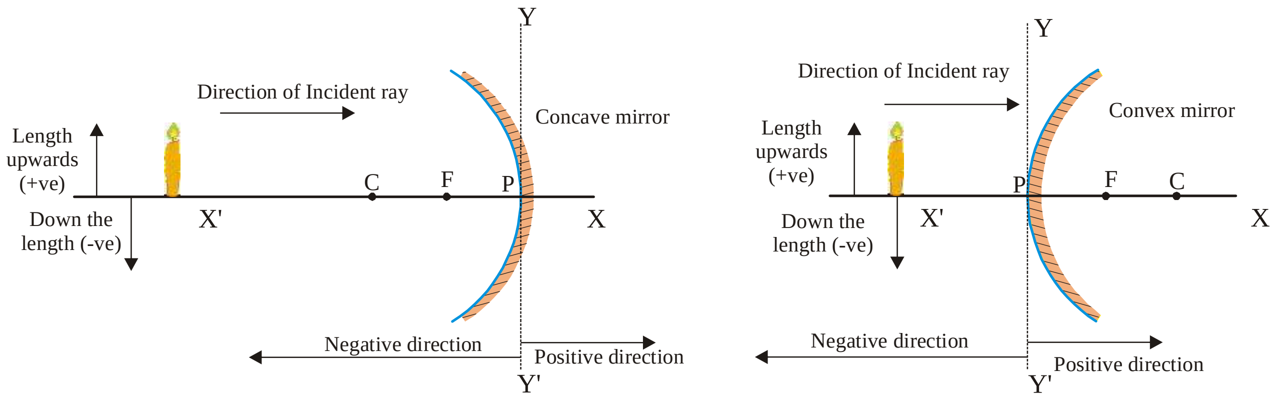


Figure-7

13.2 Laws of Image formation from spherical mirror

1. The light rays incident on the mirror parallel to the principal axis:

   (a) Converge at the focal point (before travelling away from there), in the case of concave mirror.

   (b) Appear to be coming from the focal point, in the case of convex mirror.

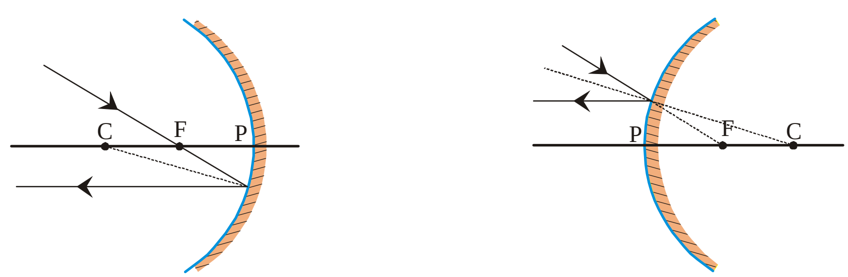
(a) Concave mirror (b) Convex mirror

Figure-8 (a)

2. The light rays, which:

   (a) Pass through the focus of concave mirror, travel parallel to principal axis after reflection.

   (b) Appear to travel towards the focus of a convex mirror, travel parallel to principal axis after reflection.



(a) Concave mirror (b) Convex mirror

Figure-8 (b)

3. We know that light rays incident normally on a mirror retrace their path after reflection. Therefore:

   (a) Light rays travelling through the centre of curvature "C" retrace their path after reflection, in the case of concave mirrors.

   (b) Light rays that appear to be directed towards the centre of curvature "C", for a convex mirror, retrace their path.

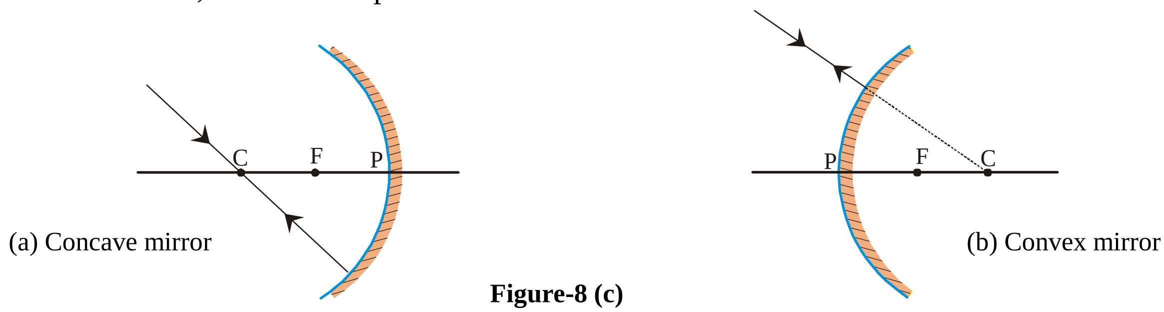


Figure-8 (c)

4. When a ray of light is incident on the pole, making some angle with the principal axis, then after reflection, it makes the same angle with principal axis in the opposite Y-axis side. This is because the Principal axis is Normal to the mirror at the pole P.

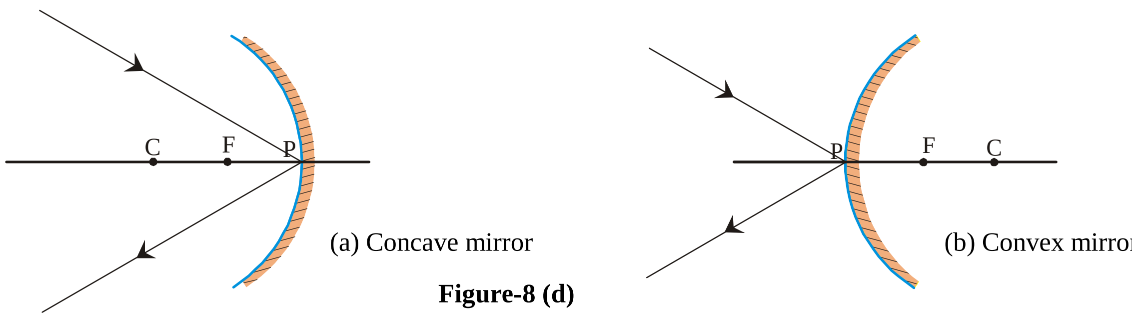


Figure-8 (d)

13.2.1 Image formation by Spherical Mirrors

Now, we will perform an activity to understand the Size, Position and orientation of image of an object formed by spherical mirrors.

Activity-4

White paper, V-Stand, Meter scale, Concave Mirror with known focal length, candle.

Procedure: Place the concave mirror on the V-stand and arrange the mirror, Candle, meter-scale and paper as shown in the diagram below. If V-sand is not available, then place some pins on a piece of thermocol to firmly hold the mirror.

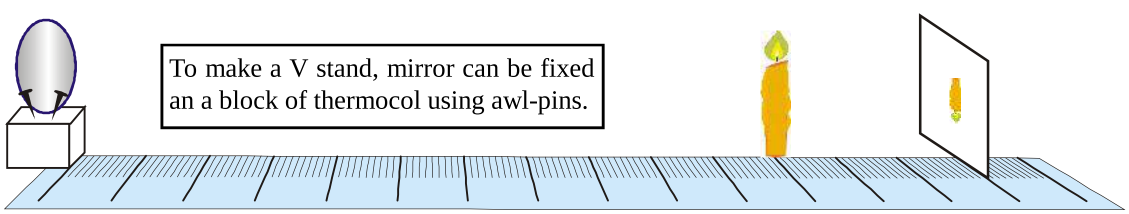


Figure-9

Vary the location of the candle and the paper to obtain a sharp image of the candle on the paper. When a sharp image is obtained, take down the readings and fill the table given below.

Table-1

S. No	Candle-Mirror Distance (u)	Paper-Mirror Distance (v)	Size of Image in comparison to object (Larger, Smaller, Same)	Image orientation (Erect/ Inverted)	Nature of Image (Real/ Virtual)
1	At infinity				
2	Beyond C				
3	At C				
4	Between C & F				
5	At F				
6	Between F & mirror				

In this activity, the Candle was an object, and the paper acted as a screen on which we tried to obtain image of the object. From the above activity, we can say that the Size, Position, Nature, & orientation of the Image depends on the position of the Object with respect to the mirror. For some cases, the Image is virtual and cannot be obtained on the paper, while for others the image is Real. Depending on the position of the object, the image can be larger/smaller/of same size as that of the object. To further understand the concept of image formation, let us try to make ray-diagrams for different positions of the object with respect to the mirror.

To see the real image, you have to place your eyes in a location from where your eyes can receive the light coming from the image. It is impossible to see the image from the backside because no light from the image is travelling in that direction. If you place a screen at the exact position of the image, then the screen will display the image and now it is possible to look at the screen from backside because screen is reflecting the light of the image in that direction.

However, If the image is virtual image, then you have to look into the mirror as it cannot be obtained on the screen.

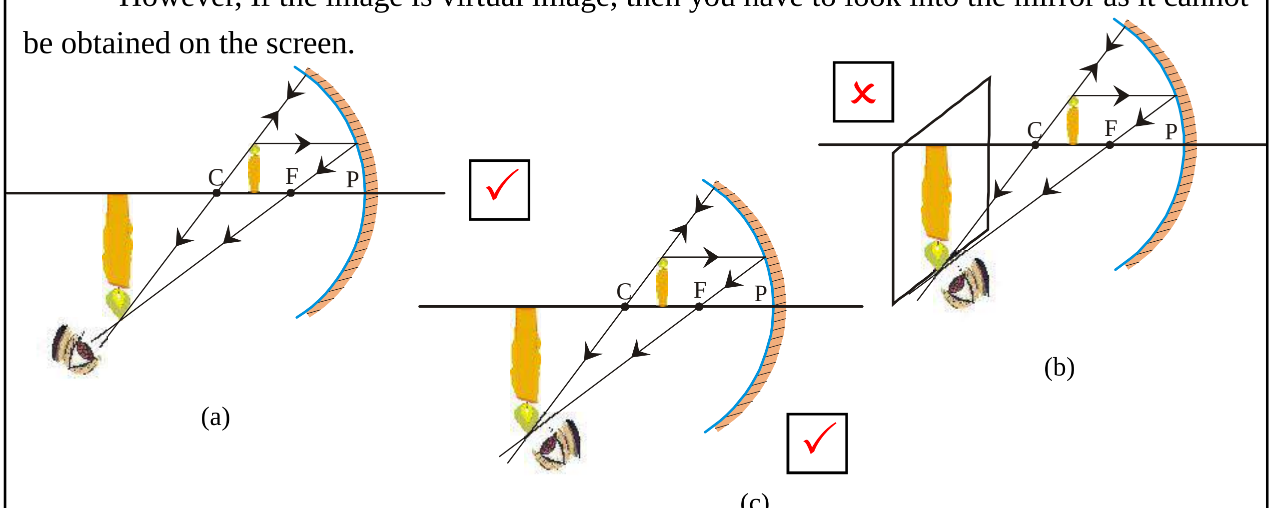
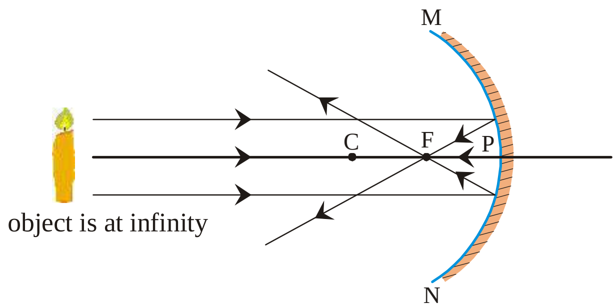


Figure-10

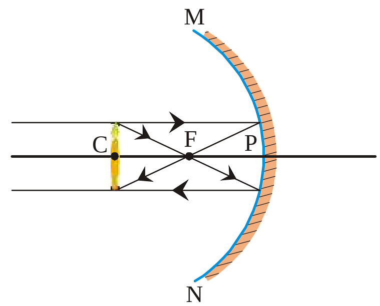
13.2.2 Ray Diagrams for different positions of the object

Based on the experience from Activity-4 and the knowledge of laws of reflection for spherical surfaces, try to draw ray diagrams for the image of the candle by assuming the candle in different positions.

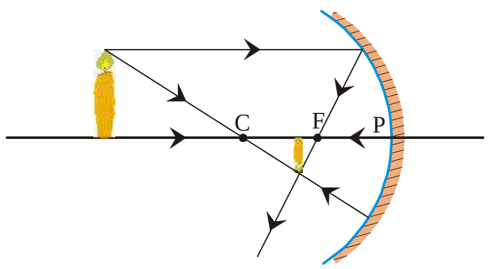
(a) Ray Diagram for Concave Mirrors



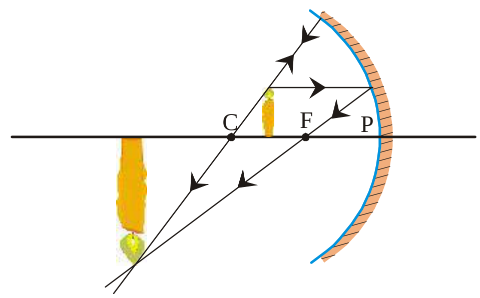
(i) When the object is at infinity



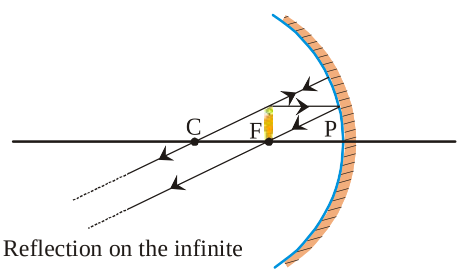
(ii) When the object is at C



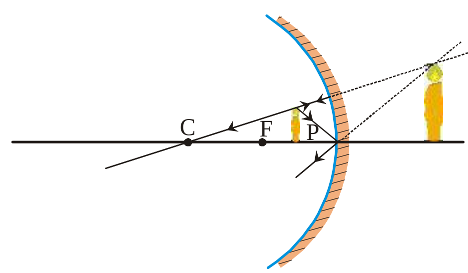
(ii) Behind the object C



(iv) When the object is between F and C



(v) On the object F



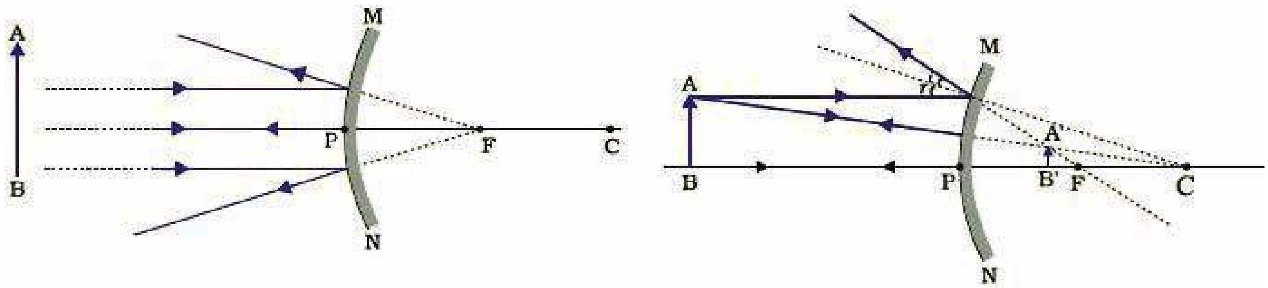
(vi) When the object is between F and the mirror

Figure-11

(b) Ray diagrams for convex mirrors

For the study of image formation by convex mirrors, we will allow two types of position for the object. Firstly, the object can be placed at infinity and second, at a finite distance from the mirror.

Fill table-2 for the size, position, orientation of image formed by a convex mirror. You can take the help of figure-12 for this.



(a) When the object is at infinity (b) when at a finite distance from the mirror.

Figure-12

Table-2

S.No.	Mirror-candle Distance (u)	Image-Mirror distance (v)	Size of Image in comparison	Image orientation (Erect/ Inverted) to object (Larger, Smaller, Same)	Nature of Image (Real /Virtual)
1	At infinity				
2	Between infinity & P				

In concave mirror, the reflected light rays actually meet at a point, while in plane mirror and convex mirrors, they only appear to be coming from a common point. The position, Size, etc. of a Virtual image is found by extending the light rays in the ray-diagram backwards. This artificial extension is shown by dotted lines.

Did you note that Real image is always inverted and virtual image is always erect?

Question

- How can you differentiate between a plane, convex & concave mirror by either touching the mirror or observing image formations?

13.2.3 Relation between Parameters for spherical mirrors

For different positions of the object placed in front of a spherical mirror, the position of the image and size of the image also varies. Can we find a relation between the various parameters involved in image formation, so that we can calculate the image properties? First of all, let's classify the various parameters into - variables & Constants of the mirror.

1. Variable: These are those quantities which can change in value for each instance of image formation.
2. Fixed: These are those quantities that hold the same value once the mirror & object have been chosen. They can only be changed if the mirror is changed.

We begin by tabulating these properties.

Variables	Fixed
Focal length of mirror (f)	Object-mirror distance (u)
Radius of curvature (R)	Image-Mirror distance (v)
Object height (h)	Height of Image (I or h')
Magnification (m)	

Now, let's try to understand the relation between them.

13.2.4 Relation between focal length (f) and radius of curvature (R)

We shall try to arrive at a relation between f & R, using previously learnt Mathematical knowledge and by drawing ray diagrams for a concave mirror.

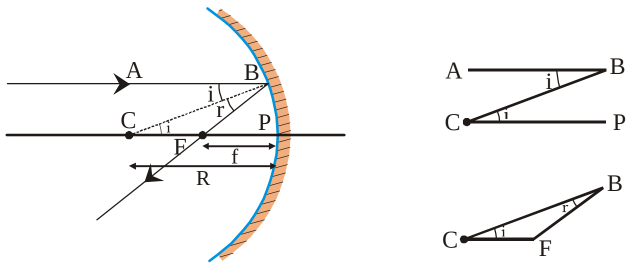


Figure-13

Take a concave mirror with centre of curvature C, pole P, focus F and axis CP. From the diagram, we can see that ray AB parallel to axis CP gets reflected along BF direction. We know that the line CB will be normal at B.

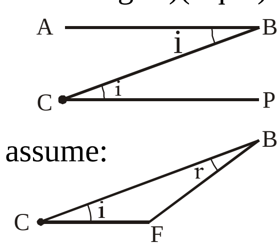
Therefore:

$\angle ABC = \angle CBF$ (from law of reflection) (Eq. 1)

$\angle ABC = \angle BCF$ (Because AB || CP, and CB is transversal. Alternate interior angles)(Eq. 2)

So, in $\angle CBF$, from (Eq. 1 & Eq. 2), $\angle BCF = \angle CBF$

Hence, CF = BF (Because $\angle CBF$ is isosceles triangle) (Eq. 3)



If the mirror is small and point P is very close to point B, then we can assume:

BF = PF (Eq. 4)

From (Eq. 3 & Eq. 4): CF = PF.

Also, CP = CF + FP = PF + FP

(from Eq. 5) = 2 PF

So, PF = $\frac{PC}{2}$. In other words, focal length = (½) Radius of curvature

$$f = \frac{R}{2}$$

This relation is valid for all spherical mirrors, convex & concave. The only condition is that the Radius of curvature should be very large so that the points B & pole P can be assumed to be close enough.

13.2.5 Relation between object distance (u), image distance (v) and focal length (f): Mirror Formula

The distance of object from pole P is called the object distance (u), distance of image from the pole is called image distance (v), and distance between the focal point F & pole P is called the focal length of the mirror.

These three quantities are related by the mirror formula, given below.

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$$

This relation holds true for all spherical mirrors. While solving Questions, take care to insert u, v, & f in the mirror formula with proper signs (+ or -) using the Cartesian sign convention system.

For concave mirror, u & f are always negative. For real image formation to take place, v will be negative. If v is positive, then it means that the Image is virtual.

13.2.6 Magnification (m)

Magnification produced by a spherical mirror is the proportional change in the size of the image as compared to that of the object. It is expressed as the ratio of the height of the image to the height of the object.

If height of the object is (h) and that of the image is (I), then magnification is given by:

$$m=\frac{I}{h}$$

It can also be expressed in terms of the object distance (u) & image distance (v).

$$m=\frac{(I)}{(h)}=-\frac{\text{v}}{\text{u}}$$

It is obvious that this is a measure of the proportional change in size. We know that for a given mirror and object, the object height (h) is fixed, but with change in the position of the object, the image height (I) can change.

If I = h, then, m = $\frac{I}{h}=1$

If I > h, then, m = $\frac{I}{h}>1$

If I < h, then, m = $\frac{I}{h}<1$

Please note that h is taken as positive because usually, the object is place on the principal axis and standing upwards. For virtual image, the image height should be taken as positive and for real images as negative. This means that magnification will be positive for virtual images and negative for real images.

13.2.7 Uses of spherical mirrors

(a) Uses of concave mirror

Usually, concave mirrors are used in Torch, Searchlights and headlights of vehicles to obtain a parallel beam of light. They are also employed as shaving mirrors to obtain a large image of face. Dentists use this type of mirror to obtain magnified image of tooth. Large sized concave mirrors are used to focus sunlight in solar power plants.

(b) Uses of convex mirror

The mirror that you see on the side of a car, which the driver uses to see the image of vehicles behind him are convex mirrors. They are used as rear view mirror because they always form erect image, not inverted. But the disadvantage is that the image is smaller than the object. Since they are curved in a manner bulging outwards, they have a larger field of view than the concave type. Some super markets have now installed large concave mirrors at the turning so that two customers don't collide.

Example-1: An object is placed at a distance of 10 cm from a convex mirror with focal length 15 cm. Find the position, size and orientation of the image.

Solution: Focal length of convex mirror (f) = 15 cm

Object distance (u) = –10 cm

(Here the negative sign has been taken as per convention)

Mirror formula : $\frac{1}{f}=\frac{1}{u}+\frac{1}{v}$

Putting values of u and f with proper signs, we get:

$$\frac{1}{15}=\frac{1}{-10}+\frac{1}{v}$$

$$\frac{1}{v}=\frac{1}{15}+\frac{1}{10}$$

$$\frac{1}{v}=\frac{2+3}{30}$$

$$\frac{1}{v}=\frac{5}{30}$$

$$\frac{1}{v}=\frac{1}{6}$$

V = 6 cm

$$= m=\frac{-v}{u}$$

$$= m=\frac{-6}{-10}$$

m = 0.6

So we conclude by saying that a mirror of focal length 15cm, forms the image of an object placed 10 cm away from it, at a distance of +6 cm from the mirror. The size of the image is 0.6 times the size of the object. Also, since the magnification produced is positive, we can say that the image will be virtual and erect.

13.3 Refraction at spherical surfaces

You would have seen many people wearing spectacles for correcting their vision. Have you ever touched the surface of the glass used? Is it thicker on the sides or thicker in the middle?

In the previous chapter, we had learnt about refraction at plane surfaces. In this chapter we extend our understanding of refraction phenomena to curved surfaces.

13.3.1 refraction by lenses

Lens is a transparent medium covered by two sides. At least one of the sides is curved. Such type of lenses either converge a parallel beam of light to a point of diverge the light away.

If a lens has both sides concave, then it is called a bi-concave (or concave) lens. If a lens has both sides convex, then it is called a bi-convex (or convex) lens. Bi-concave lenses are thinner in the centre and thicker on the sides. Bi-convex lenses are thicker in the centre and thinner on the sides.

In all our discussions, we will discuss only those lenses which are called thin lenses - it means they can be either concave or convex, but the thickness of the lens is negligible. So, the thickness of lens will not be a part of our calculations.

13.3.2 Some definitions related to spherical lenses

Each of the two surfaces of a spherical lens is part of a sphere. Since, lenses have two surfaces, there are two centres of curvature for a lens. These are called C_1 & C_2. The distances of the centre of lens (equivalent of pole of mirrors) to the centres of curvature are called the radii of curvature R_1 & R_2. The line joining C_1 & C_2 is called the principal axis and centre of lens (o) is called the Optical centre of lens.

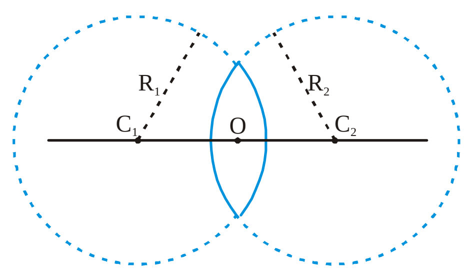


Figure-14

The effective diameter of the curved surface of a lens is called its aperture.

- Can you find the focus of a lens? Try repeating Activity-2 with lenses.

  Think: what happens when a parallel beam of light is passed through a lens.

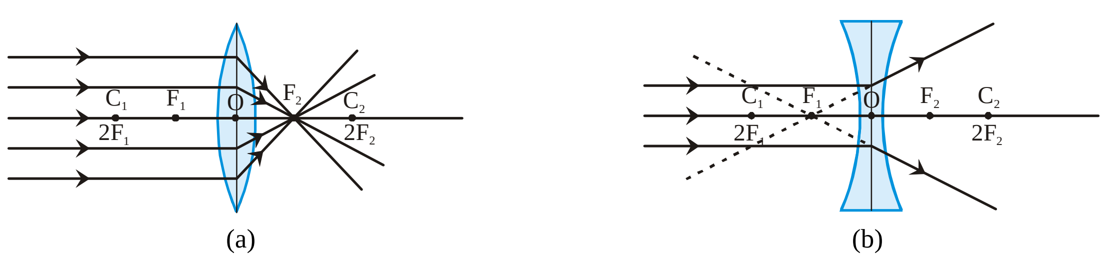


Figure-15

Observe figure 15 (a) carefully.

A beam of light parallel to principal axis converges at a point after refraction through the lens. The point of convergence on the principal axis is called Focus (F_1) of the lens. The distance between optical centre O and focus F, is called the focal length f of the lens.

A bi-concave lens is made up of two spheres bent towards inside. It is thin in the centre and thick at the sides. When a beam parallel to the principal axis of such a concave lens gets refracted due to the lens, then the rays diverge. The refracted rays appear to be coming from a point on principal axis, called the focus point (F_1) of the concave lens. Both, Convex and concave lens have two foci, which are at equal distances from optical centre O and on the opposite side. The foci are situated mid-way between the optical centre and the centres of curvature. This means, R = 2 f, Radius of curvature is double the focal length of the lens. The focal plane is the plane which is perpendicular to the principal axis and passes through the focus point.

13.3.3 Sign convention for spherical lenses

For lenses, we will use a sign convention similar to that used for spherical mirrors. We will use the same rules. The measurements in case of mirror was taken from the pole of mirror. Similarly, in the case of lenses, all measurements will be made from the optical centre of the lens. According to this convention, the focal length of convex lens will be taken to be positive and that of concave lens will be taken as negative. All measurements above principal axis will be positive while those below will be negative. We will always draw diagram so that light travels left to right. Measurements taken towards right will be positive and that towards left will be taken as negative. For all calculations, the quantities must be used with their proper signs, positive or negative.

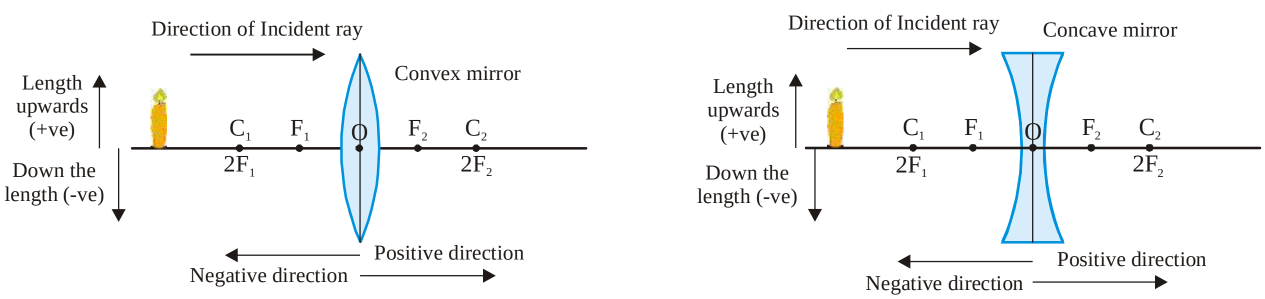


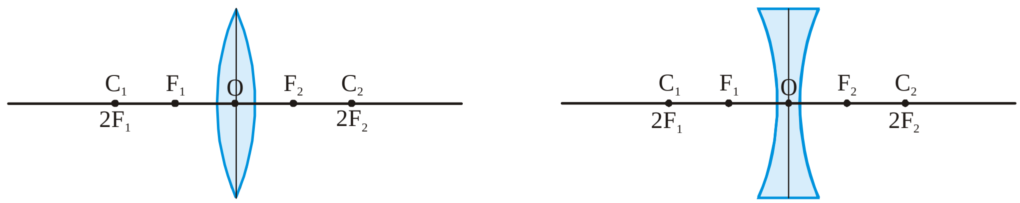
Figure-16

13.3.4 Rules for image formation by lenses

Because we are considering lenses with negligible thickness, so we can treat two surfaces of the lens as one.

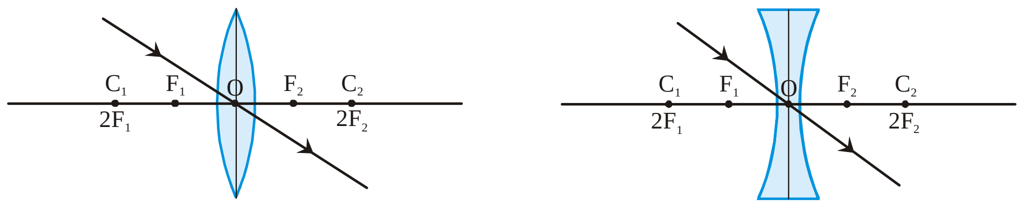
As per the rules of refraction, analyse the ray diagrams given below. Discuss amongst your-selves-

- What will happen to a ray of light travelling along the principal axis as it gets re-fracted by the lens?



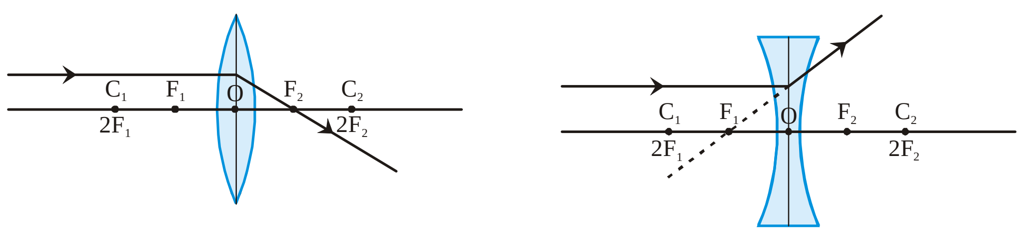
(a) Convex mirror (b) Concave mirror

- What will happen to a ray of light passing through the optical centre?



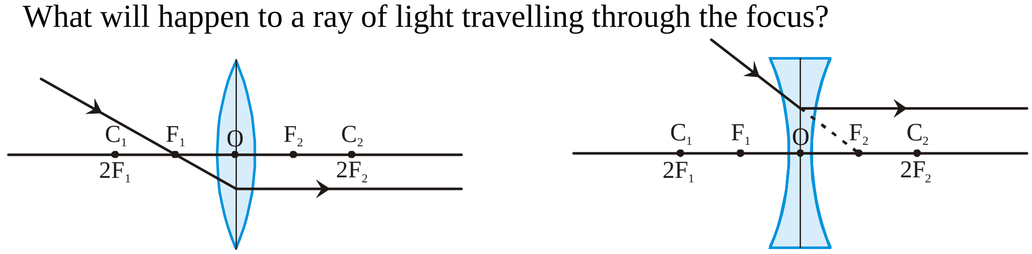
(a) Convex mirror (b) Concave mirror

- What will happen to a ray of light travelling parallel to principal axis?



(a) Convex mirror (b) Concave mirror

- What will happen to a ray of light travelling through the focus?



(a) Convex mirror (b) Concave mirror

Figure-17

Think about another situation. What will happen to a parallel beam of light passing through the lens, if it is inclined at some angle to the principal axis?

In this case, the light rays will appear to diverge from a point on the focal plane for concave lens. The light rays will converge at a point on the focal plane for convex lens.

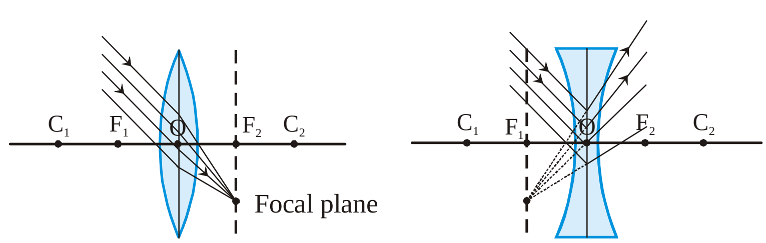


Figure-18

13.3.5 Image formation by lenses

Activity-5

Take a convex lens and find out its focal length or take a convex lens with known focal length.

Now set the lens near a scale on a V-stand, like we did in Activity-4 for mirror.

Mark both foci of the lens as F_1 & F_2 on the scale, using a chalk. Similarly mark distances $2F_1$ & $2F_2$.

Put a burning candle much behind $2F_1$. Obtain an image of the candle on a screen kept on the opposite side of the lens. Note down the size, position and orientation of the image.

Put candle in various locations, as mentioned in the table below, observe the image and fill the table.

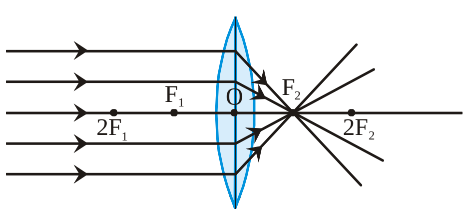
Table-3

S. No.	Candle-Mirror Distance (u)	Paper-Mirror Distance (v)	Size of Image in comparison to object (Larger, Smaller, Same)	Image orientation (Erect/ Inverted)	Nature of image (Real/Virtual)
1	At infinity				
2	Beyond $2F_1$				
3	At 2F1				
4	Between $2F_1$ & F_1				
5	At F_1				
6	Between F_1 &optical centre				

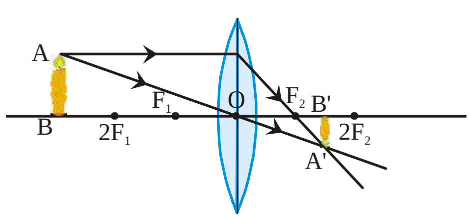
13.3.6 Ray diagrams for images formed by lenses for various object positions

(A) Ray diagrams for convex lens

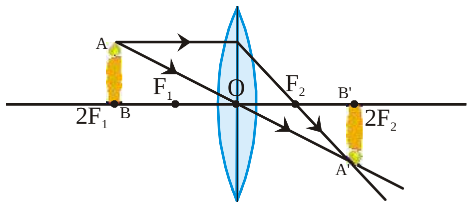
The ray diagrams for image formed by varying object position for a convex lens, as per the table-3, are given below: (Insert figure 19 here)



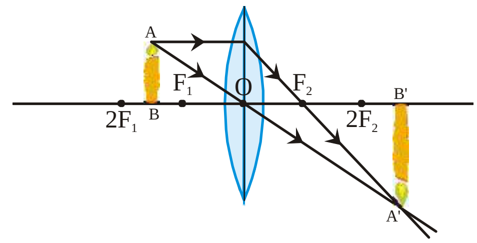
(i) When the object is at infinity



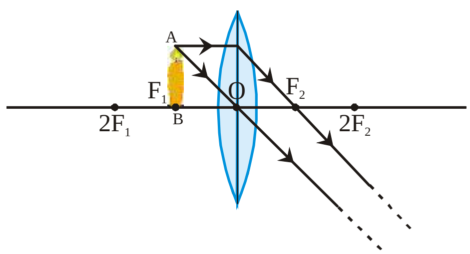
(ii) Behind the object $2F_1$



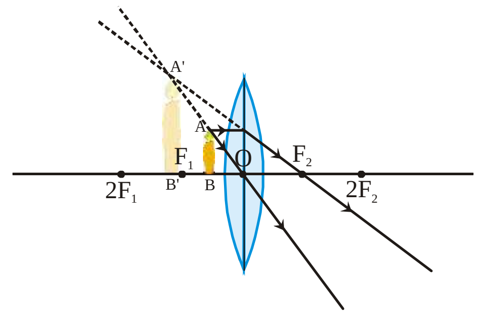
(iii) On the object $2F_1$



(iv) When the object is between $2F_1$ and F_1



(v) On the object F_1



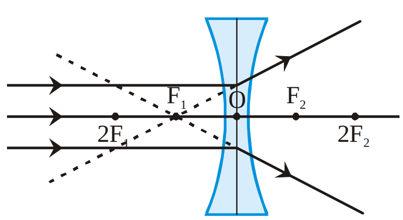
(vi) When the object is between F_1 and optical center

Figure-19

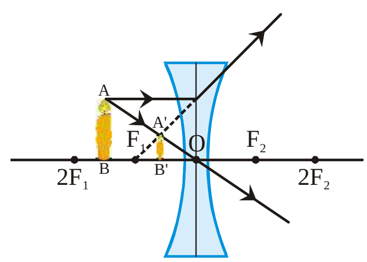
When the object is placed between Focus and optical centre, then we get a Virtual, erect, magnified image on the same side of the lens where object is placed. This characteristic of the convex lens is exploited in making simple microscopes or magnifying glasses. When the object is placed at a distance less than focal length, then the image appears magnified.

(B) Ray Diagrams for concave lens

As done above, make ray diagrams for various positions of object on the principal axis of a concave lens. You will find that for all positions, the image is virtual, erect, smaller than the object and the image is located between the focus & optical centre of concave lens.



(i) When the object is at infinity



(ii) When object is between infinity and optical center O

Figure-20

According to ray diagrams, fill table-4 given below with the position, size, orientation and nature of image.

Table-4

S. No.	Mirror-candle Distance (u)	Image-Mirror distance (v)	Size of Image in comparison to object (Larger, Smaller, Same)	Image orientation (Erect/ Inverted)	Nature of Image (Real/ Virtual)
1.	At infinity				
2.	Between infinity& optical centre				

13.3.7 Relation between parameters for lenses

Like we did for mirrors, we will first tabulate the parameters and study them.

S.No.	Fixed	Variables
1.	Focal length of Lens (f)	Object-mirror distance (u)
2.	Radius of curvature of Lens (R)	Image-Mirror distance (v)
3.	Object height (h)	Height of Image (I or h')
4.	Power of lens (P)	

13.3.8 Relation between object distance (u), Image distance (v) and focal length of Lens (f): Lens Formula

Just like we saw a formula relating u, v & f for mirrors, there is a relation between these 3 quantities for lenses as well. It is called Lens formula and is expressed as:

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

The above relation holds true for all spherical lenses and in all cases of image formation. While solving the questions, take care about the proper signs of u, v & f.

13.3.9 Magnification (m) produced by a lens

Like a mirror, the magnification produced by a lens is the ratio of height of the image to the height of the object and is denoted by the letter 'm'. If the height of the object is h, and height of image is h', then:

$$m = \frac{height\ of\ image}{height\ of\ object} = \frac{h'}{h}$$

Magnification can also be expressed in terms of the object distance and image distance as:

$$(m) = \frac{h'}{h} = \frac{v}{u}$$

13.3.10 Power of lens

By now, you know that the function of a lens is to refract (bend) the light rays passing through it. A convex (converging) lens bends the rays towards the principal axis while a concave (diverging) lens bends them away from the principal axis. The power of a lens to converge or diverge light rays, depends on its focal length. Lenses with less focal length bends light more than lenses with more focal length. Therefore, less focal length means more power and Vice-versa.

On the basis of above discussion, we can say that Power of a lens is inversely proportional to its focal length (f - measured in Meters). Power of a lens is denoted by the letter "P". The power of a lens whose focal length is f-meters is given by:

$$Power\ of\ lens\ (P) = \frac{1}{focal\ length\ (f)}$$

The SI unit of Power is called Diopter (D). 1 Diopter = 1/(1 m) . or,

1 D = 1 m-1

So, the power of a lens whose focal length is 1 m, will be 1 Diopter (D).

Because focal length of a convex lens is taken to be positive, its power will be positive. Similarly, because focal length of a concave lens is taken to be negative, its power will be negative.

Practically, when ophthalmologists make corrective-eye glasses, they express lens characteristics in terms of Power of lens and not the focal length. If the power of a lens is given to be +4.0 D, then the positive power suggests that the lens is a convex lens and its focal length can be calculated as under:

$$Power\ of\ lens\ (P) = \frac{1}{focal\ length\ (f)}$$

So, focal length (f) = $\frac{1}{P} = \frac{1}{4.0}$

= 0.25/D = 0.25 m = 25 cm.

So, the focal length of a lens with power 4.0 D will be 25 cm and the positive power means that the lens is a convex lens.

13.3.11 Uses of lenses

We use lenses in many forms in our daily lives. The spectacle use concave, convex, or mixed type of lenses. Even water drops function like a convex lens. Similarly, water or other transparent liquid kept in transparent containers act like lenses. The transparent gems (like Diamond etc.) used in ornaments also act like lenses.

The use of concave or convex lenses is seen in many optical instruments like camera, projector microscope, telescope, etc. The eyes of humans and animals too use a lens to form image of the outside world.

Example-2: A convex lens has focal length 10 cm. An object, 2 cm long, is kept at a distance of 15 cm from the lens. Find the position, size, orientation of the image and the magnification produced by the lens.

Solution: Given: focal length = +10 cm (since lens is convex),

h= 2 cm,

u = –15 cm (using proper sign convention).

We know the lens formula,

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

On putting values of f and u, we get:

$$\frac{1}{10} = \frac{1}{v} - \frac{1}{-15} \qquad = \frac{1}{v} + \frac{1}{15}$$

$$\frac{1}{v} = \frac{1}{10} - \frac{1}{15} \qquad = \frac{3-2}{30} \qquad = \frac{1}{30}$$

The positive sign of v indicates that the image is Real and inverted. Also,

$$m = \frac{h'}{h} = \frac{v}{u}$$

$$\frac{h'}{2} = \frac{30}{-15}$$

$$h' = \frac{-30 \times 2}{15} = -4 \text{ cm}$$

We know that magnification is given by:

$$m = \frac{v}{u}$$

$$m = \frac{30}{-15}$$

m = –2

This means that the image will be two times bigger than the object. Since h = 2 cm, h' = 4 cm.

The negative sign of magnification again confirms that the image is real and inverted.

13.4 Some optical instruments made using Lenses

1. **Photographic Camera:** A camera not only produces the image of objects but also captures it for later use.

A camera is made of plastic or metal with the internal body kept completely Black. Towards the front end of camera, is a converging lens whose focus can be adjusted. This lens has less focus and is called the objective. This lens forms a perfect image of the objects facing it. Behind this lens is a screen with a tiny hole in it. This controls the amount of light entering the camera and forms the image on a photographic film. The shutter controls the time duration for which the film is exposed to the incoming light. The object, whose image is desired, is kept at a distance more than twice the focal length of the objective lens. This results in a small, real, inverted image being formed on the photographic film.

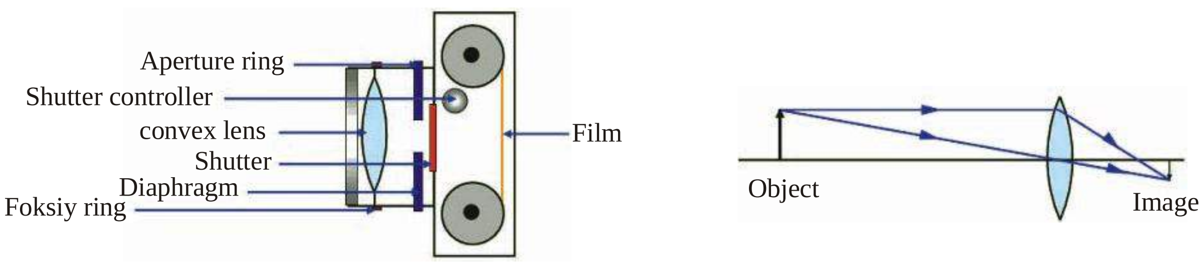


Figure-21 (a)

2. **Microscope:** A convex lens is called a microscope and is used as a "Reading lens" or "magnifying lens". A convex lens with very small focal length is called a simple microscope. If a combination of lenses is used, then the assembly is called a compound microscope.

Simple Microscope: When the object is placed between the optical centre and focus of lens, then the image is magnified, virtual and erect.

Compound Microscope: It is built by inserting a Lens L1in a hollow pipe. This lens is kept towards the object. This is called the objective lens. Another hollow pipe is mounted on this hollow pipe and the position of both pipes can be adjusted by sliding mechanism. This new hollow pipe has a lens L2 Mounted on it. The lens L2 is called the eye piece and is used by the observer to see. The objective lens has smaller aperture and focal length than that of the eye-piece lens. In this assembly, the objective forms a magnified image A'B' of the object AB. The image A'B' works like an object for the eye-piece which forms another magnified image A"B". This is the final image that observer sees.

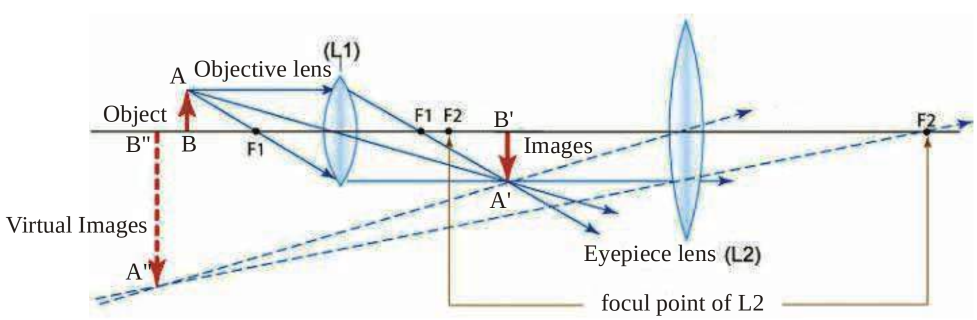


Figure-21 (b)

3. **Telescope:** It is a device used to view far away objects. It can be used to view far away objects on earth or even celestial objects like sun, moon etc.

Astronomical Telescope: There are two convex lenses L_o - the objective and L_e - the eye piece. The effective focal length of telescope is equal to $F_o + F_e$, whereFo is the focal length of the objective and F_e is the focal length of the eye piece.

When the object PQ is far away, the objective forms an image P'Q' at its focus. This image serves as the object for the eye piece. The eye piece forms the image P"Q" of the object which is real, inverted and magnified.

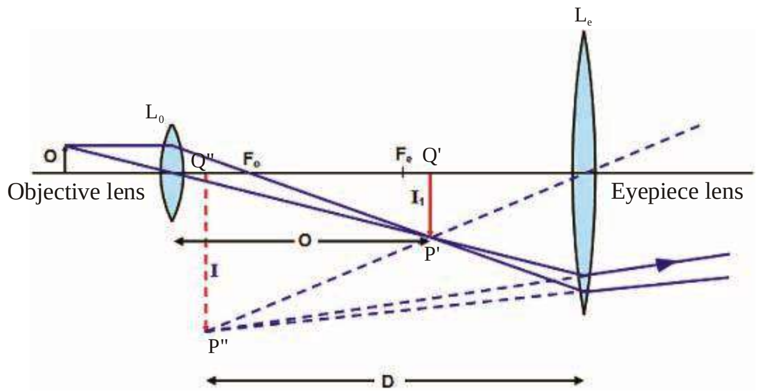


Figure-21 (c)

Keywords

Concave mirror, convex mirror, Pole, focus, focal length, centre of curvature, radius of curvature, principal axis, Lens, convex lens, concave lens, aperture, Eye piece, objective lens

What we have learnt

- Spherical mirrors and lenses form image of objects placed before them. Depending upon the position of object, the image can be real or virtual.
- All reflective surfaces obey the laws of reflection. All refractive surfaces obey the laws of refraction.
- Cartesian sign convention is used for spherical mirrors and lenses.
- Mirror formula relates object distance (u), image distance (v) and focal length of the mirror (f) as: $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$

- The focal length of a spherical mirror is half its radius of curvature. $f = \frac{R}{2}$
- Magnification produced is defined as the ration of height of image to the height of object.

  $m = \frac{h'}{h}$
- The speed of light is different in different media. In vacuum, speed of light: c = 3 × 10^8 m/s.
- Lens formula relates object distance (u), image distance (v) and focal length of the lens (f) as:

  $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
- The power of a lens is defined as the inverse of its focal length (taken in meters). The SI unit of power is Diopter D. $Power\ of\ lens\ (P) = \frac{1}{focal\ length\ (f)}$

Exercise:

1. Choose the correct option-

(i) Concave lens is -

(a) Only diverging (b) only converging

(c) Neither converging nor diverging (d) Both converging & diverging

(ii) If a mirror forms erect image for objects placed between pole and focus, and it forms Real-Inverted image for object placed anywhere between focus and infinity, then the mirror is-

(a) Concave (b) convex

(c) Plane (d) Convex or Plane

(iii) The image formed by convex mirror is always-

(a) Smaller than object (b) Larger than object

(c) same sized as object (d) Real

(iv) The image formed by a convex lens is always-

(a) smaller and virtual (b) larger and erect

(c) smaller and inverted (d) smaller and real

(v) The focal length of a concave lens is 40 cm. For an object placed 40 cm away from the lens, the image will be formed at-

(a) Infinity (b) 40 cm from lens on the opposite side

(c) Behind the object (d) Between object and lens

(vi) A lens is kept on the book and then raised by 3 cm. The text now appears erect and larger. The focal length of lens is-

(a) 3 cm (b) Less than 3 cm

(c) more than 3 cm (d) 1/3 cm

2. Fill in the blanks:

   (i) The image formed by convex mirror is always .... and ...., in all cases.

   (ii) To obtain a real image of same size as object, from a convex lens, the object must be placed at ....

   (iii) The power of a lens is +5.0 D. The focal length of the lens will be .... cm.

   (iv) The focal length of a convex lens is 25 cm. The power of this lens will be .... D.

3. Write down the relation between radius of curvature and focal length of a spherical mirror.

4. In what type(s) of mirrors is the linear magnification less than 1, equal to 1 or greater than 1.

5. The rear-view mirrors used in vehicles are convex mirrors. Why?

6. If image is to be obtained on a screen, what type of mirror should be used?

7. By drawing the ray diagrams for parallel incident beam of light, express what type of mirrors are converging & what type are diverging.

8. Define the following for spherical mirrors:

   (i) Centre of curvature (ii) Radius of curvature (iii) Pole (iv) Aperture

9. Write a note on the converging and diverging nature of lenses.

10. What is power of a lens. Write its unit.

11. Write down the sign convention used for lenses.

12. What will be the power of a convex lens of focal length 50 cm? What if the lens is concave?

13. An object is placed at 15 cm from the pole of a concave mirror of focal length 10 cm. What is the size, position, nature and magnification of the image? **(Ans: v = -30, m= -2)**

14. The radius of curvature of a convex mirror is 30 cm. An object of height 5 cm is kept at a distance of 10 cm from the pole. Find the nature, size and magnification of image.

    (Ans: v = 6 cm, I = 3cm).

15. The focal length of a concave mirror is 10 cm. To obtain an image 5 times bigger than the object, where should the object be placed so that the image is (i) Real (ii) Virtual.

    (Ans: (i) u = –12 cm, (ii) u = –8 cm)

16. The radius of curvature of a convex mirror is 30 cm. What will be the size, position and nature of the image if the object is placed at 12 cm from the pole. Do the same calculation for a concave mirror? (Ans: (convex) v = 6.66 cm, (concave) v = 60 cm).

17. The image of an object kept at 30 cm from the pole of a convex mirror forms at 10 cm. What is the focal length of the mirror?

18. The focal length of a concave mirror is 12 cm. If the object is placed at focus, where will the image be formed?

19. The focal length of a convex lens is 15 cm. Where should be the object placed to obtain a Real image 3 times magnified. **(–20 cm))**

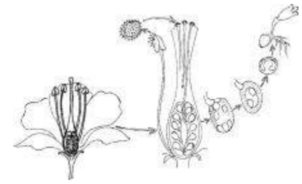
20. The focal length of a concave lens is 30 cm. What will be the position and size of the image if a 30 cm long object is placed at the focus. **(V=15,h'=15cm)**

21. For an object kept at 30 cm from a concave lens, the magnification achieved in 2/3. What is the focal length of lens? **(–60 cm)**

22. For a convex lens of focal length 50 cm, what is the position of image if the object is placed at a distance of: (i) 25 cm, (ii) 75 cm , from the optical centre. **(–50 cm, 150 cm)**

23. What is the focal length of a lens whose power is +1.5 D? **(50 cm)**

24. What is the power of a concave lens of focal length 20 cm? **(–5D)**



CHAPTER 14

LIFE PROCESSES: REPRODUCTION, GROWTH AND DEVELOPMENT

You had studied in class 9 that all living organisms are made up of cells which originate from pre-existing cells. You had also studied that the unfertilized eggs of animals and egg cells of plants are single cells. You know that seeds are formed from plant egg cells or ovules and germination of seeds require certain conditions like adequate water, air etc. You may also have had the experience of observing a plant growing from a small seed and an animal from a fertilized egg.

- If an unfertilized egg is a single cell, are fertilized eggs composed of several cells?
- Are seeds composed of several cells too?

You may be surprised to know that, a fertilized egg is a single cell till the process of division starts in it.

The fertilized egg starts dividing in the womb of a human female nearly 2 to 30 hours after fertilization. Divisions of fertilized eggs of hens start within 3 hours of fertilization while in several flowering plants the division starts in about 24 hours after fertilization.

- Does fertilization have any role in triggering the process of division?
- Is the role of male and female essential for the process of reproduction?
- Does reproduction produce off springs (or children) that are exact copies of their parents?
- Is reproduction essential for the life of an individual animal?
- Does growth and development have anything to do to reach reproductive phase?

We shall try to seek answers to such questions in this chapter.

All life processes go on in a coordinated and controlled manner in all living organisms. Life processes like nutrition, transport, respiration, excretion, growth and development are essential for the survival of living organisms. Reproduction gives rise to variations. Though this process is not essential for the survival of an individual living organism of a particular species, it is essential for the survival of the species as a whole.

Come let us study about the structures involved and the process of reproduction, growth and development mainly in humans (as an example of animals) and plants.

14.1 Reproduction, Growth and Development in Human beings

It is easy to distinguish between human males and females as various external characters are distinct in them. This is observed in several other organisms as well. Let us study the roles of male and female forms in the process of reproduction.

14.1.1 Reproduction: role of male and female forms

We find a sustained role of both human males and females from fertilization to organization and development of human off-springs. Such process of reproduction in which we find the role of males and females is called as sexual reproduction.

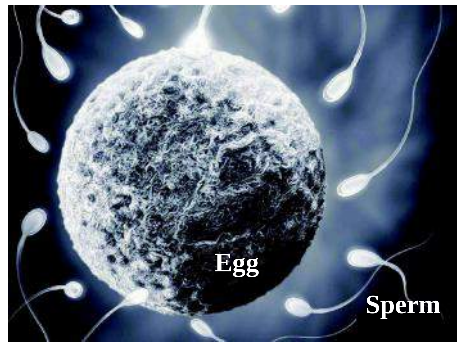


Figure- 1: Human female and male reproductive cells or gametes

As we know human life as several others, starts from a single fertilized cell. People were curious about the nature of this fertilized entity, even before the discovery of cells. They had several questions in their mind like-

- Do the male and female reproductive entities carry a small human form in them?
- Does the male entity carry all factors responsible for the development of the offspring while the female only provides for favourable conditions for the same?

For over a thousand years people have been debating over such questions. In the 17th century some scientists proclaimed that the egg itself had everything essential for life. Then, what was the role of male body and the male reproductive cell? With the development of microscopes scientists could take a closer look at microscopic structures. They did not find any small human form in these reproductive entities. They found that the male reproductive entity or sperm was small, had a nucleus and very little food resources in it. They also found that it had a long tail and it could swim upto the egg which had a nucleus surrounded by large amount of resources. Nearly 200 years ago, the proponents of cell theory, Schleiden, Schwann and Virchow made extensive studies of reproductive entities of animals and plants. They found that both the male and female reproductive cells were cells. They remarked that the role of both male and female reproductive entities were same as both were cells and contributed equally to the development of the offspring. These cells were later called as gametes (from the latin word 'gamos' meaning marriage). During this time it was also becoming clear that parental characters were passed on through these cells to the off-spring. Scientists of the time had also started proposing that the nucleus of gametes contained certain elements through which characters were passed on from one generation to the next.

It was observed that the nuclei of female and male gametes fused during fertilization. The cell thus formed (with fused male and female cells and their nuclei) was called as zygote (from Greek word that meant 'yolky'). The nucleus of the zygote contains a collection of hereditary material of parental reproductive cells. This nucleus contains information for the formation of the body of the off-spring.

We observe the role of male and female bodies in the formation of zygote in many living organisms. Distinct difference in the male and female individual bodies of several organisms is seen as in humans. The male and female bodies bear the male and female reproductive organs respectively in which reproductive cells or gametes are produced. In some other organisms like the earthworm, leech, most plants etc. the male and female reproductive organs are borne at different locations on the body of the same individual. The role of male and female can be found in several types of organisms like most vertebrates, several insects (like locusts, butterflies, houseflies, ants etc.), molluscs (snails, mussels etc.), most flowering plants, mosses, ferns etc. All such organisms reproduce sexually and role of both male and female reproductive cells is essential in such organisms. In contrast to this, in asexual form of reproduction as we see in yeast, bacteria, flatworms, several plants (like potato, grass etc.) the role of both male and female reproductive cells is not essential.

Do you know?

The generation of a type of south American lizard continues through just the females unlike most other types of lizards where both male and female forms are present. These lizards do not have male forms in any generation.

Let us study about the organization of the human male and female body and the changes that undergo in them to understand the fundamental processes that occur in the male and female bodies.

14.1.2 Growth and Development in humans

You may have observed infants growing up and wondered how a small child grows into a big individual.

Let us try to collect some data related to our body to find out about growth.

Activity-1

Find out the length of the palm and height of any child in your house or in the neighborhood as well as that of you. Carry the filled in table to class and compare the values of any of your friend (x in the table show sections you don't need to fill).

Fill in the values in the following table and compare the ratios-

Table 1: Ratios of body part

S.No.	Member	Height (H)	Length of palm (L)	H_1/H_2*	L_1/L_2*	L_1/H_1*	L_2/H_2*
1.	Small child						x
2.	You					x	

*Small child L_1, H_1, You L_2, H_2

- Compare yours and the small child's ratio of palm length to height obtained in the last two columns. Are they similar or different?
- What do you think this ratio might be showing?

- What does the ratio H_1/H_2 and L_1/L_2 show?
- Do you think our palm grows as fast as our height?
- Compare your ratio of palm length to height with that of your friend in school. Compare values in the last column). Is it more similar to you friend than the small child?
- On the basis of these observations can we say that our body grows in some proportion which gradually changes over time as we grow?
- Can we also say that some parts of our body grow faster than others?

Think, how many more cells are added to our height in comparison to our palm length. There are two different types of data that we collect and compare with the help of this table. One, the ratio of two different parts of our body that is, length of palm and height which indicates that parts of our body are in a particular proportion that varies slightly according to age. The other is data that gives us an idea about the rate of growth of different parts of our body.

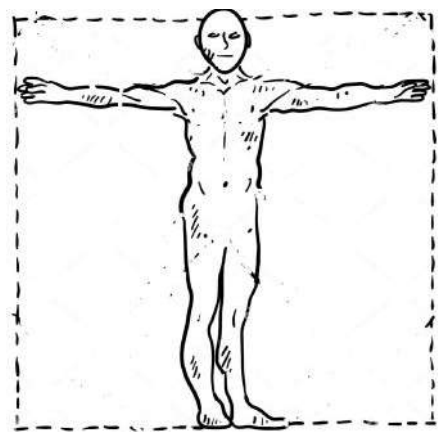


Figure-2: The human body in square

These types of observations have been made in the past as well and a drawing (like the one in Figure-2) made about 500 years back shows that our hand span and our height are same, thus a human body could fit in a square.

- Find out the values of these dimensions of your body and check if your body fits in a square as shown in the figure.

As we grow we find that certain parts of our body grow faster while certain others slowly. Gradually an adult body takes shape. During this process plenty of cells are added. Growth of our body takes place when several cells are added leading to a gradual increase of mass over time.

A graph plotted to show the change in mass of a human body over time from mothers womb to adult stage is shown in Figure 3. This thus shows growth over a particular period of time or simply the rate of growth.

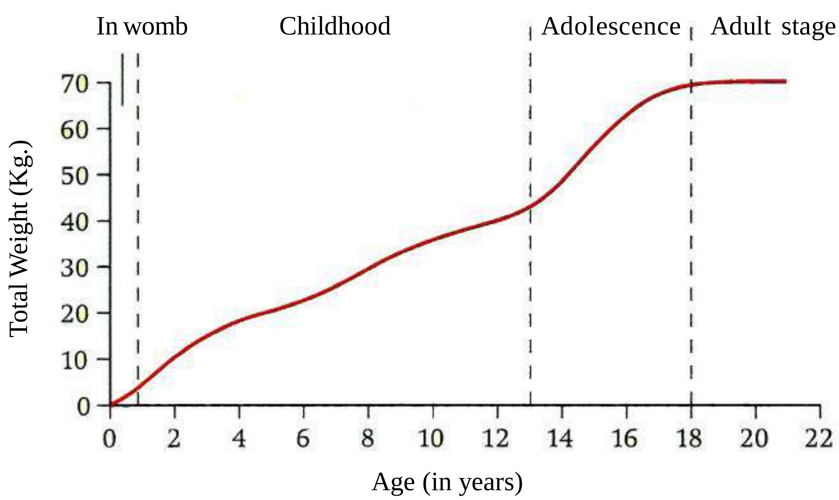


Figure- 3: Change in mass of human body (infant to adult) plotted against time

- Observe the graph and say when was growth fastest in this individual?
- What was the age after which the rate of growth slowed down?

We find that the rate of growth of various parts of our body differs. We would find that even when growth may have ceased in certain locations it may continue in others. Let us take a look at our palm.

- Do you think the growth in the area between the fingers had ceased when that in fingers continued?

Even in a child growing in the womb of mother, different parts of the body like hand, legs etc. form due to difference in rate of growth. Difference in rate of growth in different parts of our body thus leads to the development of different parts of our body.

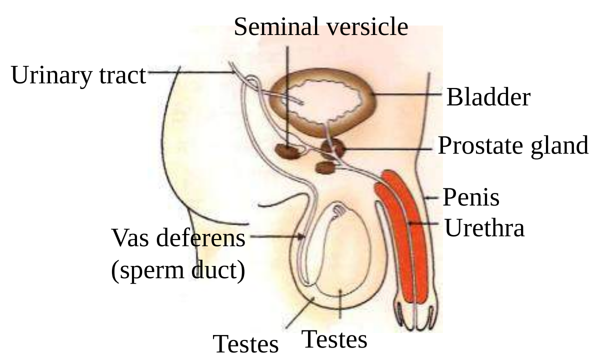
14.1.3 Development and growth of male and female body

Development and growth brings about various changes in the body.

- What changes do you find in you now as compared to when you were in the primary section at school?

Our body changes as we grow. Around the age of 11-14 years we often find various changes taking place in our body. Along with mass there is a marked change in our height. Our reproductive organs grow and develop. Certain hormones like testosterone in males and estrogen in females are released. They stimulate functioning of reproductive parts and also aid in development and growth. Muscles grow in certain areas of our body like that on our breast (more prominently in girls), thighs etc. Hair grows in our armpits and over our reproductive areas like vagina, base of penis etc. Often acne develops on the face.

There may be behavioral changes as well. We become more conscious of our body and have several questions regarding it in our mind. When we fail to get proper answers we often show irritation. This phase of our life is called as adolescence (in Latin, it means to become mature). In human males, voice becomes low pitched, beard and moustache starts growing while in females mammary organs grow and become prominent. Changes in behavior or changes on our body are easily visible. But we hardly come to know about changes inside our body. As for example, we know that a child develops in the womb but we do not know about the changes that take place inside it and other organs of the female reproductive system in preparation for development of child. We would have to know more about our reproductive parts where internal changes take place during adolescence. See figure 4 that shows us the location of parts of female and male reproductive organs and the connections between them.



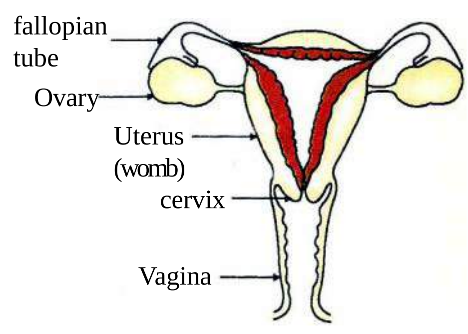


Figure- 4: The human male and female genital organs

- Observe the figure and make a list of all parts of the female reproductive system.
- Make a list of all the parts of male reproductive system.

The reproductive organs in both males and females mature during a addescence. Sperms are produced in coiled tubes inside the testes (If the coils were opened and laid out they would be around 500m long). Over 2000 lakh sperms are produced per day. Testes are found hanging in scrotal sacs outside the body. Here the temperature is lower than that of our body that helps the sperms to remain preserved.

A phase called menstrual cycle starts with the onset of adolescence is human femaly. Once every month an egg or ovum is produced by any of the ovaries. See Fig 5 for detail. Blood vessels and layers of tissue are laid in the inner wall of the uterus or the womb. This is a way in which the womb prepares for development of a child. If fertilization takes place, the development of child may continue for nearly 9 months. This phase is called as pregnancy. Menstrual cycle is arrested during pregnancy till a child is born and the body may get back to usual functioning. This is usually for a period of about 15 months from beginning of pregnancy. In case fertilization does not occur, the egg cell or ovum produced is shed off with blood and other tissues that are formed. Menstruation continues every month for nearly 35 years after reproductive maturity.

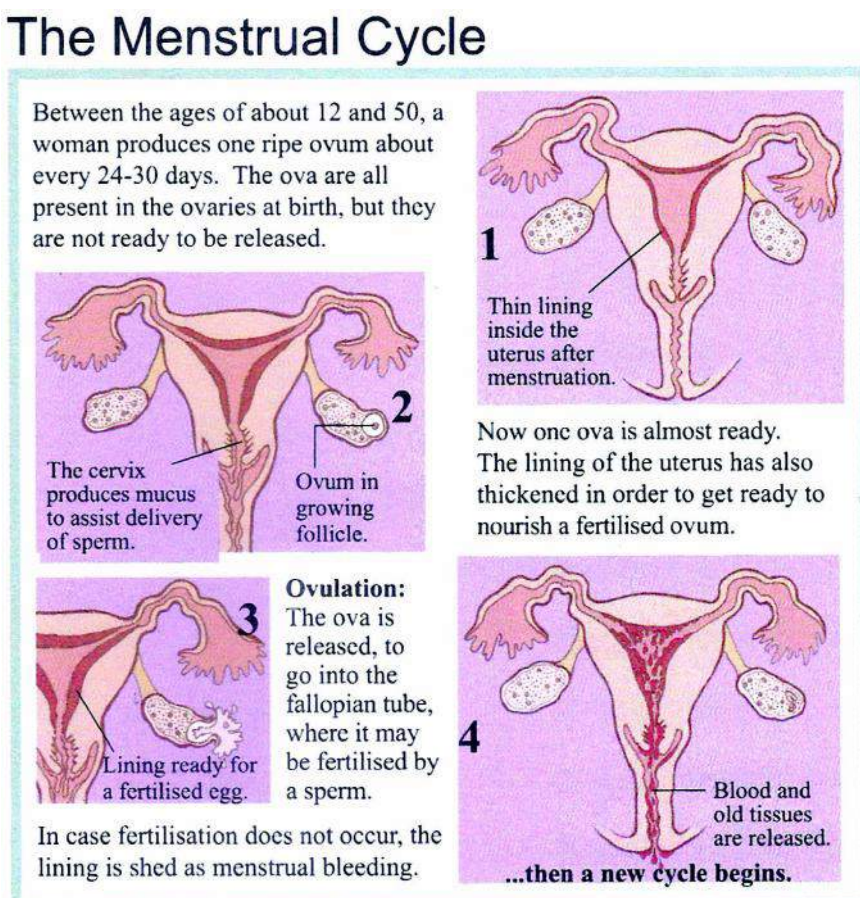


Figure- 5: Menstrual Cycle

The process of fertilization occurs via the vagina of the female. Lakhs of sperms are introduced into the vaginal passage by the penis. They travel into the fallopian tubes where the process of fertilization takes place. Only about one out of the thousands of lakhs of sperms get to meet an ovum and a successful fertilization occurs.

- But how are sperms and ovum formed?
- How are layers of cells laid in the uterus every month?
- How do we grow and how does development take place?
- We know that our body is formed of cells; do our cells increase in size or change in form when we grow?
- Do cells start dividing?

It has been observed that growth of our body is initiated mainly by division of cells as well as their increase in size. As for example in the body of a three month old child developing in the womb, four cells of the shoulder area start dividing faster than their neighboring cells and projections for hand are formed. Apart from this, it has also been observed that cells also start changing form and roles- a process we call as differentiation. As for example, cells of certain areas of the skin of a child developing in the womb are influenced by certain secretions of cells surrounding them. These skin cells transform to nerve cells under such influence.

We find similar processes of growth and development in plants as well. It is easy to observe plant growth and development in certain annual plants like pea, mustard etc. We can also observe the reproductive parts of some plants easily. Thus we shall do a few activities to study plant growth, development and reproduction.

14.2 Growth development and reproduction in plants

You have studied in earlier classes about reproductive parts of plants. Usually a flower bears the reproductive organs in plants.

Let us observe them once again

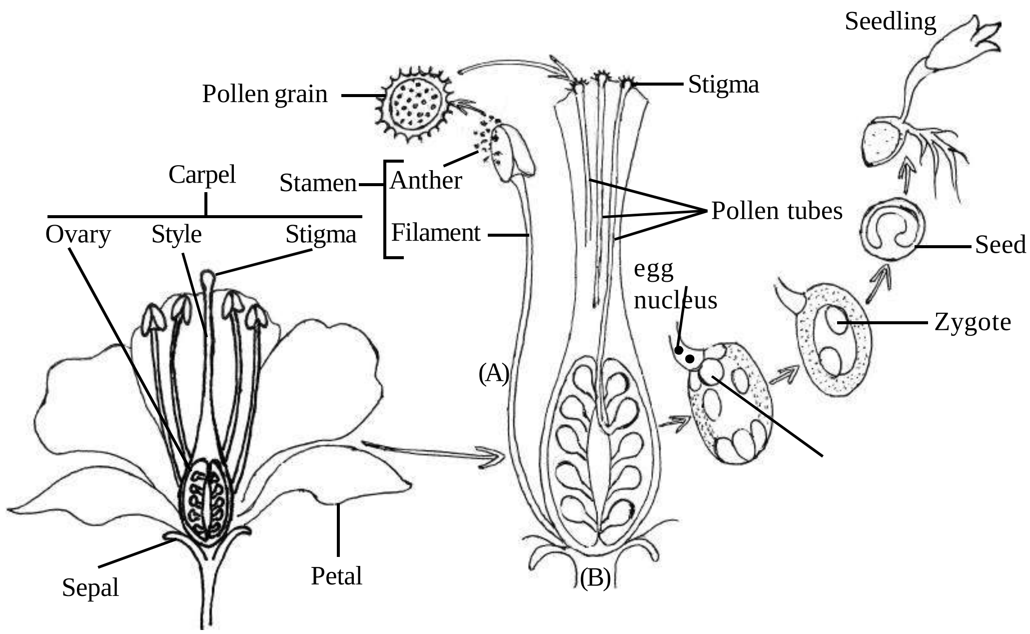
Activity-2

You would require a flower of dhatura or railway creeper, slide, brush, forceps, needle, petridish/watchglass, coverslip, hand lens, glycerine.

Take the flower in your hand and open it up (refer to the section of practical work for figure). Now observe the female and male reproductive parts. Figure 6 A and B shows the male and female reproductive organs of plants.

The male reproductive organ of a flower is composed of all the stamens present in the flower. Each stamen has a head formed of anther bearing pollen in pollen sacs. Pollen are structures that pass on to the stigma of the female reproductive part. The process of transfer of pollen from anther to stigma is called as pollination. If recognized on stigma they germinate to reach the ovule where the fusion of male and female nuclei takes place. Plants may be self- pollinated when pollen of a flower reaches the stigma of the same flower or other flower on the same plant. Cross pollination occurs when pollen from flower on one plant reaches stigma of flower on another plant and is recognized there.

The female reproductive organ of a flower is composed of all the carpels. A carpel is mainly composed of three parts called as stigma, style and ovary (see figure 6). Ovules are female reproductive cells or gametes present in the ovary. Ovules (after fertilization) develop into seeds.



Stages of development fertilization to formation of seedling

Figure- 6: (A) Male reproductive part (B) Female reproductive part

Now let us observe what happens after germination of seeds. For this you would have to grow some mustard seeds in a pot and observe them regularly to see the changes that occurs in the plant as it grows.

Activity-3

Take a few mustard seeds and sow them in a medium sized pot. Note this day as day 1.Water the pot everyday with around a cup of water. Observe the pot and see when the plants grow out of the soil. Note the day. Keep observing till the plants are around 30cm in length.

1. After how many days from sowing the seed did you find the plants grow out?
2. When did you find a pair of leaves growing on the plants?
3. When did the next pair of leaves grow?
4. Was there any change in the first pair of leaves as the plant grew taller?

As in humans, growth and development occurs in plants as well. We find that leaves grow at a time after germination and flowers and fruits grow at a stage which we call as the stage of maturity of plants. The mature plant is much larger as compared to the seed from which it grows.

14.3 The relation of cell division, growth and development

The weight of a mature body is thousands of crore times more than that of a reproductive cell. Thus growth leads to a massive accumulation of resources in our body. This happens in the body of most organisms. The rate of accumulation of resources varies from one organism to another. Accumulation of resources may lead to the change in size and shape of a cell or may also lead to its division. It may also influence the cell in any other manner. In multicellular organisms, the greater the number of cells more is the resource and differentation accumulated in the body.

Let us study about cell division to know more about this.

14.3.1 Growth and Development by Cell division and Differentiation

Cell division takes place continuously in our body in processes of repair, growth, defense etc. for example layers of new cells of our skin are formed by the process of cell division.

We had studied in class 9 that new cells come from pre-existing cells. Let us try to understand how this happens.

People have been trying to find out about this long back. Studies conducted in the past 300 years have helped us to understand the process of cell division better. Scientists found that certain cells in certain tissues appeared to be dividing very fast while in some others very slowly. They also found that in certain conditions of disease, cells appeared to be growing in an uncontrolled manner (Now, we call the state of uncontrolled division of cells as cancer.). This was a challenge for and they wanted to find out what happened inside the cells. While studying division of human blood cells, a doctor named Rudolf Virchow found that the information for cell division came from the nucleus (you have studied about role of nucleus in development of Acetabularia in class 9). He found that the division of the nucleus was followed by division of cytoplasm and cell membrane.

Figure 7 A and B are types of sketches that were drawn during 1850- 1860. These are illustrations of stages of Cell Division. A, B, C, D, E shows the various stages. During this time, Walter Fleming observed the nucleus of dividing cells and found that there were thread like structures in dividing cells. He thus named the process of division 'Mitosis' (the meaning of Mitosis in Greek is thread like). He found that cells divided to produce more cells like their own. Thus production of cells or reproduction of cells occurred by the process of cell division or 'Mitosis' according to Fleming.

We know now that most cells in the body of multicellular organisms divide by mitosis to give rise to more of their kind. Several unicellular organisms like yeast, bacteria, amoeba, paramecium etc. and certain multicellular organisms like plants, hydra etc. also reproduce by processes that are based simply on mitotic cell division.

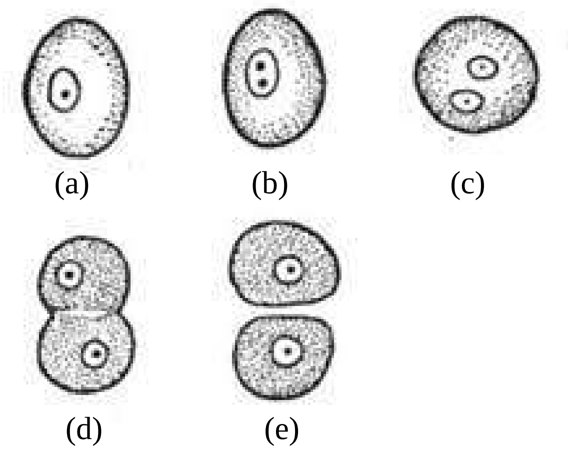


Figure- 7 (A): Cell Division

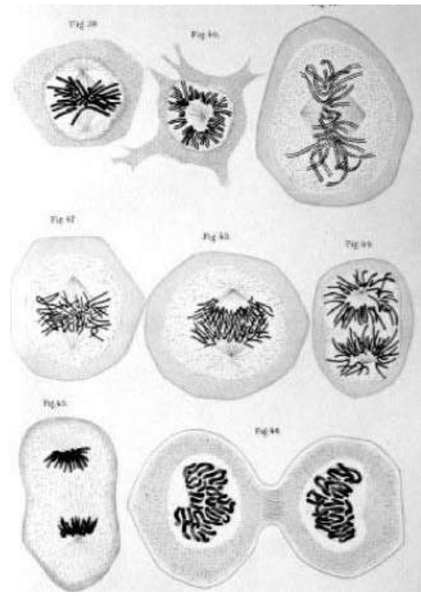


Figure-7 (B): Descriptive sketches of mitosis by Walter Fleming

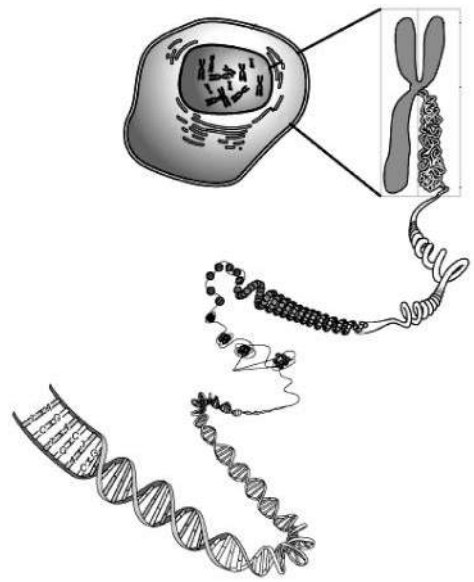
- But what is involved in starting the process of division?

Virchow had suggested that it was the nucleus. Fleming saw thread like structures in the nucleus. Scientists started observing these thread like structures to find out what they were composed off. If the cells divided and the information for division seemed to be coming from the nucleus and the thread like structures contained information even from parental generation (hereditary material) then what was their composition? Reproduction was a process that distinctly separated the living and non-living entities. Thus, the composition of the nuclear material could reveal a lot about living entities.

It was found that the thread like structures were mainly composed of proteins and a compound called deoxyribonucleic acid(DNA in short) . DNA was a material that carried information that was passed on from one generation to the next. Thus it was also called as hereditary material. Thread like DNA was wrapped around proteins to form structures that we call chromosomes. The thick thread like structures in Fig 5 are chromosomes. It was further observed that the process of mitosis lead to formation of cells that contained the same number of chromosomes as the parental cells. It is therefore also called as equational division.

As for example there are 46 chromosomes in each cell of our body. Cells formed by mitosis will also have 46 chromosomes. Mitosis occurs in most cells of our body. The process of cell division involved in growth and development of a child in the mother's womb is largely also mitosis.

Do you know?



During the decade 1940-1950 several scientists were involved in research to reveal the structure of DNA. European scientists, Rosalind Franklin and Maurice Wilkins were trying to take photographs of the DNA molecule by a special technique. In the year 1963 another European two from Cambridge, U.K. observed a photograph of DNA taken by Rosalind Franklin and made the model of DNA, the molecule of life(a molecule at the basis of cell division and differentiation). They described its structure as well. They found that it contained a type of sugar molecule, phosphate molecule and some complex compounds in a particular sequence. Watson, Crick and Wilkins received Nobel prize for their discovery. Franklin's name could not be included for the prize as she had cancer and was dead. Characters of most organisms are mainly controlled by the chemical compound DNA. The colour of the eye, skin colour etc.are all expressed due to DNA.A slight change in the chemical composition of DNA may lead to vast changes in characters. We have been able to identify areas of DNA that are responsible for specific characters and make changes in the DNA composition as well as synthesize certain small strands of the DNA molecule according to our use. Several scientists of our country like Hargobind Khorana, Lalgi Singh, Yamuna Krishnan etc. have been involved in such efforts over time. Hargobind Khorana had helped to identify specific segments of the DNA molecule that carried information for specific amino acids. He had received Nobel prize in 1968 for this discovery.

14.3.2 Life span of cell and the phase of division

Most cells of our body divide but the rate of division may be different in different types of cells. Division occuss in a very small phase in the life span of a cell. It is a very important phase for cells to maintain their existence. Fig 8 shows the extent of dividing phase in the life span of a cell. You can see phases marked as G1 and G2. These are growth 1 and growth 2 phases when resources are collected in the cell and the size of the cell increases.

- Which is the longest phase that you observe in the figure?
- Why do you think it may be the longest phase?
- Do all cells of our body divide in this manner forever?

If all cells in our body keep on dividing mitotically at the same pace or at the same time we would get a lump of cells. All cells in our body do not divide together or even at the same rate. Moreover shape and size of certain cells also change over time (faster inside the womb than outside). Thus, we see the development of different parts of our body.

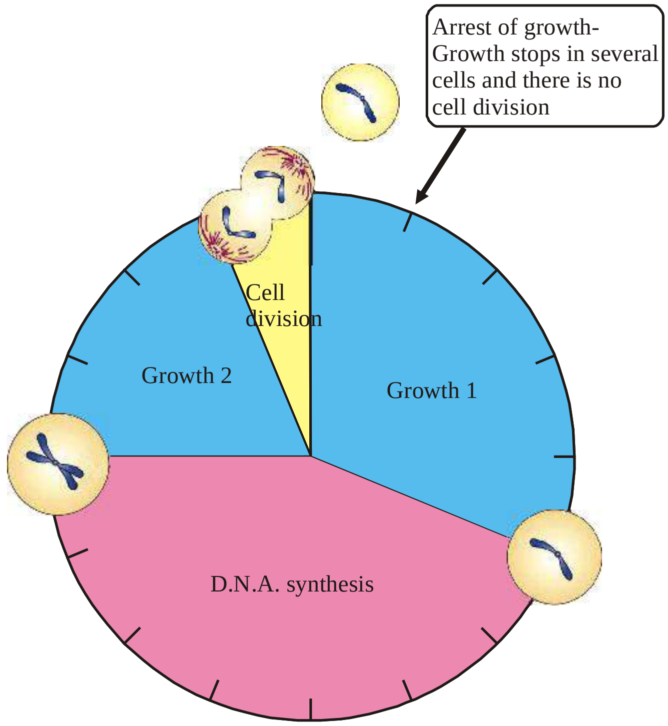


Figure-8:

14.3.3 Cell division and differentiation: and asexual reproduction, development

Most cells reproduce by the process of mitosis, and some organisms reproduce by this process of division. These may be unicellular organisms like bacteria, yeast, amoeba, paramecium etc. and multicellular organisms like hydra and plants (that grow from root shoot etc.).

The process of reproduction that takes place by the involvement of the body of a single parent organism such that cell division involved is simply mitosis, is called as asexual reproduction. There are several ways in which organisms may reproduce asexually (some examples are given in the annexure to this chapter). It is noteworthy that examples of ways in which organisms may reproduce asexually like fission or division into two parts as in yeast, budding etc. are processes that are all basically dependent on mitosis.

As we have already studied, even in our body, development and growth takes place due to different rate of mitosis in different groups of cells. Even the body of a child developing in a womb is formed by the process of mitosis. The womb itself grows as mitosis takes place in its cells. A mere 2.5-3cm long womb grows to nearly 40cm in length. Figure 9 shows some stages of development of a child in the womb.

If the egg is fertilized

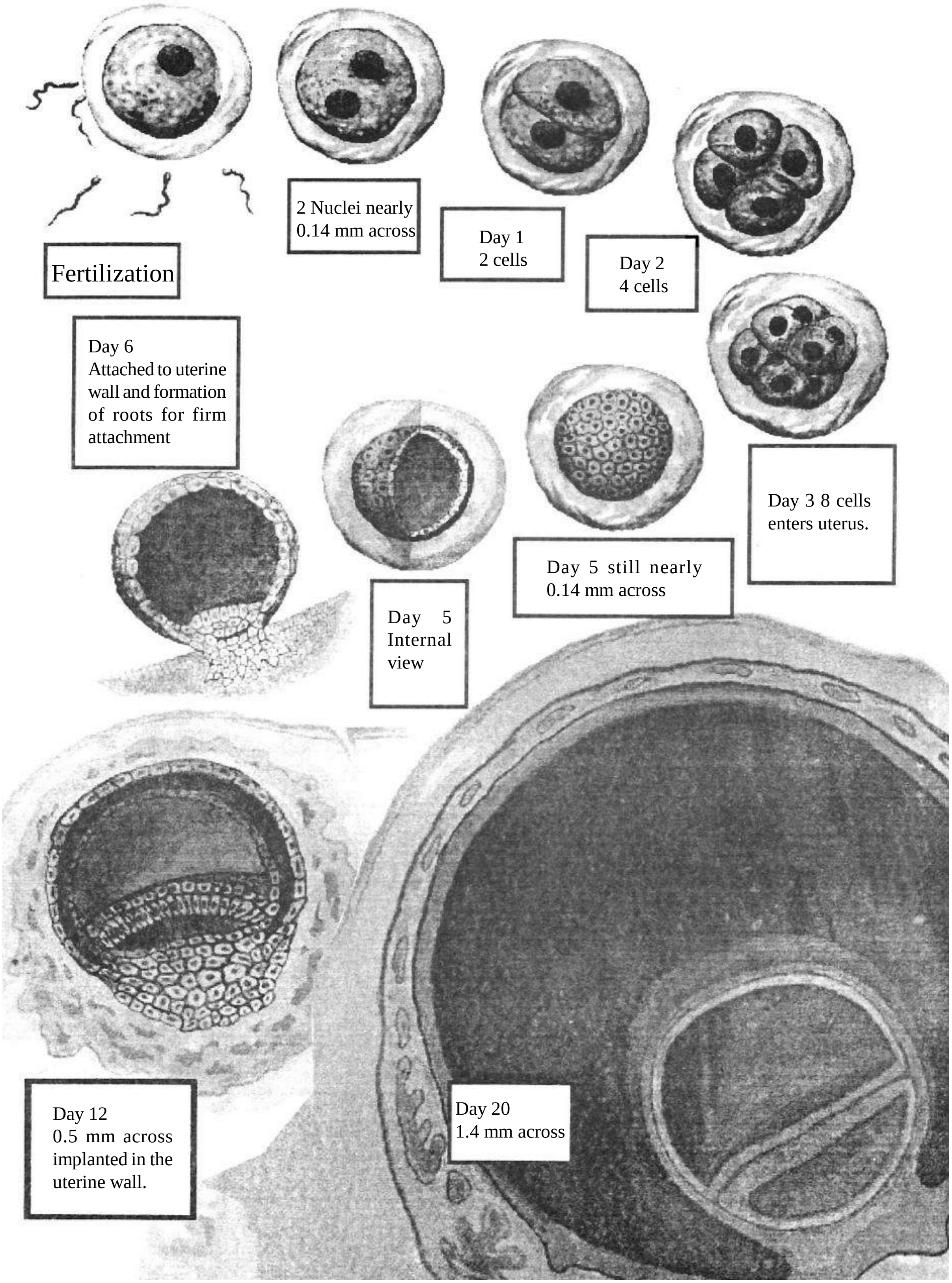


Figure- 9: Some stages of development of a child in the womb

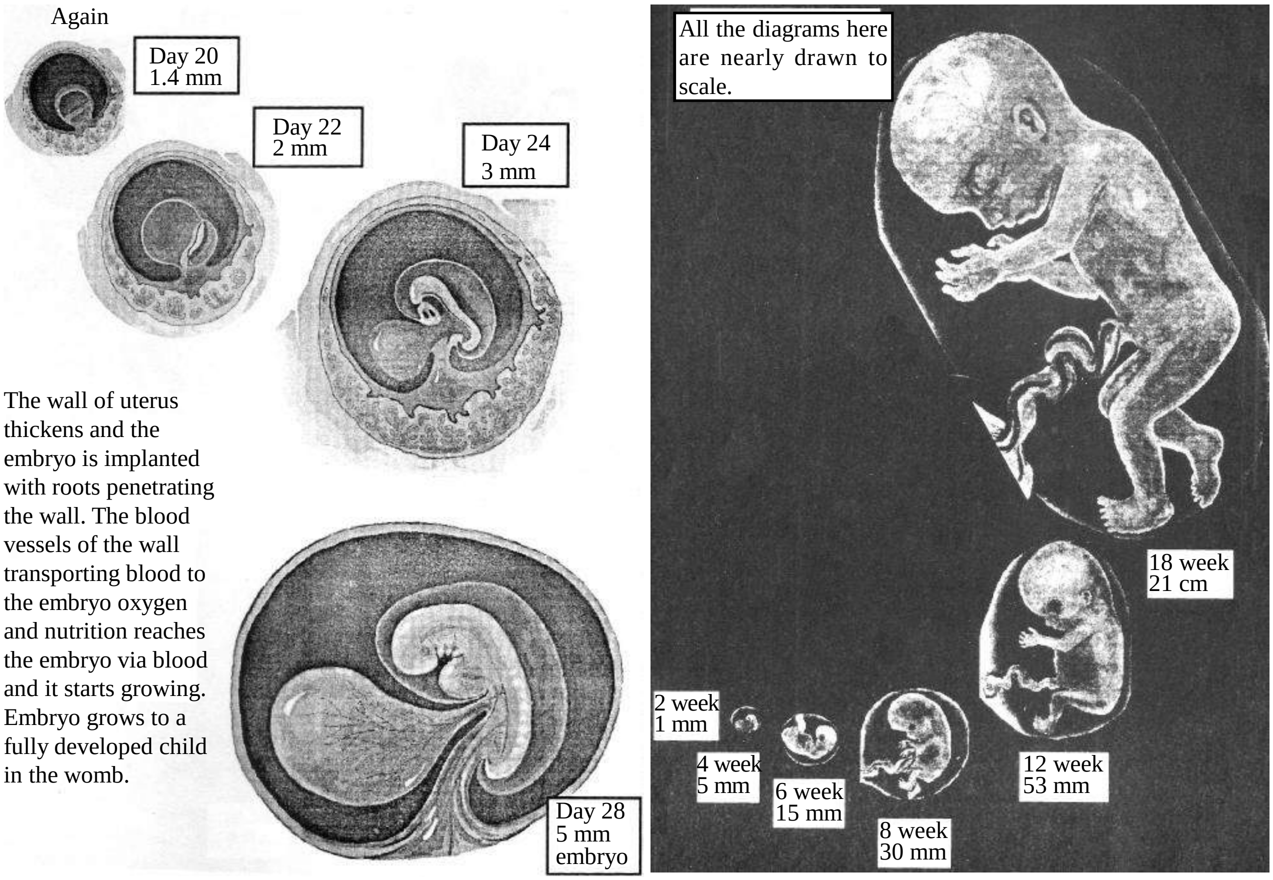


Figure- 9: Some stages of development of a child in the womb

- Observe the single cell of the first day and the ball of cells of the 5th day. Is there any change in volume?

You may see that from the first day to the fifth day there is no change in volume but the number of cells increase. It has been observed that though the volume does not change there is a marked change in mass. From the outer lining of the group of these cells of the 5th day, a connection for supply of oxygenated blood, nutrients, water etc. between the mother and child is formed. This connection is the placenta.

- We do not find any organs till the fifth day so where do life processes occur in the child?

After the fifth day a change in the shape of cells is also observed. Cells of a location may reach other locations as well. Gradually tissues, different organs and organ systems are formed and various life processes start. After the onset of cell differentiation in a fast dividing zygote, it is called as embryo (a Greek word meaning swell and grow).

- Are organs involved in the oxygenation of blood or digestion of food etc. developed and functioning in a child developing in a womb?
- Do all life processes occur in a child in the same manner as in us?
- A child remains in liquid medium in the womb so how do you think it respires?

Only after birth the lungs of a child become functional. During the period in womb of the mother, gaseous exchange occurs through the placenta as oxygenated blood reaches the body of the child from the body of the mother.

As organs and organ systems form in the womb, some of them become functional. Functional heart, eyes, limbs etc. are often seen to develop early. Reproductive organs develop in the 7th week. Certain organ systems like respiratory system, digestive system etc. develop gradually and remain non-functional till birth.

- When organs and organ systems develop and become functional at different times can they still have anything in common?
- We have studied that all cells of our body have the same DNA so how is it that cells, tissues, organs and organ systems look so different from each other?

These had been the type of questions that scientists working with DNA functioning had in mind. They found that during development, certain sections of DNA were functional in some cells while in certain other cells some other sections were functional and this brought about different changes in the cells both structurally and functionally.

- According to the discussion so far in this chapter and the chapter on evolution, would it be fair to state that different kinds of cells have the same origin?
- Would this origin be the zygote?
- Does the zygote carry information of characters of parental cells as well (remember that zygote is formed by fusion of female and male reproductive cells)?

We know that a zygote is formed after fertilization when the nuclei of male and female reproductive cells or gametes fuse. We also know that gametes are formed in the reproductive organs of our body. Similarly gametes are formed in the reproductive organs of plants and several organisms that reproduce sexually. The process of formation of gametes involves a division similar to mitosis to some extent. It differs from mitosis in such a manner that the number of chromosomes after fusion of male and female gametes remains same as that of parental cell. Let us study about the process of cell division in certain parts of the reproductive organs find out how this happens.

We have seen that organs grow and develop by mitosis but in certain areas of our reproductive organs another form of division takes place due to which gametes are formed.

14.3.4 Cell division: Sexual Reproduction and formation of gametes

We had studied that a type of cell division similar in certain aspects and differing in certain others takes place in certain parts of the male and female reproductive system. We find this in the ovaries of human female and testes of human males. Deep inside the tissues of these organs another type of cell division called meiosis takes place that leads to the formation of gametes in which the chromosome number is reduced to half as that of parental cells(See figure 10). This process of division is called as meiosis. 'Meiosis' is a Greek word that means 'being reduced' and this type of division is also called as reductional division. As for example a human cell has 46 chromosomes while the gametes have 23 chromosomes only. Thus one chromosome of a pair in a parental cell passes to a gamete. During meiosis as gametes are formed, there is a lot of shuffling of genetic material (as compared to mitosis) between certain chromosomes.

- If gametes were formed by mitosis, how would the hereditary material increase in subsequent generations?
- What should be the amount of hereditary material in gametes, as compared to parent cells, so that the amount of hereditary material remains as in parental cells in all subsequent generations?

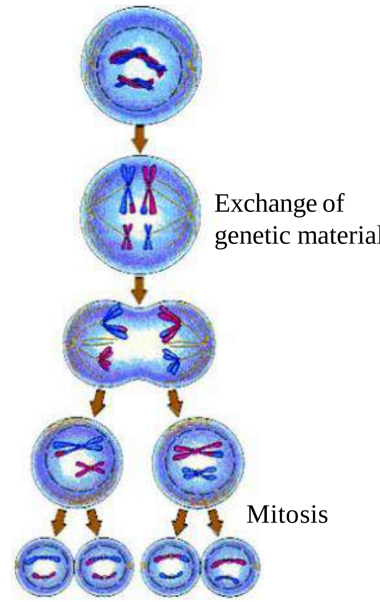
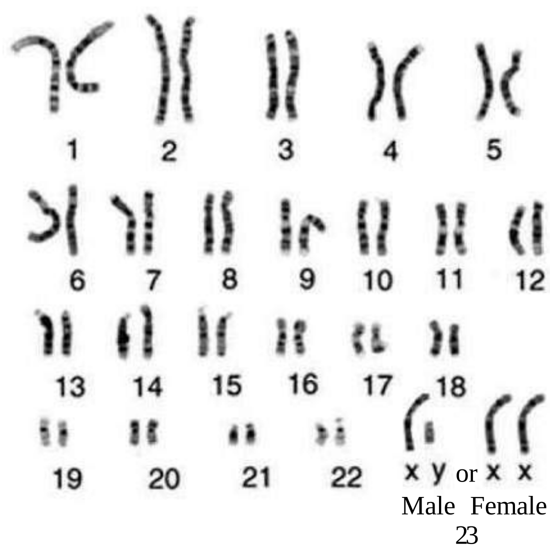


Figure- 10: Some stage of mitosis

Do you know?

Human chromosomes if arranged and displayed separately would look like the figure given here. Each cell of our body has a total of 46 chromosomes. The 23rd pair marked as XX and XY determine the sex of an individual. Those with XX being females and with XY males.



14.3.5 Asexual versus Sexual reproduction

We found that the process of mitosis is at the base of asexual reproduction while the process of meiosis is at the base of sexual reproduction. We had stated that there is a greater shuffling of hereditary material in meiosis as compared to mitosis. Thus more shuffling of hereditary material increases the scope of variation.

- What is the role of variation in the evolution of species?
- Which form of reproduction would lead to greater scope of survival?

Since variation in a population increases the chances of adaptability to changes in the surrounding environment, therefore organisms reproducing by sexual reproduction have better chances of survival.

If sexual reproduction leads to more variations does asexual reproduction cause no variations at all? Let us do an activity involving asexual reproduction only to observe this. As we know asexual reproduction does not involve the formation of gametes. Plants reproducing by root, shoot or leaves do so asexually.

Activity-4

It would good to do this activity just after the rainy season.

Make pieces of a potato such that each one has an eye. Cut the pieces carefully such that they are blocks of similar size(let them be as closely similar as possible). Select 4-5 such blocks which are most similar. Take a large pot, fill it with soil from your garden or field and sow the blocks in at equal distances (about that of your palm length). Do not sow them too deep inside the pot.

Keep watering the pot at regular interval of time with a cup of water(at least on each alternate day).

- After how many days did you find plants growing out of the soil?
- How many plants grew? Was the number same as that of blocks?
- Were all the plants same?
- What variations did you observe in them?
- How do you think variations originated in them?
- Can we say that variations can be found even in asexually reproducing organisms as well? Why?

We found that variations though often less as compared to sexual reproduction may arise in asexually reproducing animals as well. Variations lead to the continuity of life forms on earth.

14.4 Growth development and reproduction in unicellular organisms

Most as we have studied earlier, mitosis is instrumental in the reproduction, growth and development of unicellular organisms unlike most multicellular organisms. Even in certain plants like china rose, potato etc. growth development and reproduction occurs mainly by the process of mitosis. In most multicellular organisms reproduction mainly occurs by the process of meiosis. Moreover though environmental factors influence the reproductive ability and rat of growth and development of multicellular organisms, its effects are more easily observed in unicellular organisms.

The presence of unicellular organisms in a nutrient medium is indicated by their fast reproduction and growth of the population. There may be certain factors that influence the rate of reproduction of these organisms.

Let us see the effect of changes in nutrient medium on the rate of reproduction of unicellular organism.

Activity-5

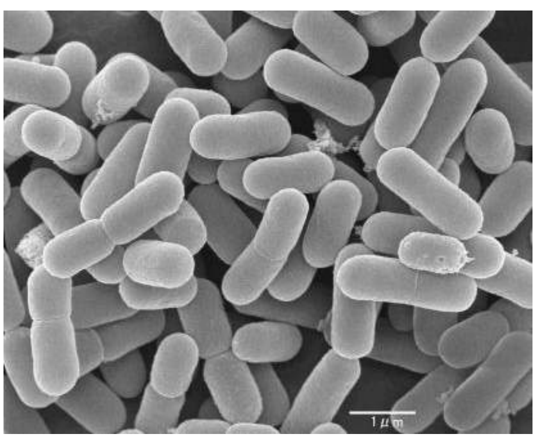
Take two bowls of same volume. Fill one bowl with warm milk which would be bowl A, while the other with boiling hot milk(pour carefully with the help of an adult) which would be bowl B. Let us add one teaspoon of curd to each of the bowls and mix it well. Now cover the bowls and leave them aside for around 5-6 hours. Remove the cover now and observe the milk in both the bowls.

- Is there any difference?
- What could be the reason for such difference?

If we observe bacteria responsible for formation of milk under an electron microscope (at around 500000 times magnification) they would look like that in Figure 10

Due to favourable conditions in bowl A most bacteria may have survived thus we find them to reproduce and curd formation is observed. Bacteria survive and grow on nutrients in milk. As their size increases they divide and their number increases.

- What do you come to know about cell division from this section?
- What is the relation between growth and reproduction according to this section?



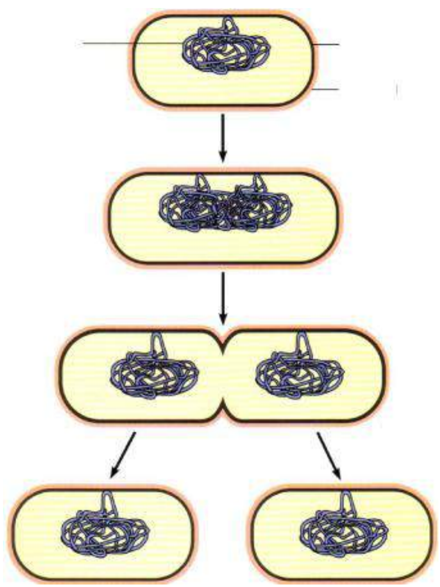
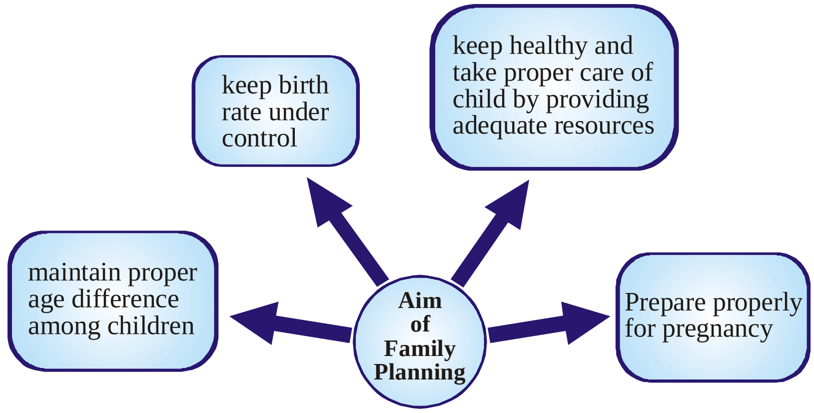


Figure-11:

14.5 Reproductive health of humans

Sexual parts are as important as all other parts of our body so we must take proper care of them by keeping them clean. We have seen, that the process of sexual maturation is gradual and takes place while general body growth is still going on. Therefore, some degree of sexual maturation does not necessarily mean that the body or the mind is ready for sexual acts or for having and bringing up children. How to decide if the body or mind is ready for this major responsibility? All of us are under



many different kinds of pressures about these issues. There can be pressure from our friends for participating in many activities, whether we really want or not. There can be pressure from families to get married and start having children. There can be pressure from government agencies to avoid having children. In this situation, making choices can become very difficult. We must also consider the possible health consequences of having sex. Our marriageable age is not same as our age of adolescence as there may be severe effect of having sex at adolescence. Neither our mind nor our body is prepared to bear its consequences at this age. Thus sex only after marriageable age (18 years for girls and 21 for boys) is advised. Even then certain constraints may be very helpful. We had discussed in class 9 that diseases can be transmitted from person to person in a variety of ways. Since the sexual act is a very intimate connection of bodies, it is not surprising that many diseases can be sexually transmitted These include bacterial infections such as gonorrhea and syphilis, and viral infections such as warts and AIDS(Acquired Immuno Deficiency Syndrome) caused by the dreaded group of HIV or human immuno-deficiency virus. Any infection that may spread through contact of body fluids like AIDS, gonorrhea or syphilis can be prevented by having sex safely. Moreover sexual act always has the potential to lead to fertilization and thereby pregnancy. Pregnancy makes major demands on the body and mind of the woman if she is not prepared for it. Thus her health may be affected adversely. There are thus many ways of avoiding pregnancy. In a country where we have a staggeringly high growth rate of population it becomes essential that we exercise ways to reduce it. All this can be achieved by having safe sex and adopting ways that would not lead to pregnancy. Such methods are called as contraceptive methods. It is advisable that human males take the initiative to exercise methods of control. Usually a literally painless operation helps to block the sperm carrying duct or vas deferens. Another means that men may adopt for safe sex is by using condoms which are coverings that fit on a penis. This arrests the passage of sperms into the vagina. There are also ways in which human females may exercise safe sex that does not lead to unwanted pregnancy. Contraception for females maybe by a minor operation of tying the fallopian tubes or blocking them. There may also be certain devices that may be introduced into the uterus to block passage of sperms to fallopian tubes, copper-T being one such device. Moreover such devices should be monitored by health practitioner regularly. There are certain medications that affect the normal release of hormones thereby arresting the release of eggs from the ovary. These pills are easily available in health centers and most widely used. But, contraceptive pills or devices for females have severe side effects and thus surgery is the best option. Of course surgery if not conducted properly or in properly sterilized (that is disease free and clean) conditions may lead to serious consequences.

Often unwanted pregnancies are aborted or removed by surgical methods. This is more of a malpractice than genuine act of birth control. Most often sex- selective abortion is conducted and a developing female child is aborted. This has lead to an alarming rate of decrease in child sex ratio in our country in spite of laws against determination of sex of developing embryo. It is important for a healthy society to have a stable sex ratio with similar female to male numbers.

Reproduction is a process that helps in increasing the population of organisms. But uncontrolled rate of increase in population will adversely affect resources. Alarming increase in population is also a challenge to raise living standards of many individuals. Birth rate and death rate of a population controls size of populations. Exercising ways and means to reduce birth rate by planning family size and having less children (around two per a married couple) would help in reducing population growth by large. As responsible citizens it is largely our duty to check population growth in this manner.

Keywords

Growth, development, mitosis, meiosis, gametes, zygote, adolescence, embryo, pregnancy, sexual reproduction, asexual reproduction

What we have learnt

- A living body grows at a definite rate.
- The increase in mass of a living body with time is growth.
- The differential rate of growth of different parts of a living body leads to development.
- During development in a multicellular body, a change in shape and size of a cell takes place along with change in shape and size of the multicellular body.
- Alike other life processes, reproduction is also an important life process that gives rise to variations in living organisms. The continuity of a species is maintained by reproduction.
- Alike sexual reproduction, asexual reproduction does not need the role of male and female. A single parent may give rise to offspring straightaway.
- An offspring receives the same amount of hereditary material(complete set) as that of the parent cell by asexual reproduction. In sexual reproduction gametes are formed that contain half the amount of hereditary material as parents. Thereafter, the offspring formed by fusion of gametes contains the same amount of hereditary material as parents.
- Asexual reproduction occurs by mitosis while gamete formation in sexual reproduction occurs by meiosis.

- Reproduction in flowering plants involves transfer of pollen grains from anther to the stigma which is referred to as pollination. This is followed by fertilization.
- Reproduction in animals involves the introduction of sperms into the female reproductive tract. This is followed by fertilization which is fusion of sperm and ovum
- Changes in the body at adolescence, such as increase in breast size in girls and new facial hair in boys, are signs of sexual maturation.
- Our health will be maintained only if we take care of all parts of our body and keep them clean. Reproductive health is extremely important and it is an integral part of our general health.
- Adopting different ways of family planning are essential for the health of a family as well as that of a society.

Assessment

1. Choose the right option-
   - (i) The following type of division takes place in most cells of our body-
     (a) meiosis (b) unisexual (c) bisexual (d) mitosis
   - (ii) Which of the following is not a part of the female reproductive system-
     (a) Ovary (b) Uterus (c) sperm duct (d) oviduct or fallopian tube
   - (iii) Sexual reproduction leads to-
     (a) Increase in variation
     (b) Fertilization of male and female gametes lead to formation of zygote
     (c) None
     (d) Both a and b
2. Is the placenta essential for the child developing in the uterus? Why?
3. What is the role of male and female in the process of fertilization.
4. Draw a flower and label the male and female reproductive parts in it.
5. Write at least five differences between asexual and sexual reproduction.
6. What is menstruation? What is its effect on the body of a human female?
7. Write in detail about two ways of contraception.
8. Write a detail note on the reproductive processes of unicellular and multicellular organisms.
9. How does reproduction help in sustaining the population of a species?
10. How do plants that do not produce seeds reproduce?

11. What do you understand by growth and development? Describe with example.
12. What are the different aspects that need to be taken care of for the health of pregnant women?
13. You may have heard about the birth of 5 baby girls after a period of pregnancy of just 6 months. Usually a single child is born at a time in humans after pregnancy. Sometimes two children may be born. Birth of 5 children together is surprising for us. The development of the body of a child starts with the division of the zygote. Division goes on at a particular rate. Usually the birth of more than one child occurs due to the division of the zygote and the development of each division into a body of a child. Often more than one egg matures at a time and is released into the fallopian tube. The fertilization and development of all the eggs at a time gives rise to more than one child.

    Read the section and write about the ways that lead to development of more than one child in the uterus.

Annexure

There are different types of asexual reproduction. Some of them are-

(1) **Fission:** the organism divided into two or more parts. You had studied about this in activity 5 where fission in bacteria was illustrated. Apart from this we find amoeba, paramecium, malarial parasite etc. to divide in this manner.

(2) **Budding:** A bud forms due to mitosis in cells of epithelial tissue in certain organisms. The bud develops into a complete organism. This can be observed in hydra, yeast etc.

(3) **Spore formation:** in this process certain cells with a thick covering are formed which can last in adverse environmental conditions and develop into the organism with the return of favorable conditions. We usually find this in bacteria, fungi, mucor, Rhizopus etc.

(4) **Fragmentation:** Off springs are formed in planarian worms, hydra etc. by division and development of parent body into fragments containing cytoplasm and nucleus.

(5) **Vegetative propagation:** The development of organisms from parts other than reproductive system is called as vegetative propagation. You had observed in Activity-4 how plants developed from potato pieces. We see other examples like rose and grape vines developing from stem grafts, carrots, pointed and ivy gourd(parwal and kundru) by roots and begonia and bryophyllum by leaves.

CHAPTER 15

HEREDITY: FROM PARENTS TO OFFSPRINGS

We have studied earlier that organisms reproduce to produce offsprings like themselves. The Babul(Acacia sp.) produces seeds that produce babul plants. The offspring of a goat resembles a goat while that of humans a human. Though offsprings resemble their parents they show some dissimilarity as well. Let us study the observable similarities and dissimilarities in humans and plants with the help of activities.

15.1 Similarities and dissimilarities in organisms

15.1.1 Variations in animals (Example: Humans)

Activity-1

Last year you had studied several similar and dissimilar characters among you and your friends. Now you shall study these within your family. Observe the characters given in the table among family members mentioned (those whom you have) and in you and put a mark (✓) wherever you find the character present in you and your family members.

Table-1

S.No.	Character		You	Mother	Father	Maternal grandpa	Maternal grandma	Paternal grandpa	Paternal grandma
1.	Colour of eye	Black Brown Green Any other (mention)							
2.	Dimple chin	Yes No							
3.	Rolling of tongue	Yes No							
4.	Finger next to toe	Longer than toe Shorter than toe							
5.	Ear lobe	Attached Free							
6.	Capable of bending the thumb backwards	Yes No							

Observe the filled table and answer the following questions-

- What are the characters present both in you and your parents?
- Are there any characters that you share with your parents and grandparents?
- What are the characters that are present in you and your grandparents but not in your parents?
- How do you think such characters may have passed on to you?

You may have observed that some characters have passed on to you from your parents and grandparents. Such characters that pass from one generation to the next are called as heritable characters and the study of the process in which they are transferred is called 'Heredity'. You have observed that some characters present in your family members were not present in you. The dissimilarities that we observe in spite of similarities are Variations about which we have studied in Chapter 1.

15.1.2 Variations in Plants

There are several similarities and dissimilarities in plants as well. Plants of the same species share several similarities like similar shape of flower or leaves but variations are such that even on the same plant it is impossible to find two same leaves (as you observed in your last class). Can you find two same seeds of a plant? Let's find out.

Activity-2

Observe the seeds in a pea or bean pod.

- Are there any seeds that are same?
- What are the variations that you see in them?

People have been observing variations in plants over a long period of time and developing plants of different races by selecting different characters. People had observed that characters of on generation pass on to the next or forthcoming generations.

But the question was how do different characters develop and how are they passed on from one generation to the next?

15.2 Heredity and Mendel's Contribution

Intensive studies started in the 19th century to find out how characters are passed on from one generation to the next. We studied in Chapter 1 that Darwin had observed different characters in organisms across generations and proposed the theory of origin of species by evolution. Though he observed characters passing from one generation to next he could not explain the mechanism of the process clearly. Darwin and many of his contemporary scientists were working towards understanding the mechanism among which the observations and contributions of Gregor Johann Mendel are most remarkable.

A monk in a monastery in Austria, Mendel, was inquisitive from childhood and interested in gardening. He would plant different plants in the garden of his monastery and try out different experiments on them. He conducted a series of around 10,000 well documented experiments for a period of nearly 12 years starting from the year 1856 . This lead to path breaking observations and a research paper which though not acknowledged in his time forms the basis of Heredity now. Even after that he carried on with his experiments to understand the process of heredity better and check if his previous observations were universally applicable. He documented all his observations and continuously communicated the same with his contemporaries. He would also read and analyzeddocuments written by other scientists of his time like Darwin who were performing similar experiments and writing about them. We came to know a lot about the process of heredity(that is transfer of characters from one generation to the next) with the help of Mendel's experiments. Mendel used mathematical calculations to hypothesize and confirm his results.

15.2.1 Mendel's experiments and their objectives

Mendelwas trying to look for a law that could be applicable to the heredityof at least contrasting characters like yellow and green seed coat colour of pea seeds or white and purple colour of pea flowers as observed by him. He was also trying to look for a way to be able to predict how much variations may be observed from one generation to the next.

Gregor Johann Mendel

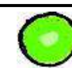
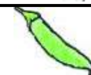
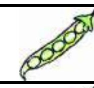
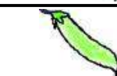
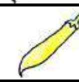
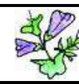
Mendel had started experimenting on bees but he quickly shifted to peas as plants were easy to control and observe. Moreover there were certain characters of plants of pea family that Mendel was already aware of.

He gave the following reasons for his choice of pea plants.

1. Peas are annual plants. Their life cycle being small, generations of pea plants may be observed and studied easily.
2. Pea flowers are usually self- pollinated where pollination is completed in the bud stage due to the presence of a protective crown over reproductive parts. This also helps to maintain characters of pea plants pure across several generations.
3. Cross pollination can thus be done artificially and acquire expected results as there is little chance of other pollen grains reaching the flower. Thus expected crosses or hybrids of pea plants can be obtained easily.
4. The plants are bisexual(having both male and female flower on the same plant, here in the same flower). If the male sexual part or stamens are removed, then the plant behaves as a unisexual one.
5. Hybrids formed are fertile and not sterile as found in most cases.
6. Peas have varieties that show clear contrasting characters.

Some contrasting characters that Mendel chose are given in the table-

Table - 2

S.No.	Type of Character	Clear contrasting varieties			
1.	Shape of seed	round		wrinkled	
2.	Color of seed	yellow		green	
3.	Color of flower	violet		white	
4.	Condition of pod	Swollen		Constricted	
5.	Colour of pod	Green		Yellow	
6.	Position of flower	Axial		Terminal	
7.	Length of plant	Tall		Dwarf	

He made certain arrangements for his experiments. He would allow self- pollination in some pea plants while cross pollination in others. He would continue experimenting with seeds obtained by cross pollination (that is, by the process of hybridization) in a separate manner as compared to those obtained by self -pollination. Each time that he obtained seeds in a particular experiment, he would count all of them and select and sow seeds of plants that showed a particular type of character. He would maintain records of all his experiments.

- Why did Mendel carry out cross-pollination to obtain hybrid seeds?
- Why was Mendel studying mostly contrasting characters?

15.2.2 Results of Mendels Experiments(with respect to crosses related to purple and white flower bearing plants)

Some pea plants bear white flowers while some others bear white flowers. Mendel selected such varieties of plants, obtained their seeds and grew more plants out of them. He now allowed self-pollination to take place in plants of a particular variety (that is - those with white flowers or those with purple flowers. Each time he selected flowers on the basis of their colour, he carried out this process for some generations till he could ensure that seeds of plants with purple flowers would yield only purple flowers while those with white flowers would obtain white. Thus by the process of repeated self-pollination, Mendel obtained plants that would produce seeds of purple or white varieties respectively for several generations. Mendel called these varieties pure. He started his experiments with these varieties of pure plants. He sowed seeds of pure varieties of white and purple plants. As the plants grew and started flowering he cross-pollinated them. The seeds obtained from cross pollinated flowers, or the hybrid seeds, yielded varieties that bore only purple flowers. This generation of plants obtained from parental varieties of pure plants was first generation (F1 generation) plants.

- Think why intermediate varieties (those between purple and white) may not have been obtained?

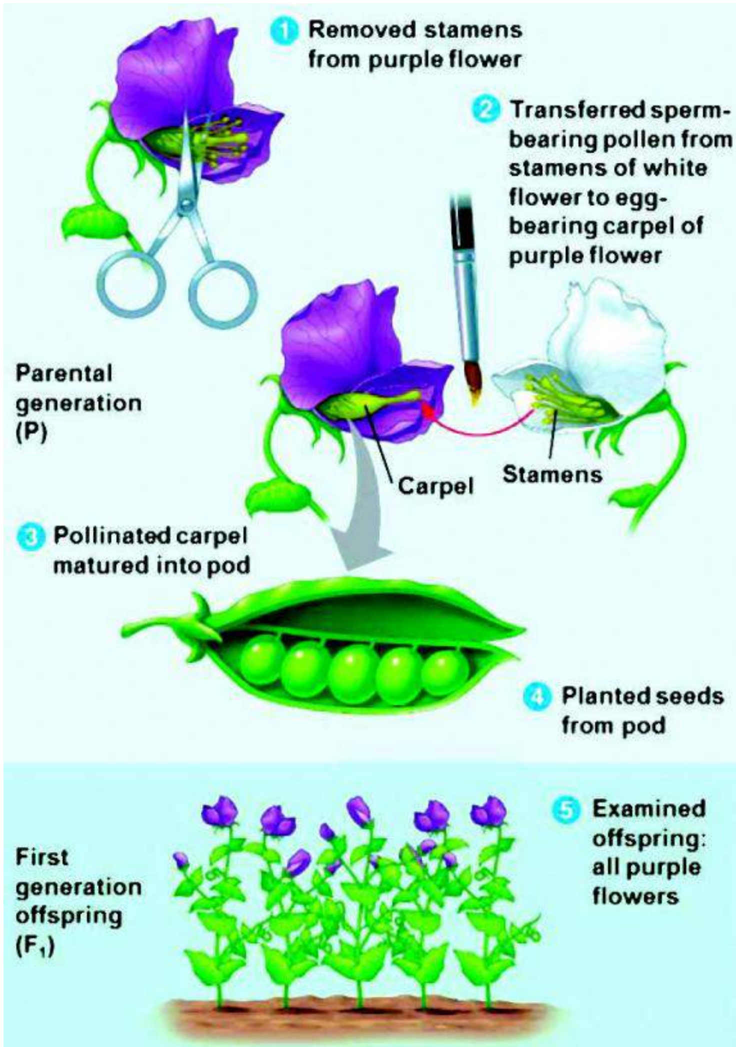


Figure-1: Cross pollination of pure parental types

Mendel now self- pollinated these first generation plants. The seeds obtained were then sown. To his utter surprise he found that these yielded plants of pure parental generation as well that he had started with. Not all plants yielded purple flowers. There were some that yielded white flowers as well. Among the 929 plants that had grown from the hybrid seeds, 705 of them bore purple flowers while the rest bore white flowers. Now if we see the ratio of purple to white varieties, it is 3.15:1.

Mendel studied several contrasting characters. He found that parental varieties with contrasting characters always gave a ratio of nearly 3:1 in the second generation.

Do you know?

The observations of experiments performed by Mendel-

Experiment	No. of Plants	Cross between Characters	F_1Generation	F_2Generation	Ratio
1	7324	Round and wrinkled	All round	5474 Round 1850 wrinkled	2.96: 1
2	8023	Yellow and Green seeds	All yellow	6022 yellow 2001 green	3.01:1
3	929	Purple and white flowers	All purple	705 violet 224 white	3.15:1
4	1181	Swollen Pod and Constricted pod	All swollen	882 swollen 299 constricted	2.95:1
5	580	Green and Yellow pods	All green	428 green 152 yellow	2.82:1
6	858	Axial and terminal flowers	All axial	651 axial 207 terminal	2.14:1
7	1064	Tall and dwarf	All tall	787 tall 277 dwarf	2.84:1

These observations lead Mendel to believe that the character, purple flower colour masked that of white completely in the first generation and partially in the second generation. Thus purple colour according to him was dominant and white recessive. He believed that expression of white colour in F2 generation could only happen if both characters were present independently in a hybrid seed.To find out how a character was expressed, Mendel took the help of mathematical calculation to figure out how this could be possible.

15.2.3 Assumptions based on experimental observations

Following are certain assumptions on the basis of experimental observations-

1. Each character is represented by two factors.
2. An offspring receives one factor of a character from parents. This is how an offspring always has a new pair of factors.
3. Among a pair of contrasting characters one is dominant and the other recessive.

Now, let us find out what was the mathematical basis of these assumptions.

15.2.4 Confirming assumptions with the help of Probability

Activity-3 The coin game

Let us take a pair of either one rupee, two rupee or five rupee coins. Mark both sides of one of the coins. See that the mark does not cover the head or tail portion of the coin completely (see figure for help).

Let this marked coin be 'A' and the one without marks be 'B'. Now toss both coins together and as they fall observe both and put a tally mark according to the condition you observe in the table given as under.

Table- 3

A B	A B	A B	A B
H H	H T	T H	T T
卌 |||	||||	卌 |	卌 |

Repeat tossing the coin around 500 to a 1000 times. Now find out the percentage of all four conditions (HH,HT,TH,TT) as shown in table. Are you getting a value close to nearly 25% in all the said conditions? You would find that the ratio of all the four combinations of coins HH,HT,TH and TT is 1:1:1:1 (that is a probability of 25% each).

- If you would have played with the same coin what would be the probability of getting a head or a tail?

Thus if we assume that a coin represents a pair of Mendels' factors, and HH represents pure variety of purple coloured plants and TT represents pure variety of white coloured plants, then, HT, TH could represent a combination of characters, purple or white flowered plants. But Mendels' observation shows that nearly 75 percent(nearly 3 out of 4 parts showed by the ratio 3:1) bore purple flowers and around 25% plants bore white flowers.

To get a total of 75 we will have to add the percentages of HT and TH conditions to the HH condition. Thus starting with a pair of characters probability calculations started matching Mendel's observations. The presence of even a single purple factor leads to the expression of purple character. Mendel thus conducted several experiments with several contrasting characters to check his assumptions. Whether characters were represented by a pair of factors and among a pair of contrasting characters one was dominant?

Some more assumptions

As we have studied so far we know that Mendel prepared pure varieties of plants for a particular character and then started experimenting with them.

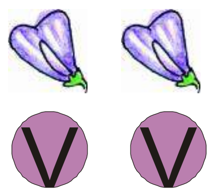
Mendel started his experiments with contrasting characters in the following manner (in the context of plants bearing purple and white flowers-

Assuming the characters of pure purple and white flower bearing plants to be represented by a pair of factors in each caseas under we get -

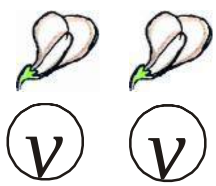
VV - purple

vv - white

Their male and female gametes would be formed as-



Purple



White

Cross pollinating purple and white flowered plants we get-

	V	V
v	Vv	Vv
v	Vv	Vv

All plants of F1 generation have a combination of factors as-

These F1 generation plants would yield male and female gametes for F2 generation plants as-

The factors of second generation plants would be as-

	V	v
V	VV	vV
v	Vv	vv

This shows that the second generation yields 25% of plants each bearing purple and white flowers are like the parental varieties of first generation. While 50% of plants bearing purple flowers are like those obtained after F1 or the parental generation for F2.

Vv represents heterozygous factors while VV and vv represent homozygous factors.

Do you know?

We know now that factors that represent a character are called as genotype while the character that is expressed is called phenotype. But when the scientist A. Johannsen was proposing the use of these terms for the first time in the year 1909 in an article on the study of biodiversity, he wrote-'Gene is the unit of factors present in a cell formed by the fusion of male and female gamete while all genes together form the genotype.Organisms show a lot of similarities across generations. Phenotype is the variations caused due to effect of environment on organisms with same genotypic combinations. Thus genotypes are heritable characters while phenotypes are non-heritable characters.' We can see that the meaning and use of scientific terms change over time.

15.2.5 Mendel's Laws

Mendel observed that while the formation of gametes a pair of factors representing a character segregated independent of each other. Even when they formed a zygote by the fusion of male and female gametes they did not mix with each other. As for example the gametes of purple and white flower bearing plants would have a factor for purple and that of white respectively. The zygote formed by the fusion of male and female gametes would have a pair of factors for the type of colour. It could be VV or Vv for puple colour bearing plants or vv for white colour bearing plants. That factors segregate independent of each as gametes are formed and do not mix in zygote was Mendel's Law of segregation.

Mendel did not study just single pairs of contrasting characters but he combined two or more pairs of contrasting characters to see what would happen during the formation of gametes of such plants, whether the characters would mix or not. He also wanted to study whether characters influenced each other. The discussion of Mendel's cross with more than a single pair of character is given in annexure to this chapter.

Do you know?

Mendel's observations of crosses of similar and contrasting characters formed the basis of heredity. Nobody during his time could understand the importance of his work. It was about 30 after his death that scientists working in the area of heredity could recognize and appreciate the immense importance of his work.

We do know now that mixing of characters do take place and that Mendel's laws may not be applicable completely as such.For example in organisms that reproduce by asexual reproduction and several of those where they do not have factors in pairs (Mustard where chromosomes are quadrupeds and wheat upto dodecapeds or codominant characters as in human blood group).

15.3 Human inheritance on the basis of Mendel's laws

We had studied a few characters in activity 1. A Mendellian character or that which exactly follows Mendel's law is 'dimple chin'. Sickle cell anaemia, a dreaded condition of heritable characters is an example of a character that follows Mendellian inheritance.

15.3.1 Factors for Sickle cell anaemia and their inheritance

The 11th pair of autosomal chromosome(see page….) has factors responsible for formation of the protein haemoglobin.

- What is the function of this protein(refer to chapter 7 for the answer)?

The presence of these factors help in the formation of normal haemoglobin and normal disc like red blood cells. To show a normal pair of factors we have used the symbol RR(representing normal haemoglobin) in figure 3. A change in the composition of these factors leads to a change in composition of haemoglobin (abnormal haemoglobin)leading to the formation of sickle shaped red blood corpuscles. A condition represented by 'rr' Sickle celled blood cells have very little oxygen carrying capacity. Moreover the life cycle of such cells are 15 to 20 days only while that of a normal blood cell is 100 to 120 days. Patients suffering from sickle cell anaemia become tired and fatigued quickly. It becomes fatal when the factors are homozygous for the recessive character 'rr' as shown in the figure. The factor forming normal haemoglobin is dominant over that of abnormal type.

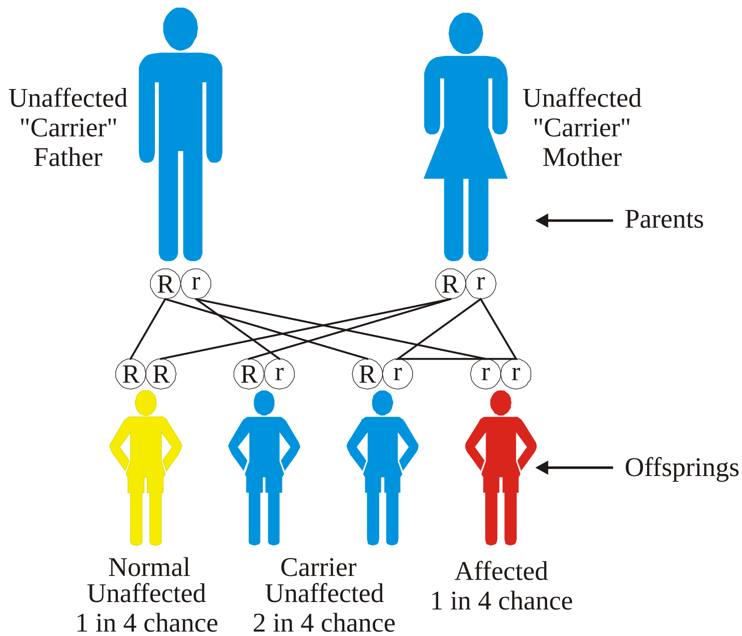


Figure-2

Do you know?

Sickle cell anemia may also be a favourable character. Those that are carriers of the character are have developed resistance towards the malarial parasite as it fails to colonize in the sickle shaped blood cells. The incidence of sickle cell anemia is seen in places that also have a high incidence of malaria.This is not only found in our state but in several other parts of our country as well as the world especially in certain African countries.

15.3.2 Sex determination in Humans

We have studied about human chromosomes in the previous chapter. We also studied that a pair of sex chromosomes (the 23rd pair of chromosomes) are responsible for sex determination. A female carries a homozygous pair (XX) while males have a heterozygous one (XY, Y being shorter than X).

Gametes as we know carry only one set (haploid) of a pair of set of chromosomes and after the fusion of male and female gamete, the zygote so formed contains a diploid pair of chromosomes. The sex of the child formed from this zygote depends on whether it has a pair of XX chromosomes or has XY chromosomes in the 23rd pair.

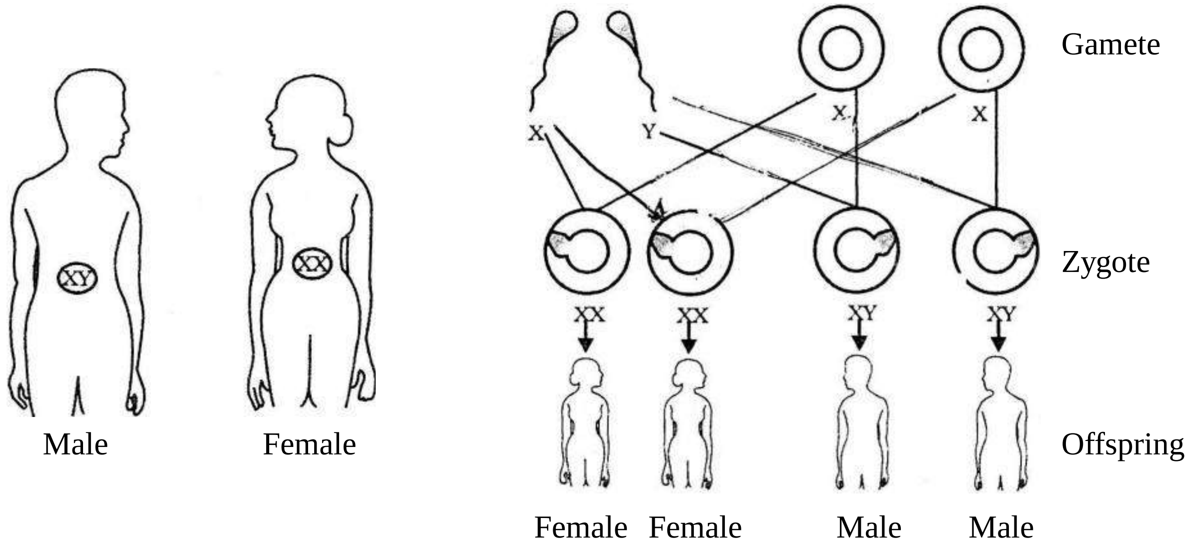


Figure-3: Sex determination in Humans

- See Figure 4 what do you think are the probabilities of each of the four conditions XY,XY, XX and XX?
- What do you think is the probability of having a female child?

We can understand from the figure that the probability of having a male or a female child is 50% each.

Thus having a male or a female child is just one out of two chances. None of the parents are responsible for the same.

- "The human male carries the Y chromosome so to have a male child a human male might have some role." Do you agree with this statement? Why/why not?

15.4 Factors to genes:

Mendel's contribution to heredity forms the basis of our knowledge of the same. He is thus called father of genetics. Mendel had hypothesized that characters are expressed by a pair of factors. Nearly a 60 years after Mendel's findings, in the year 1920, Sutton, a scientist working on the chromosomes of locust showed that Mendellian factors were located on chromosomes and only one chromosome of a pair of parental chromosome passes to the offspring.

If we consider Mendel's purple and white coloured flowers of pea plants, we find that there was no intermixing of characters. It was found that they are located on different chromosomes of a pair representing the colour and there is no shuffling of characters.

Mendel's factors later came to be known as genes. Genes were considered as the units of heredity. We also came to know later that expression of purple flower colour of peas is due to a single gene.

But what are genes? As research in the area extended further and the genetic material DNA(deoxy ribo nucleic acid) was discovered, we came to know that gene was that part of DNA that carried information for the formation of protein. When even a single gene is shuffled the whole group of genes changes and a new combination is formed. Offspring with such a group of genes contain a new genetic combination.

Concept of species on the basis of formation of new genetic combinations is often referred to as genetic species concept.

The whole human genome has been mapped andit is now being used for many purposes like the identification and cure of genetic diseases.

Key Words

Heredity, contrasting characters, dominant, recessive, homozygous, heterozygous, carrier.

What we have learnt

- The transfer of characters across generations is called heredity.
- Inspite of similarities the differences in characters that are present in members of a species of organism is called as variation.
- Those variations that pass from one generation to the next like -dimple chin, hair colour are heritable variations.
- Those characters which do not pass from one generation to the next like mark of a wound, obesity etc. are called as acquired characters.
- Mendel performed experiments for several years to understand how characters were passed from one generation to the next. He extensively experimented mainly with pea plants provided us with some fundamental laws of heredity.
- He used mathematical deductions(mainly probability and chance) to test his hypothesis and deduce his laws.
- We come to know about the following about heredity from Mendel's experiments-
- Each character is expressed by a pair of factors
- During reproduction offspring receives only one of a pair of factors from a parent.
- Contrasting pairs of characters are represented by pairs of contrasting factors
- Law of Segregation: Factors do not mix but are passed on to gametes independently.
- Sickle cell anaemia follows Mendellian inheritance. The composition of haemoglobin changes, thereby changing the shape of normal red blood cells from disc shaped to sickle shaped.
- Zygotes containing XX as the 23rd pair of chromosome form females while those containing XY form males. The probability of having a female or male child is 50% for each case.

Assessment

1. Choose the right option-

(i) What do you think may have been the reason for Mendel's success?

(a) Clear planning based on reasoning, experimenting, recording observations etc. and duly writing article regarding the same.

(b) Focusing on certain clear contrasting characters.

(c) Use of mathematical calculations.

(d) All above options

(ii) Mendel had studied certain contrasting characters of pea plants. Which character do you think was not chosen by Mendel?

(a) Tall and dwarf plants (b) Yellow and green coloured seeds

(c) Terminal and axial flower (d) Round and wrinkled stem

(iii) Some people can roll their tongue (roller represented by RR/Rr) and this is an autosomal dominant character. Those who can't roll have the recessive factors(Non roller represented by rr)

A child is capable of rolling her tongue. Her brother fails to roll the tongue while two of her sisters can roll their tongues. If both of the parents can roll their tongue, what do you think would be the combination of factors in them?

(a) RR and RR (b) Rr and Rr (c) RR and rr (d) rr and rr

2. Let us consider 4 major blood groups of humans A, B, AB and O. These had been named on the basis of certain antigenic factors.. The presence of both A and B factors represented AB blood type while absence of both represented O blood type. Let us take I to represent the substance responsible for the said factor. IO then represents absence of the substance. Now observe the following table and answer the questions given below the table.

Blood Group	Factors
A	I^AI^A, I^AI^O
B	I^BI^B, I^BI^O
AB	I^AI^B
O	I^OI^O

- Those having blood group A would have how many IA factors?
- Those of blood group O should have how many IO?
- Which factor do you think is recessive . IO, IA or IB?
- 'A recessive character represents pure parental generation.' Justify this statement.
- A child of parents having blood group A has O group. What do you think are the factors that the parents have? What do you think could be the probable blood group type of a second child that they have?

3. When a blue flowered plant (Bb) is crossed with a white flowered plant (bb) what are the combinations possible in offspring generation?

4. A variety of cow named 'Zeba' is adapted to survive in hot conditions. Another variety 'Sahiwal' gives 20,000 liters of milk every year. The variety 'Angush' has a well built body. If we want to acquire maximum milk from a variety of Cow here in Chhattisgarh, which varieties of cows do you think must be crossed? Give reasons for your answer.

5. How will our knowledge of heredity help in improving our crop plants to acquire maximum production?

6. How can we choose suitable characters to obtain new varieties of plants? (Hint: We had studied about plants of mustard family in Chapter 1, you may site examples of other plants)

7. A farmer sowed seeds of purple flowered pea plants and claimed that all plants in the following generation would have purple flowers. Was he right? Why, why not?

8. We have been able to successfully obtain pink flowered Rose plants by crossing white and red coloured Rose plants respectively. .Do you think that some characters do intermix? Why? Site some other examples of this type that are related to agriculture.

9. What would happen if you played the game of coins with just one coin? What is the probability of getting a head then?

10. Can we develop high yielding variety seeds by hybridization? Can such seeds be developed only by crossing pure varieties?

11. The sweetness of milk is due to the presence of Lactose (a type of sugar) in it. You may have heard about people who fail to digest milk and milk products. The factor responsible for the production of the enzyme capable of digesting lactose is usually not present in these people. Even if a single factor for formation of the enzyme is present, lactose digesting enzyme is formed. Now answer the following questions on the basis of this information-

    - What would be the combination of factors of a child who fails to digest milk and milk products? What are characters represented by such factors called?
    - What is the combination of factors in the parents of such a child(take a lactose digesting factor as L)who are capable of digesting milk?
    - What percent of children of such parents would be able to digest milk?

12. In green gram, the development of two flowers at the axial position is a recessive character, while the development of a single flower at the axial position is a dominant character. If the dominant condition is represented by 'SS' and recessive by 'ss' then answer the following questions -

    - Find out the percentages of pure and hybrid plants obtained in the second generation(F2 generation) after crossing pure parental varieties.

- Find out the percentage of each variety of offsprings obtained by a cross between Heterozygous Ss and pure ss varieties.
- What would be the percentage of varieties with single axial flowers when a cross between homozygous variety SS and heterozygous variety Ss is conducted?

Show the formation of gametes and combination of factors in each of the questions of this section.

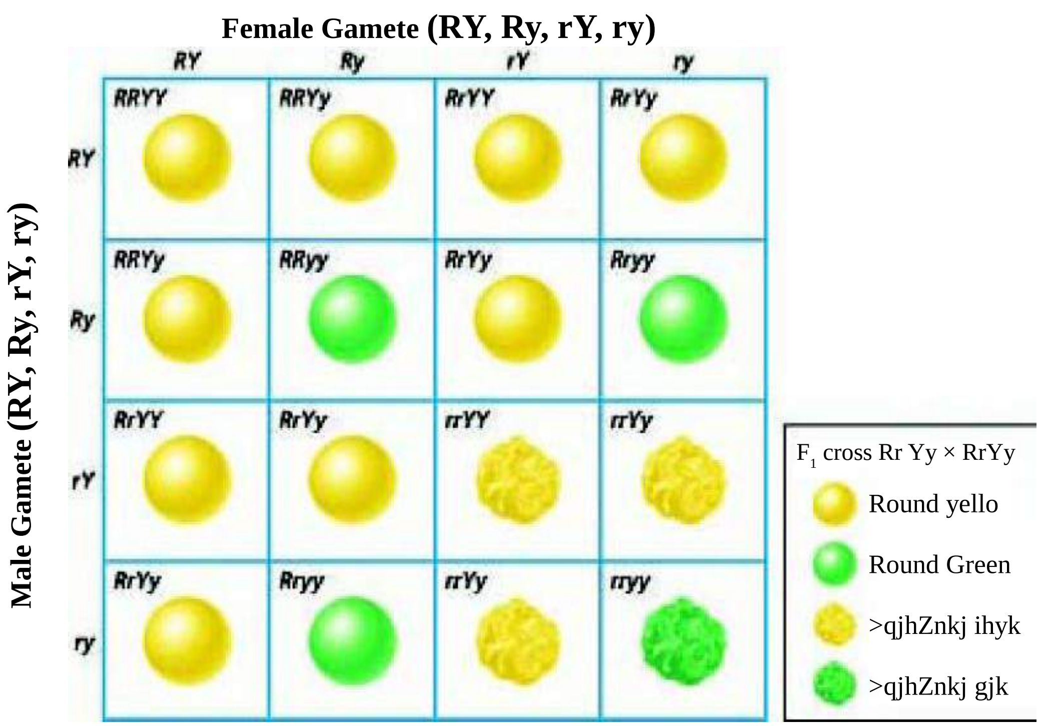
Annexure

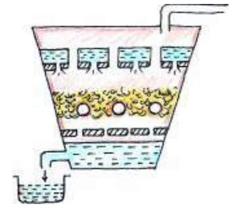
Dihybrid cross and another Law of Mendel-

Mendel had not only observed the inheritance of single characters, he had also observed characters in combinations. As for example Mendel observed crosses of plants that were grown from such characters as round and yellow seeds(RRYY) and wrinkled and green seeds(rryy).

He started with pure parental combinations(of nearly 600 seeds) and found that all plants obtained at the end of F1 generation bore round yellow seeds. When plants were grown from such seeds, he observed combinations like 315 round yellow, 108round green, 101 wrinkled yellow and 32 wrinkled green. The ratio of 9:3:3:1 obtained could only be possible if the hybrid varieties RrYy formed gametic combinations in the form - RY, Ry, rY and ry respectively.

Law of Independent assortment - Mendel concluded that different characters assort independently of each other while formation of gametes and form new combinations in forthcoming generations. Mendel deduced this law by observing inheritance of more than one character at a time. The following diagram shows a schematic representation of results obtained after a dihybrid cross(crosses obtained by observing two characters at a time in parental varieties)





CHAPTER 16

DERIVATIVES OF HYDROCARBONS

It was once believed that we could obtain carbon containing substances such as sugar, starch, camphor, urea etc. only from living organisms because only these organisms contained the 'vital force' necessary for their synthesis. Therefore, the branch of chemistry which deals with these compounds was known as organic chemistry. But in 1828 German chemist Friedrich Wohler used ammonium cyanate, an inorganic compound, to synthesize urea, an organic compound found in human urine. The laboratory synthesis of urea proved that vital force was not needed in the production of organic compounds. This was the first time that an organic compound (urea) was synthesized from an inorganic compound (ammonium cyanate.)

Friedrich Wohler

Friedrich Wohler (1800–1882), a German chemist, is known for being the first person to synthesize an organic compound from an inorganic compound. By making urea in the laboratory, he dealt a mortal blow to the vitalistic force theory which said that a vital force was necessary to produce the compounds found in living organisms.

Along with Liebig, Wohler studied the oil of bitter almonds and worked with other scientists on finding a method for the separation of silicon and beryllium from their mixtures. He also played an important role in the synthesis of calcium carbide and silicon nitride.

Carbon chemistry is the branch of chemistry which deals with the study of carbon and its compounds. We know that carbon atoms are capable of forming long chains by bonding to each other, a property known as catenation. Catenation is one of the reasons why such a large number of carbon compounds are found in nature. Of the compounds known today, almost 96% contain carbon.

We know that the compounds that contain only hydrogen and carbon are known as hydrocarbons. If all four valences of carbon in any compound are satisfied through single bonds, the compound is called alkane and is a saturated hydrocarbon. If they are satisfied through double or triple bonds then compounds are alkenes and alkynes respectively and are also known as unsaturated hydrocarbons.

In class 9^{th}, we studied alkanes in some detail. Alkanes are depicted by the general formula RH. When a hydrogen atom is removed from the alkane then the group (radical) formed is referred to as alkyl group and is generally depicted by **–**R. For example, when a hydrogen atom is removed from methane (CH_4) we get methyl ($–CH_3$) and it is removed from ethane we get ethyl ($–C_2H_5$) group. Are the properties of carbon compounds determined by these alkyl group or by some other group? Let us explore.

A functional group is an atom or group of atoms which when joined to an alkyl group determines the characteristic chemical properties of that carbonic compound. Some functional groups are shown in table–1.

Table–1: Some functional groups seen in carbonic compounds

Name of functional group	Formula
Aldehyde	$-\overset{O}{\overset{\Vert}{C}}-H$
Ketone	>C=O
Carboxylic acid	$-\overset{O}{\overset{\Vert}{C}}-OH$
Halo (chloro, bromo etc.)	–Cl, –Br

Questions

1. Identify and write the names of the functional groups in the following compounds

   C_3H_7OH, C_4H_9Cl, CH_3CHO, $C_5H_{11}COOH$

2. Write the names of the compounds formed by joining **–**OH functional group to ethyl and propyl groups respectively.

3. Name the compounds formed when **–**Br and **–**COOH are added to methyl groups.

You must have heard about caustic soda. The chemical formula of caustic soda is NaOH which means that sodium is joined to **–**OH group. Let us see another compound where **–**OH is present.

If one hydrogen atom of methane (CH_4) is replaced by **–**OH group then we get methyl alcohol. Now we know two compounds where the **–**OH group is present. These are:

NaOH and CH_3OH

Draw the electron dot structures of the two compounds given above. What is the type of bond joining Na^+ and **–**OH in NaOH and that between **–**CH_3 and **–**OH?

We looked at the structural differences between NaOH and CH_3OH. Let us now understand the nature of the two compounds through an activity.

Activity–1

- Take two beakers or glasses.
- Take 5 mL water in the first beaker and add a sodium hydroxide pellet to it.
- Take 5 mL methyl alcohol in the second beaker.
- Test the solutions in the two beakers with litmus paper and universal indicator and fill in your observations in the table given below.

Table–2: Nature of sodium hydroxide and methyl alcohol

Substance	Effect on red litmus paper	Effect on blue litmus Paper	pH according to universal indicator
Solution of sodium hydroxide			
Methyl alcohol			

From our observations in Activity–1 and our understanding of the nature of chemical bond (ionic bond in sodium hydroxide and covalent bond in methyl alcohol), we can see that both the compounds have an –OH group but their natures are different. NaOH has hydroxide ion (OH^- ion) and CH_3OH has hydroxyl group (–OH). Since methyl alcohol is a carbonic compound therefore –OH acts as a functional group. Therefore, the nature of the two substances also depends on the root group to which OH is attached.

16.1 Alcohol

When an alkyl group bonds with –OH (a functional group) then the resulting compound is known as alcohol or alkyl alcohol or alkanol. Alkanols are also known as hydroxyl derivative of hydrocarbons.

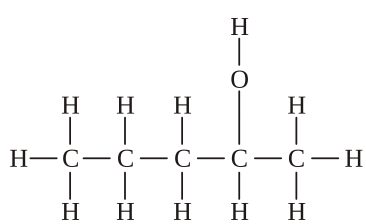
16.1.1 Nomenclature of alcohols

According to IUPAC nomenclature, the suffix –e in the parent hydrocarbon is replaced by the suffix –ol when naming alcohols. Table–3 has some examples; use them to replace the question marks with the correct alcohol names.

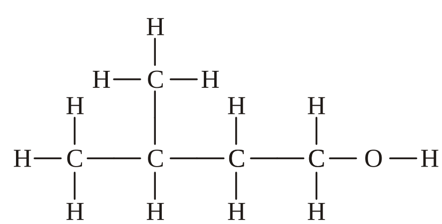
Table-3

Parent hydrocarbon	IUPAC name	Formula
Methan***e***	Methan***ol***	CH_3OH
Ethan***e***	Ethan***ol***	CH_3CH_2OH
Propane	?	?
?	Butanol	?

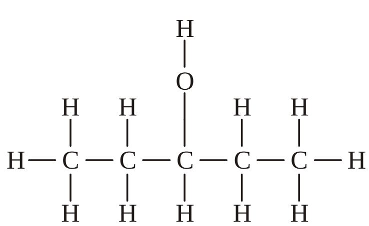
Are the four structures shown below same or different? Name the compounds.



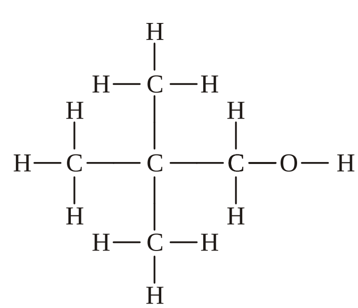
(a)



(b)



(c)

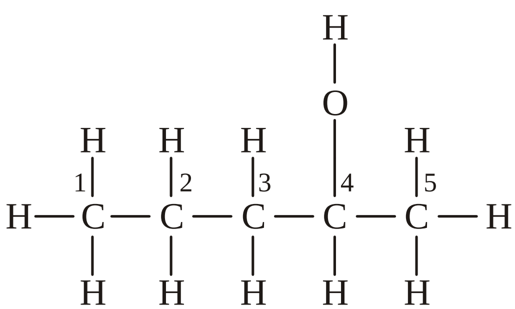


(d)

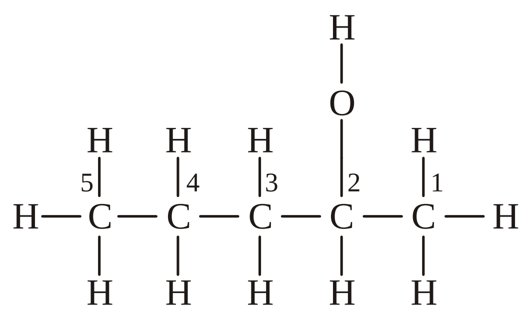
We find that all four compounds have the same molecular formula, $C_5H_{12}O$ but their structural formulae are different. We learnt the IUPAC nomenclature of hydrocarbons in class-9th. For naming alcohols according to IUPAC:

- Choose the longest, continuous carbon chain having –OH (alcohol) functional group.
- The longest chain of carbon atoms containing the –OH group is numbered in such a way that the –OH group is attached at the carbon atom possessing lowest possible number in the chain.
- Now follow the steps you used while naming hydrocarbons. Write the position number of alkyl group followed by the name of the parent chain followed by a dash, then the position number of the –OH group followed by a dash and the suffix –ol.

Let us now use these rules to name the structures shown above. In structure 'A', the carbon chain can be numbered in two ways as shown below:



A (i)



A (ii)

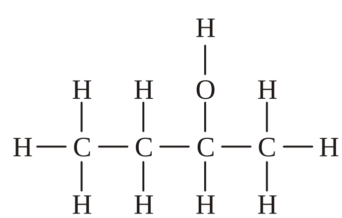
Which numbering is correct, A (i) or A (ii)? According to IUPAC rules, the numbering shown in A(ii) is correct because in A (ii) the carbon to which the –OH group is attached is numbered 2 where as in A (i) it is numbered 4. Therefore, the structure shown in A(ii) is pentan–2–ol.

If we examine 'A' and 'C' we find that their molecular formula are same but the locations of the carbon atoms to which –OH groups are attached are different. Compounds whose molecular formula is same but which differ from each other in the location of the functional groups on or in the carbon chain are called positional isomers.

Similarly, if look carefully at 'B' and 'D', we find that the carbon chains of the two molecules are different although their molecular formula is same. Compounds whose molecular formula is same but which differ from each other in the arrangement of the carbon chain are called chain isomers.

Questions

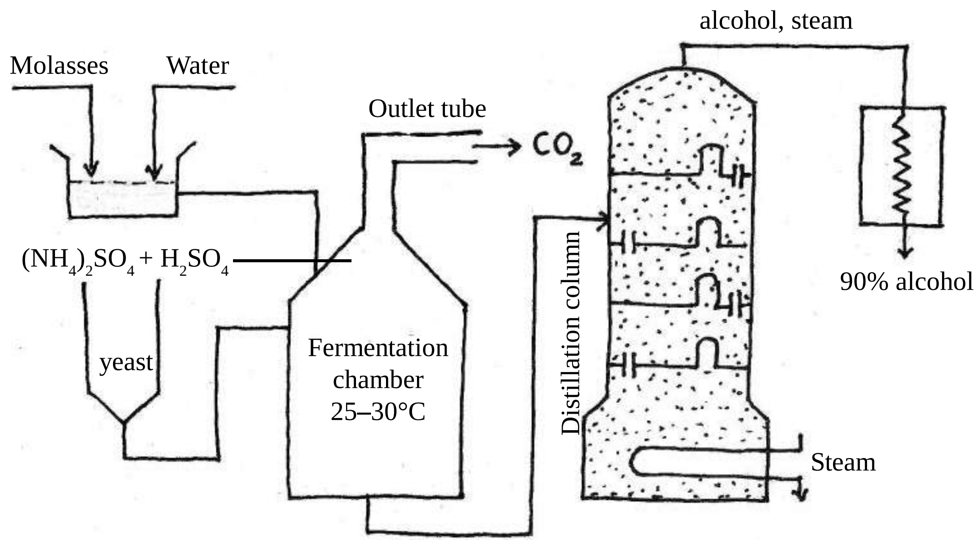
1. Write the names of two compounds having hydroxyl group and two having hydroxide group.
2. Write the IUPAC name of the given compound.



3. Write the structural formula of 2–methylpropan–1–ol.
4. Write the structural formulae of all possible isomers of C_3H_8O.

16.1.2 Industrial manufacture of ethanol

Industrial manufacture of ethanol (ethyl alcohol) is done using fermentation method. In this process, sugar is first separated from cane–sugar juice by crystallization. The thick, yellow syrupy substance left behind is called molasses. Molasses are diluted by adding water to obtain a 8–10% solution. Then ammonium sulphate, which promotes yeast reproduction, is added to the solution. A small amount of sulphuric acid is also added to the solution. Sulphuric acid also promotes the growth of yeast and kills other microorganisms.



Figure–1: Industrial manufacture of ethanol from molasses

The mixture is filled in a tank (as shown in figure1) and 5% yeast is added to the tank and the mixture is left for two-three days, in the absence of air, at 25-30°C. Yeast is a type of fungus which has the enzymes invertase and zymase. Invertase converts the sucrose present in molasses into glucose and fructose. Ethanol is obtained by fermentation of glucose and fructose in the presence of zymase. In this process, carbon dioxide gas is released with rapid bubbling and is removed via the outlet tube. We can show the formation of alcohol by the following equation:

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{\text{Invertase}} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

$$C_6H_{12}O_6 \xrightarrow{\text{Zymase}} \underset{\text{Ethanol}}{2C_2H_5OH} + 2CO_2\uparrow$$

Biocatalysts : Enzymes – Catalysts are substances that do not themselves take part in a chemical reaction but whose presence affects the rate of the reaction. Catalysts that effect biological processes and reactions are called enzymes or biocatalysts.

The alcohol obtained by this method is quite dilute. 100% alcohol, that does not have any trace of water, is called absolute alcohol. Ethanol which has 5% water is called rectified spirits. The mixture of petrol and ethanol is called power alcohol and it is used as a fuel in automobiles.

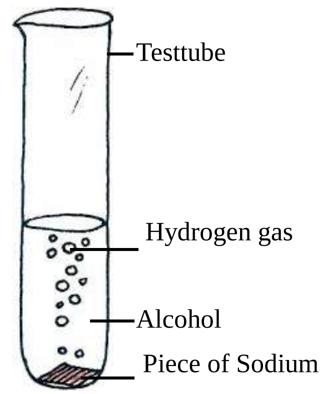
16.1.3 Properties of alcohols

Usually alcohols range from weakly acidic to neutral in nature. Let us understand this through an activity.

Activity–2

- Take 10 mL ethanol in a testtube.
- Cut a rice grain–sized piece of sodium from kerosene and dry it on a filter paper.
- Add this sodium to the ethanol in the testtube and observe and record what happens.

Ethanol reacts with extremely reactive metals such as sodium and magnesium to release hydrogen gas.



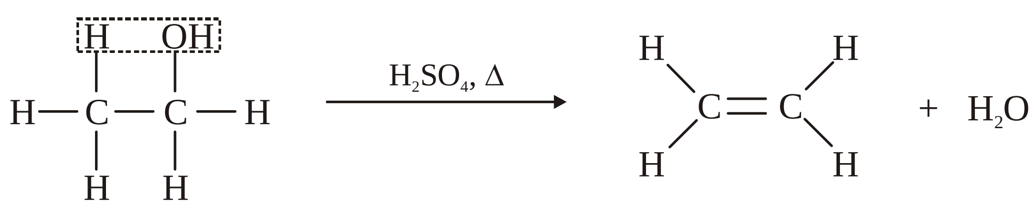
Figure–2: Reaction of alcohol with sodium metal

$$C_2H_5OH + Na \longrightarrow \underset{\textit{Sodium ethoxide}}{C_2H_5ONa} + H_2\uparrow$$

Similarly, methanol reacts with sodium to give sodium methoxide. What will happen when ethanol reacts with magnesium?

16.1.3.1 Dehydration of alcohols

When ethanol is heated at 443 K with excess of concentrated sulphuric acid the –OH group combines with the hydrogen on the nearest carbon atom to give water. Thus, the dehydration of alcohol leads to alkene formation.



16.1.3.2 Oxidation of alcohols

Alcohols are easily oxidized in the presence of strong oxidizing agents to form carboxylic acids.

$$C_2H_5OH \xrightarrow{\text{Oxidizing agent}} \underset{\textit{Ethanoic acid}}{CH_3COOH} + H_2O$$

$$CH_3OH \xrightarrow{\text{Oxidizing agent}} \underset{\textit{Methanoic acid}}{HCOOH} + H_2O$$

16.1.4 Uses of alcohols

1. Since many substances are soluble in alcohol therefore it is used as a solvent in paints, varnish etc.
2. The boiling point of methanol (methyl alcohol) is 65°C and it is highly inflammable therefore it is mixed with petrol and used as a fuel.
3. Ethanol is less harmful as compared to methanol therefore in most countries ethanol is mixed with petrol. Ethanol is also used as fuel in spirit lamps.
4. The freezing and melting point of alcohol is –114°C so it is used in low temperature thermometers. Alcohol is a colourless liquid that expands easily and uniformly. A red dye is added to it so that temperature can be read easily.
5. Glycol and glycerols are also types of alcohols which are used to make soaps, medicines and also used as antifreeze in car radiators.
6. Ethanol is used as a sterilizing agent in the medical field.

Harmful effects of alcohol

Consumption of small quantities of dilute ethanol causes intoxication. Long-term consumption of high quantities of alcohol can affect many vital organs such as the liver. Alcohol also slows down the metabolic processes in our body. Intake of very small quantities of methanol can cause death. It reacts rapidly with components of liver cells and poisons the entire body.

Ethanol is an important industrial solvent. It is manufactured on a large scale for industrial purposes. To prevent the misuse of ethanol, it is made unfit for drinking by adding poisonous substances like methanol (10%-15%) to it. Dyes are also added to colour the alcohol blue so that it can easily be identified that methanol has been added. This mixture is known as methylated spirit.

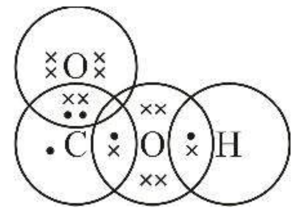
Questions

1. What are molasses?
2. What will happen when:
   (a) Ethanol is heated in the presence of concentrated sulphuric acid.
   (b) Yeast is added to molasses

16.2 Alkanoic Acids

You have read about acids in the chapter on acids, bases and salts. Carbonic acids are scattered all around us in nature, for example, acetic acid, citric acid, lactic acid etc. All these acids have the functional group –COOH which is known as the carboxylic group. Let us see the electron dot structure of –COOH.

When the carboxylic group is joined with the –H group then we get HCOOH which is known as formic acid. If instead of –H , we place –R (alkyl group) then we get RCOOH. In IUPAC nomenclature, these are called alkanoic acids, that is, the –e of alkane is replaced by –oic acid. Table-4 has some examples; use them to replace the question marks with the correct acid names.

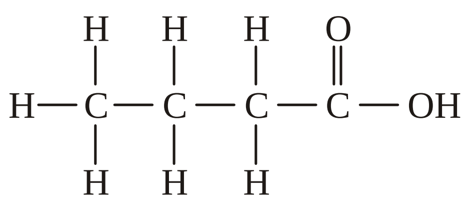


Structure of –COOH

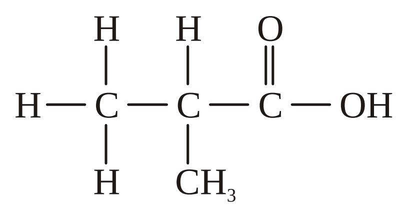
Table-4

Parent hydrocarbon	**IUPAC name**	**Formula**
Methan***e***	Methan***oic acid***	HCOOH
Ethane	?	CH_3COOH
Propane	?	?
?	Butanoic acid	?

You have read about isomerism in alcohol. Is it possible for alkanoic acids to have structural isomers? Will their names be different? Let us understand through some examples-



(A)



(B)

Just as we did for alcohols, in alkanoic acids also we must choose the longest, continuous carbon chain having the –COOH functional group. While numbering the carbon chain, the carbon atom to which –COOH group is attached is always given the number 1. In this way, the alkanoic acid shown by structure 'A' will be called butanoic acid and 'B' will be called 2–methylpropanoic acid.

When we look at structures 'A' and 'B' we find that both have the molecular formula $C_4H_8O_2$ but they are structurally different. Therefore, 'A' and 'B' are isomers of each–other. Look carefully at the two structures and tell whether 'A' and 'B' are chain isomers or structural isomers?

Questions

1. Write the structures of all possible isomers of $C_6H_{12}O_2$.
2. What is the IUPAC name of formic acid?

16.2.2 Industrial preparation of ethanoic acid (Quick vinegar method)

The industrial preparation of vinegar involves the fermentation of alcohol. In this method, a tank with holes at the bottom, to allow air–circulation, is used (figure-3). The tank is filled with wood shavings and mixed with ammonium sulphate. Ammonium sulphate is useful in increasing bacteria population. Then, 10% ethanol is added slowly to the tank from above. Ethanoic acid is produced in the lowest portion of the tank by fermentation process. The ethanoic acid produced as a result is known as vinegar and the concentration of ethanoic acid in vinegar is 3-4%.

Pure ethanoic acid which is free from water is known as glacial acetic acid. Its boiling point is 118°C.

To test whether ethanoic acid has been produced or not, sodium carbonate is added to the product obtained. If acid has been formed then carbon dioxide gas would be released with rapid bubbling.

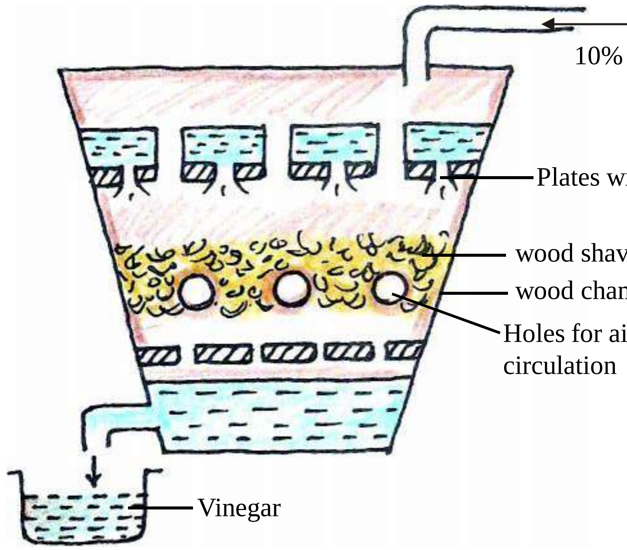


Figure-3: Quick vinegar method for preparing acetic acid

16.2.3 Properties of alkanoic acids

Ethanoic acid is acidic in nature and most acids are soluble in water. However, high molecular weight alkanoic acids (fatty acids), for example, citric acid are insoluble in water. Because of their acidic nature, they turn blue litmus red. Let us learn more about the chemical properties of some alkanoic acids:-

1. Salt formation: Since alkanoic acids are acidic in nature therefore they react with bases to give salt and water. For example, ethanoic acid (acetic acid) reacts with caustic soda to give sodium acetate salt.

$$CH_3COOH + NaOH \longrightarrow \underset{\textit{sodium acetate}}{CH_3COONa} + H_2O$$

Similarly, methanoic acid reacts with calcium hydroxide to give calcium formate.

$$2HCOOH + Ca(OH)_2 \longrightarrow \underset{\textit{calcium formate}}{(HCOO)_2Ca} + 2H_2O$$

Name the product formed when acetic acid reacts with magnesium hydroxide. Write the balanced chemical equation of the reaction.

Acetic acid reacts with sodium carbonate and sodium hydrogencarbonate to form salts with evolution of carbon dioxide gas.

$$CH_3COOH + Na_2CO_3 \longrightarrow CH_3COONa + H_2O + CO_2\uparrow$$
$$CH_3COOH + NaHCO_3 \longrightarrow CH_3COONa + H_2O + CO_2\uparrow$$

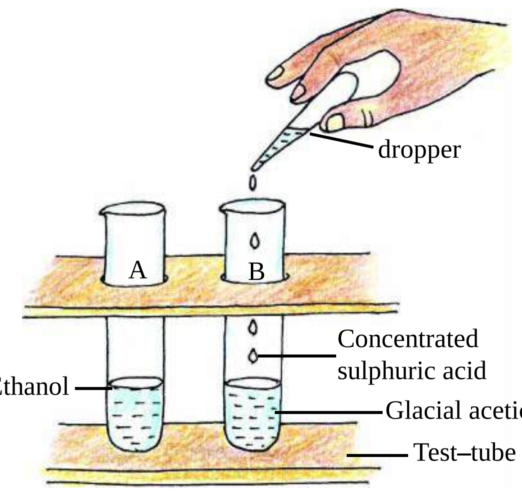
Balance the two equations given above. Can you think of some activity to test the presence of CO_2 gas?

2. Reaction with alcohol: When an alkanoic acid is heated with an alcohol in the presence of concentrated sulphuric acid, ester is formed as product. Esters have a distinct fruity smell and the reaction is known as esterification.

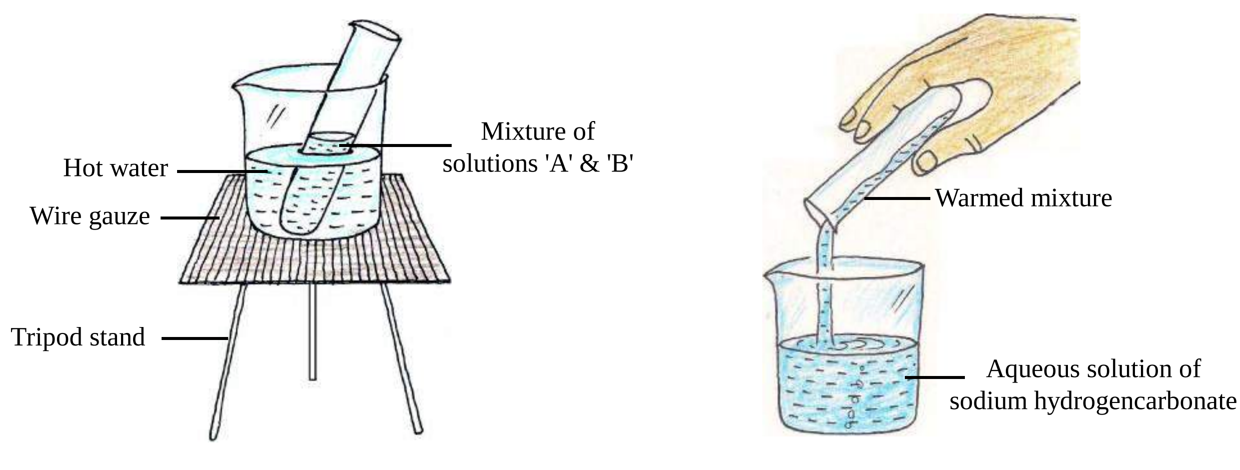
$$\underset{\textit{Ethanoic acid}}{CH_3COOH} + \underset{\textit{ethanol}}{CH_3CH_2OH} \xrightarrow{\text{Conc. sulphuric acid}} \underset{\textit{ester}}{CH_3COOCH_2CH_3} + H_2O$$

Activity–3

- Take 150 mL water in a beaker and warm it to 60°C.
- Take two test tubes and label them A and B respectively.
- Take 5 mL ethanol in test tube A.
- Take 5 mL glacial acetic acid in test tube B and add 4-5 drops concentrated sulphuric acid to it.
- Now add the solution in test tube A to the solution in test tube B.



- Now place the test tube in the warm water so that the reaction mixture also becomes warm. Keep shaking the test tube from time to time.
- Pour the reaction mixture in a solution of sodium hydrogencarbonate in water. Doing this will cause the unreacted ethanoic acid to react with $NaHCO_3$. Did you see any bubbles? (Figure-4).



Figure–4: Esterification

- Observe the reaction mixture and note if there is any distinct smell (sweet and fruity). The smell could be due to which substance?

3. Reaction with metals: Similar to other acids, alkanoic acids also reacts with metals such as sodium to release hydrogen gas.

$$CH_3COOH + Na \longrightarrow CH_3COONa + H_2\uparrow$$

Balance the equation given above. How will you test that the gas produced is hydrogen gas?

16.2.4 Uses of alkanoic acids

1. A dilute solution of acetic acid is known as vinegar and it is used as a preservative in pickles, sauces etc.
2. Alkanoic acids are used to make esters which are used in making perfumes, polymer etc.
3. Citric acid, tartaric acid and lactic acid are hydroxyl acids (that is, **–**OH functional group is also present along with **–**COOH group in these compounds). These acids are used as food preservatives.

Questions

1. What will happen when ethanol reacts with ethanoic acid? Write the balanced chemical equation of the reaction.
2. How can we make magnesium formate from formic acid? Show the reaction using a balanced chemical equation.

16.3 Polymers

In previous classes we saw that carbon compounds have chains of carbon atoms. Carbons atoms bond with each other to give compounds having very long chains, from two to thousand carbon atoms. Lower molecular weight carbonic molecules link to each other to give high molecular weight carbonic molecules and this process is known as polymerisation. The lower atomic weight mplecules are known as monomers and the high molecular weight molecule formed is known as polymer.In this way, each polymer has many monomers and their number is denoted by n. Proteins, carbohydrates, terylene, polythene etc. are some examples of polymers.

16.3.1 Natural and synthetic polymers

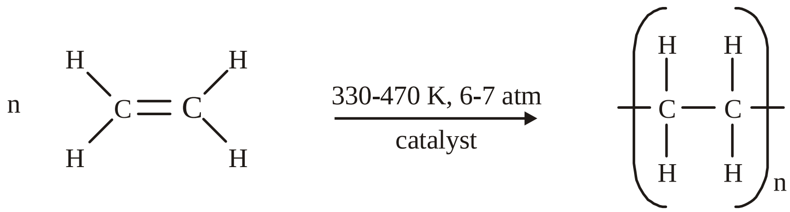
We obtain certain polymers such as wool and silk from animals and others such as starch and cellulose from plants. These polymers are known as natural polymers.

On the other hand, polymers made by human beings are called synthetic polymers. Polymers have made an immense difference in our daily lives and we use them in a variety of ways. Let us learn about some polymers.

16.3.2 Polythene

Polythene is a long chain polymer of the monomer ethane. There are two main methods of polymer production and the nature and properties of the polymers obtained by these methods are different.

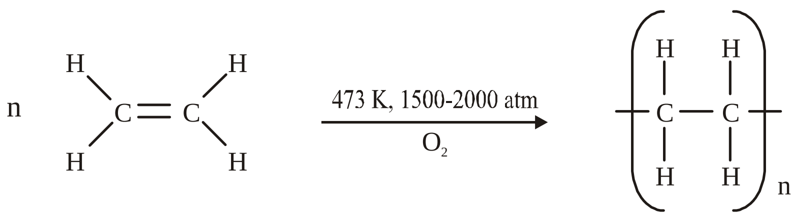
16.3.2.1 Low density polythene (LDPE): When a large number of ethene (ethylene) molecules are heated to 330-470 K under 6-7 atm pressure in the presence of a catalyst, we get a polythene which has a high melting point and low density.



Ethene *low density polythene*

This polymer is semi-transparent and hard and is therefore, used for making pipes and buckets. It is inert towards most chemicals.

16.3.2.2 High density polythene (HDPE): When a large number of ethene (ethylene) molecules are heated at 473 K in the presence of minute quantities of oxygen under 1500-2000 atmospheric pressure, we get a transparent polythene which is called high density polythene or HDPE.



Ethene *high density polythene*

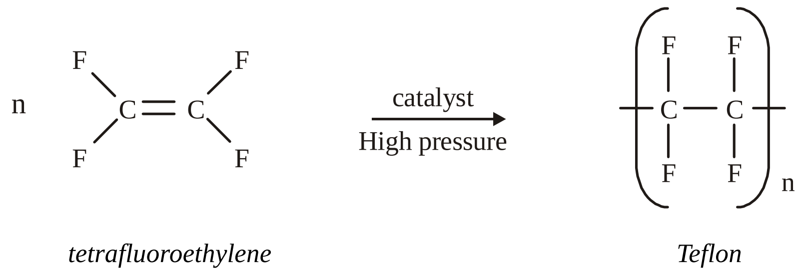
Since this type of polymer has high density and low melting point, it is used for making bottles and sheets.

16.3.3 Teflon

Have you heard of cooking utensils in which the food does not stick when we cook it? What is the substance that is used to coat these utensils? This substance is actually the polymer, Teflon which is also used for making insulated instruments. Teflon is also used in making pipes or tubes that often come in contact with corrosive substances such as concentrated acids, concentrated alkalis, aqua regia. These days Teflon is also used in making packing gaskets (figure-4).

Figure–5: Packing gaskets

Teflon is made from tetrafluoroethylene at high pressures in the presence of a catalyst.

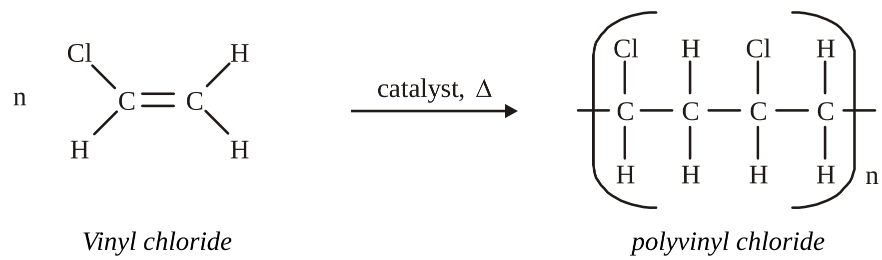


Note that Teflon is inert to all chemicals but can melt at temperatures above 330°C. Therefore, while using Teflon coated utensils in cooking we should not cook at high flames.

16.3.4 Polyvinyl chloride

Have you ever wondered what is common to the material used to make raincoats, table covers, mudguards of cycles and motorcycles, toys, gloves and electrical–wire coatings?

You will find that all these materials are electrical insulators and made of polyvinyl chloride (PVC). To produce PVC, vinyl chloride is heated in the presence of a catalyst. PVC is also inert to heat and chemicals.



16.3.5 Harmful effects of polythene

Till very recently, most of the materials and objects that we used in our day to day lives such as furniture, paper bags, jute fabrics etc. were made from plant-products. These were easily decomposed although cutting trees in excess to obtain products caused environmental imbalance.

We started using polythene, which is a petroleum product, thinking that this would reduce the cutting of trees. We now know that most chemicals do not affect polythene and so it cannot be decomposed easily. Therefore, it is rapidly becoming a cause of environmental pollution.

Because polythene does not decompose, it affects not only the lives of humans but the entire ecological system. If we try to destroy it by burning, gases such as CO_2 and CO are produced. It is clear from figure-6 that regular use of polythene leads to pollution of environmental factors such as water, air and soil. When animals eat polythene they fall sick and can even die because they are unable to digest it. So we see that polythene affects not just non–living aspects but living beings as well. We humans have also been harmed by use of polythene.

Figure–6: Environmental effects of polythene

In this situation, it is of primary importance that we eliminate or minimize the use of polythene. Several positive steps have been taken in this direction. Research shows that some microorganisms are capable of decomposing polythene but more research is still needed in this area. It is also proposed that polythene can be melted to build roads. Many other initiatives have been undertaken to recycle polythene.

Keywords

Functional group, alcohol, methanol, ethanol, fermentation, enzyme, absolute alcohol, rectified spirit, methylated spirit, carboxylic acid, ethanoic acid, glacial acetic acid, monomer, polymer, polymerization, antifreeze, ester, esterification, PVC, low density polyethylene, high density polyethylene, Teflon

What we have learnt

- ROH and RCOOH are used to denote alcohols and acids respectively.
- An atom or group of atoms which when joined to an alkyl group determines the characteristic chemical properties of that carbonic compound, is known as a functional group.
- Alkyl groups are depicted by –R.
- The functional group in alcohols is –OH and that in alkanoic acids is –COOH.
- Fermentation of molasses is used for industrial preparation of alcohol.
- Pure alcohol which does not have any water is known as absolute alcohol.
- Rectified spirit is ethanol having 5% water.

- To prevent the misuse of ethanol, it is made unfit for drinking by adding poisonous substances like methanol (10%-15%) to it. This mixture is known as methylated spirit.
- Fermentation of ethanol is used to prepare ethanoic acid.
- 3-4% solution of ethanoic acid is known as vinegar.
- Pure ethanoic acid is known as glacial acetic acid.
- Low molecular weight monomers combine together to give high molecular weight polymers. This process is known as polymerization.
- Polymers like silk and wool which are obtained from animals and those like starch and cellulose which are obtained from plants are called natural polymers. Those polymers that are made by humans are called synthetic polymers.
- The monomer of polythene is ethene. The polymer of vinly chloride is called polyvinylchloride. The monomer of teflon is tetrafluroethene.

Exercise

1. Choose the correct option

   (i) When ethanol has 5% water added to it, it is called-

   (a) Rectified spirit (b) Methylated spirit

   (c) Methanol (d) Absolute alcohol

   (ii) Packing gasket is made of

   (a) Low density polythene (b) High density polythene

   (c) teflon (d) Polyvinyl chloride

   (iii) If sodium carbonate is added to ethanoic acid, a gas is evolved with rapid bubbling. This gas is-

   (a) CO (b) CO_2

   (c) O_2 (d) Water vapour

   (iv) The IUPAC name of acetic acid is-

   (a) Ethanoic acid (b) ethanol

   (c) Methanol (d) Methanoic acid

2. What happens when-

   (i) Ethanoic acid reacts with sodium

   (ii) Ethanol reacts with sodium

3. Complete the following chemical eqautions:

   (i) $C_2H_5COOH + ? \longrightarrow (C_2H_5COO)_2Mg + H_2$

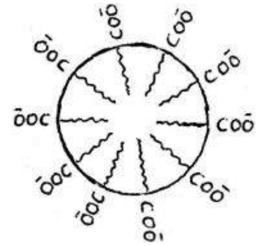
   (ii) $CH_3OH + CH_3COOH \longrightarrow ? + H_2O$

   (iii) $CH_3COOH + Na_2CO_3 \longrightarrow ? + ? + CO_2$

4. Why is ethanol used in thermometers?
5. How is ethene obtained from ethanol?
6. Write the structures of possible isomers of $C_5H_{10}O_2$.
7. How is ethanol manufactured industrially?
8. What is vinegar? How is it manufactured?
9. What will be the condensed structure of PVC? Write any four uses of PVC.
10. Nadira was studying the chemical properties of ethanol and ethanoic acid. To do this, she took ethanoic acid and concentrated sulphuric acid in a testtube and heated the mixture. While she was carrying out this activity, Meena came and added ethanol to the mixture. When this mixture was added to water, there was a unique odor. Can you tell which chemical reaction took place and write the balanced equation for the reaction.
11. Abraham had two solutions - ethanol and ethanoic acid. He added sodium to both the solutions and saw that a gas was produced. When a burning matchstick was placed near the gas, a pop sound was heard. Show the reactions through chemical equations.
12. Jaspreet has ethanol and ethanoic acids in two separate beakers but she forgot to label them. Help Jaspreet identify which beaker has ethanol and which has ethanoic acid.
13. What is a polymer? Explain the polymerization of ethene.
14. What is the difference between low density polythene and high density polythene? Write their used based on their properties.
15. When a carbon compound, A having molecular weight 46u was oxidized, a carbonic acid B was obtained. Compound A is used a sterilizing agnet. Identify A and B and write the balanced chemical equations.

CHAPTER 17

CHEMISTRY IN DAILY LIFE



We use a number of chemical compounds - for example, water, salt, sugar, soap etc. - in our day to day lives. Would life be possible without water? Can you imagine how food would taste if we did not add sugar and salt to it? Not just salt but many other inorganic chemicals such as baking soda, baking powder etc. are used in food preparation and also in the baking industry. Bleaching powder is used to disinfect water and make it free of germs. Cement, glass, Plaster of Paris are used in construction of buildings. We will study many such important chemical compounds and mixtures in this chapter.

17.1 Water

Three-fourth of the earth's surface is covered with water and it is found in oceans, rivers, lakes etc. Water is also found up to a certain depth beneath the earth's surface. For all living beings (plants and animals), water is as essential as oxygen for survival. On earth, water is present in three forms. These forms are solid (ice), liquid (water) and gas (water-vapour).

Usually the density of a substance in the solid state is more than its density in the liquid state. At 4°C, the density of water in the solid state (ice) is 0.9 g/mL and its density in the liquid state is 1 g/mL. As you can see, at 4°C the density of ice is less than the density of water and therefore ice floats on water. This is a boon for water-life. In colder regions of earth, the surfaces of rivers and lakes freezes to ice. Since ice is a thermal (heat) insulator therefore, water below the ice-surface cools more slowly and does not freeze easily.

Water vapour present in air is known as humidity. Humidity levels can change from season to season. Water is capable of dissolving many-many substances and therefore it is also known as universal solvent.

17.1.1 Soft and Hard Water

Water is called hard water or soft water depending on the amount of salts present in it and also on how much lather it produces with soap.

Soft water: It quickly forms a lot of lather with soap. Rain water and distilled water are two examples of soft water.

Hard Water: It takes a long time to form lather with soap and very little lather is seen. Instead, hard water forms a precipitate, known as soap scum, with soap.

17.1.2 Causes of hardness of water

The presence of dissolved salts of magnesium or calcium causes hardness of water. The salts can be hydrogencarbonates or suphates or carbonates. If the dissolved salt is of sodium the water will be soft. Soap is a sodium salt of long chain fatty acids, for example, sodium stearate ($C_{17}H_{35}COONa$). It reacts with calcium and magnesium salts to give a precipitate. The reaction can be written as follows:

$$2C_{17}H_{35}COONa + M^{2+} \longrightarrow \underset{\textit{Precipitate}}{(C_{17}H_{35}COO)_2 M\downarrow} + 2Na^{+}(aq)$$

Here, M^{2+} is being used for Ca^{2+} or Mg^{2+}.

Water will form lather with soap only after all the magnesium and calcium salts are precipitated. A lot of soap is wasted during the precipitation reaction. Additionally, the residual soap scum clings to clothes giving them a dull gray appearance.

17.1.3 Types of hardness

1. **Temporary hardness:** This is caused if dissolved calcium or magnesium hydrogencarbonates are present in water. When we boil water, the soluble salt (calcium hydrogencarbonate or magnesium hydrogencarbonate) gets precipitated as insoluble carbonate. You may have seen a white ring or white film deposited in utensils which are used for heating water; this is the insoluble carbonate.

$$Ca(HCO_3)_2(aq) \xrightarrow{\text{Boiling}} CaCO_3\downarrow + H_2O + CO_2\uparrow$$

Suppose the hardness of water is due to magnesium hydrogencarbonate. In this case, what will happen when we boil water? Can you write the chemical equation for this reaction?

Boiling is one method of getting rid of temporary hardness. Another way is by adding a fixed quantity of limewater to it.

$$Ca(HCO_3)_2(aq) + Ca(OH)_2 \longrightarrow 2CaCO_3\downarrow + 2H_2O(l)$$

2. **Permanent hardness:** This is caused by the presence of dissolved salts of calcium or magnesium chlorides and/or calcium and magnesium sulphates in water. Permanent hardness cannot be removed by boiling or treatment with limewater.

Modern techniques for softening hard water

Generally, two techniques are commonly used for softening of hard water that has excessive salts. One of the techniques is reverse osmosis (RO) method. You know that when two solutions are separated by a semi-permeable membrane then the solvent molecules of the dilute solution flow towards the concentrated solution through this membrane. This process is known as osmosis. But in reverse osmosis, high pressure is used so that water molecules from the concentrated solution (in this case, hard water) flow through the semi-permeable membrane and we get pure water on the other side. Thus, a semi-permeable membrane is used to separate salt molecules from hard water. However, a lot of water is wasted during reverse osmosis purification.

In the second technique, water is softened using ion-exchange resin (where the resin is porous). A resin with sodium ions is used to filter hard water. When the hard water passes through the resin, Ca^{2+} and Mg^{2+} ions present in the water get exchanged with Na^{+} ions. The water thus obtained is soft as it is free from Ca^{2+} and Mg^{2+} ions. The Na^{+} ions in the resin decrease with use and the resin has to be replenished from time to time.

17.1.4 Potable water

Drinking water should be clean, colourless, odourless and free from germs. It should also have a sufficient amount of dissolved salts. To make the available water potable, we can add alum, bleaching powder, potassium permanganate, chlorine etc. as needed to water purification devices. We can use ultraviolet rays to purify water.

Distilled water, which is obtained by distillation, is used in medical research, car batteries and in experimental work.

Try to use solar energy to prepare distilled water for your school's laboratory.

17.1.5 Uses of water

1. Water is used as a solvent.
2. Water is essential for crops and in agriculture.
3. Water is used in a number of industries such as textile industry, paper industry, mining etc.
4. Water is used to wash clothes and for cleaning purposes.
5. Since water has high specific heat, it is used in boiler engines, coolers etc.

17.1.6 Water pollution

When water is used (for cleaning or in industries), some undesirable substances get mixed in it. Further, there can be decrease in amount of oxygen dissolved in water due to many reasons and this can affect the properties of water. This water is now polluted and is no longer suitable for use.

You must be familiar with many causes of water pollution; list some factors that cause water pollution in your area. It is our responsibility to prevent water pollution and control it. Some ways of preventing and limiting water pollution are:

1. Making it compulsory for all industries to install water purification devices to treat waste water produced by them.
2. Household waste water and sewage water should be treated before it enters rivers and lakes.
3. The use of harmful pesticides should be limited and their excessive use should be banned.
4. Many human activities, such as bathing; washing clothes; immersing dead bodies, ashes of cremated persons, idols, flowers etc. in rivers; also pollutes water. Such activities need to be monitored and controlled.

17.2 Common Salt

Sea water has 30-35 g of dissolved salts per liter of water. The primary salt present is sodium chloride which is also known as common salt.

17.2.1 Salt production

Sea water is collected in shallow ditches near the seashore and left for evaporation. Once the water evaporates it leaves behind raw salt, which contains many other salts and a small quantity of sand along with common salt (figure-1). This raw salt is purified and crystallized for use. Obtaining salt from sea water is difficult and the task has to be carried out very carefully. During the purification process of raw salt, some desired and necessary substances are also added to it for example, iodine. Iodine is added in the form of potassium iodate. Can you tell why iodine is added to common salt?

Figure-1: Production of salt from sea water

A few regions of the world have salt mines that give us rock salt. It is believed that some parts of seas or oceans must have dried up long ago and resulted in these salt mines.

Common salt is an essential component of our diet but can we use sea water to cook food?

Salt plays an important role in several biological processes. Therefore, our food should have the right quantity of salt in it. High amounts of salt in our body can cause high blood pressure and low amounts may lead to low blood pressure.

Do you know that many packaged foods such as chips and *namkeen* have very high amounts of salts and are therefore harmful?

17.2.2 Uses of salt

1. Common salt is used as a preservative that prevents food from spoiling by stopping the growth of bacteria.
2. Common salt is an important raw material in production of many substances, such as sodium hydroxide, baking soda, washing soda, bleaching powder etc.
3. Oral rehydration solution (ORS), which is a solution of sugar and salt in water, is the primary treatment for when our bodies get dehydrated.

Questions

1. We have two water samples, 'A' and 'B'. Sodium hydrogencarbonate was found in sample 'A' and magnesium sulphate was found in sample 'B'. Which sample of water is hard and why?
2. Give two natural sources of common salt.

17.3 Baking Soda

Baking soda is often used in the kitchen to obtain spongy cakes and breads. Sometimes, it is also used to cook food faster. Its chemical name is sodium hydrogencarbonate and it is also known as sodium bicarbonate.

Baking soda is produced by Solvay ammonia process which uses salt as one of the raw materials.

$$NaCl + H_2O + CO_2 + NH_3 \longrightarrow \underset{\textit{Ammonium chloride}}{NH_4Cl} + \underset{\textit{sodium hydrogencarbonate}}{NaHCO_3}$$

In a previous chapter, you checked the pH value of sodium hydrogencarbonate. Can you tell why it is used to neutralize acidic solutions?

When sodium hydrogencarbonate is heated it decomposes to form sodium carbonate with production of carbon dioxide gas.

$$2NaHCO_3 \xrightarrow{\text{Heat}} Na_2CO_3 + H_2O + CO_2$$

17.3.1 Uses of baking soda

1. In making baking powder – Baking powder is a mixture of baking soda and tartaric acid. When baking powder is heated or mixed with water, the following reaction takes place–

$$NaHCO_3 + \underset{\textit{(from acid)}}{H^+} \longrightarrow CO_2\uparrow + H_2O + \text{Sodium salt of acid}$$

   Carbon dioxide produced during the reaction causes bread or cakes to rise, making them soft and spongy.

2. Sodium hydrogencarbonate is used as an antacid to reduce acidity of stomachs. Being alkaline, it neutralizes excess acid in the stomach.
3. Baking soda is also used in soda-acid fire extinguishers.

17.4 Washing Soda

The chemical formula of washing soda is $Na_2CO_3.10H_2O$. We have seen that sodium carbonate can be obtained by heating baking soda and recrystallization of sodium carbonate gives washing soda. Washing soda is also a basic salt.

$$Na_2CO_3(s) + 10H_2O(l) \longrightarrow Na_2CO_3.10H_2O(s)$$

Can you tell: What does $10H_2O$ signify? Does it make Na_2CO_3 wet?

10 molecules of water are attached to each molecule of crystalline sodium carbonate. This does not mean that it is in the form of a solution. Washing soda is a white-coloured crystalline solid with attached water molecules. Water of crystallization is the fixed number of water molecules presentin one formula unit of a salt. When washing soda is left in open air, it loses nine water molecules and gets converted into a white powder of sodium carbonate monohydrate. This property is known as efflorescence.

$$Na_2CO_3.10H_2O(s) \xrightarrow{\text{left in open}} Na_2CO_3.H_2O(s) + 9H_2O$$

17.4.1 Uses of washing soda

1. Sodium carbonate is used as a cleaning agent for domestic purposes.

2. It is used in glass, soap, textile and paper industries.
3. It is used for removing permanent hardness of water.

Questions

1. Write the chemical formula and two important uses of baking soda.
2. What is efflorescence?
3. Baking powder is a mixture of which two compounds?

17.5 Plaster of Paris

Chemically, Plaster of Paris is calcium sulphate hemihydrate. Its chemical formula is $CaSO_4.½H_2O$ or $(CaSO_4)_2.H_2O$

It is formed by heating gypsum at 100°C.

$$\underset{\text{gypsum}}{CaSO_4.2H_2O} \xrightarrow{100°C} \underset{\text{Plaster of Paris}}{CaSO_4.½H_2O} + 1½H_2O$$

Plaster of Paris is a white powder and on mixing with water, it changes once again to gypsum giving a hard solid mass.

$$CaSO_4.½\ H_2O + 1½\ H_2O \longrightarrow CaSO_4.2H_2O$$

17.5.1 Uses of Plaster of Paris

1. It is used by doctors for supporting fractured bones in the right position.
2. It is used for making toys and idols.
3. Used to make casts and models.
4. Used in making chalk.

When idols made of Plaster of Paris are immersed in lakes, ponds and rivers, they pollute the water source. In your classroom, form groups and discuss how these idols cause water pollution. These days, to counter this problem of water pollution, people are encouraged to buy idols made of clay instead.

17.6 Bleaching powder

Chemically, bleaching powder is known as calcium oxychloride ($CaOCl_2$). It is also referred to as chloride of lime. Bleaching powder is produced by the action of chlorine gas on dry slaked lime.

$$\underset{\textit{slaked lime}}{Ca(OH)_2(s)} + Cl_2(g) \longrightarrow \underset{\textit{bleaching powder}}{CaOCl_2(s)} + H_2O(g)$$

It is a white powder having a yellowish tinge with a strong smell of chlorine. When left in the open, it reacts with carbon dioxide to release chlorine gas.

$$CaOCl_2(s) + CO_2(g) \longrightarrow CaCO_3(s) + Cl_2(g)$$

17.6.1 Uses of bleaching powder

1. For bleaching cotton in the textile industry. This bleaching action is due to the chlorine gas released by bleaching powder.
2. For bleaching wood pulp in paper factories.
3. For disinfecting drinking water to make it free of germs.

Questions

1. Which property of Plaster of Paris is the reason why doctors use it in setting fractures?
2. Name the substance that reacts with chlorine to give bleaching powder.

17.7 Cement

Cement is essential in construction of buildings. The meaning of the word cement is something that binds or glues together other materials. Cement was first made by Joseph Aspidin. He called it Portland cement because it was as hard as the limestones found in Portland.

Cement is not a chemical compound. It is a mixture of chemical compounds such as silicates and aluminates of calcium. Therefore, it does not have a fixed chemical composition or formula. The properties of cement are also not fixed, for example, it does not have a fixed melting point. The percentage composition of cement is shown in table-1:

Table-1 : Percentage composition of different components in cement

Substance	Formula	Percentage composition
Calcium oxide	CaO	61-65%
Silica	SiO_2	20-25%
Alumina	Al_2O_3	5-10%
Magnesia	MgO	2-3%
Iron oxide	Fe_2O_3	1-2 %

When the fine powder of this mixture comes in contact with water, it sets into a hard substance.

17.7.1 Cement manufacture

The raw materials needed in manufacture of cement are limestone ($CaCO_3$), clay and gypsum. Clay contains large quantities of oxides of iron, aluminium and silicon. The steps in cement production are as follows:

(i) Three parts limestone and one part clay are pulverized to fine powder separately. The powders are mixed and heated in a kiln where temperature is maintained between 1100-1800°C (figure-2).

(ii) At 1100°C, limestone undergoes thermal decomposition and forms calcium oxide.

$$CaCO_3 \xrightarrow{1100°C} CaO + CO_2$$

(iii) Calcium oxide reacts with the other oxides present in clay.

$$2CaO + SiO_2 \xrightarrow{1400\text{-}1500°C} 2CaO.SiO_2$$

Dicalcium silicate

$$3CaO + SiO_2 \xrightarrow{1400\text{-}1500°C} 3CaO.SiO_2$$

Tricalcium silicate

$$3CaO + Al_2O_3 \xrightarrow{1400\text{-}1500°C} 3CaO.Al_2O_3$$

Tricalcium aluminate

$$4CaO + Al_2O_3 + Fe_2O_3 \xrightarrow{\text{above } 1500°C} 4CaO.Al_2O_3.Fe_2O_3$$

Tetracalcium alumino ferrite

(iv) The aluminate and silicate mixture obtained from the furnace is in the form of small, hard balls or pebbles and is called clinker.

(v) Clinker is cooled and 2-3% gypsum ($CaSO_4.2H_2O$) is added to it. This mixture is pulverized into a fine powder.

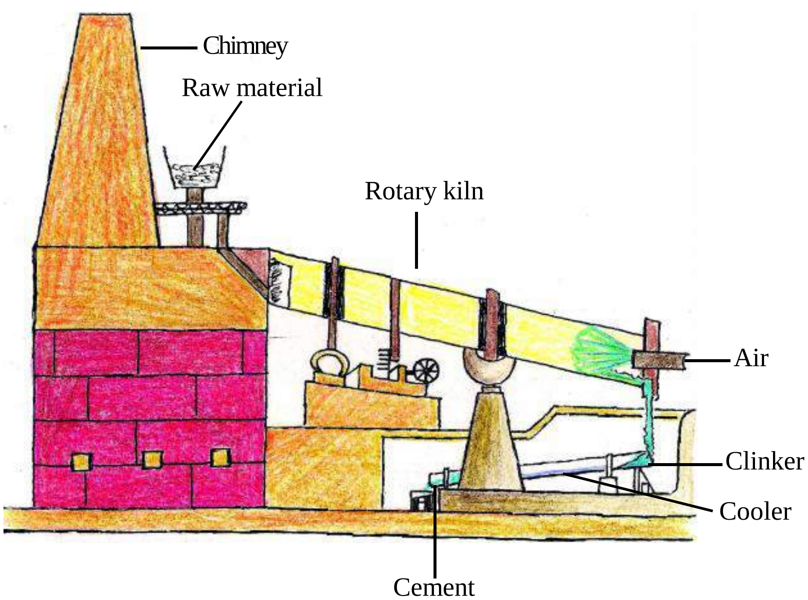


Figure-2: Manufacture of Cement

Limestone + Clay

↓ Mixed in correct proportion & pulverized

Rotary kiln

↓ Heated

Clinker

↓ Cooled

2-3% Gypsum

↓ Added

Ball mill

↓ Pulverized

Cement

Flow chart-1: Method for cement preparation

17.7.2 Setting of cement

When cement is mixed with sand and water and left for some time, it sets and becomes as hard as a rock. Gypsum is added to cement to slow down the setting process.

The demand for cement is increasing day by day and to reduce the cost of cement manufacture, these days industrial waste materials such as fly ash are used to produce cement. In some countries, rice bran ash is also used to make cement because it has high quantities of silica.

17.7.3 Cement industries in Chhattisgarh

Cement factories in Chhattisgarh are located in the following districts- Raipur, Bilaspur, and Ballaudabazaar.

17.8 Glass

Glass is a mixture of silica and metal silicates. It is non-crystalline, hard, brittle, and transparent and appears solid. In reality, glass is a super-cooled liquid which looks solid but is capable of flowing.

The general formula of glass is: $xR_2O.yMO.6SiO_2$ where

R is a monovalent alkali metal such as Na, K etc. and M is a divalent metal such as Ba, Ca, Pb, Zn etc. x and y indicate number of molecules.

17.8.1 Manufacture of glass

The materials used in manufacture of glass are:

1. Silica: in the form of sand.
2. Alkali metal: in the form of sodium carbonate or potassium carbonate or mixture of salt cake and carbon (Na_2SO_4 + C).
3. Divalent metal: such as calcium in the form of limestone or lead in the form of litharge (PbO) or red lead oxide (Pb_3O_4).
4. Oxidizing agents or materials to remove colour (bleaching agents): manganese dioxide (MnO_2), potassium nitrate (KNO_3) or sodium nitrate ($NaNO_3$).
5. Cullets: pieces of broken glass
6. Colouring materials: Various compounds used to impart different colours to glass (table-2).

Table-2: Colouring materials

Colour of glass	Colouring material
Green	chromium oxide
Yellow	cadmium sulphide
Red	copper oxide
Purple	manganese oxide
Blue	cobalt oxide

To manufacture common glass or soda glass, the necessary raw materials - sodium carbonate, calcium carbonate and sand - are mixed in the right proportion and ground finely. Then cullet, which acts as flux, is added to this mixture. The mixture thus obtained is called batch. Batch is heated upto 1400°C (figure-3) in a tank furnace. The following reactions take place in the furnace:

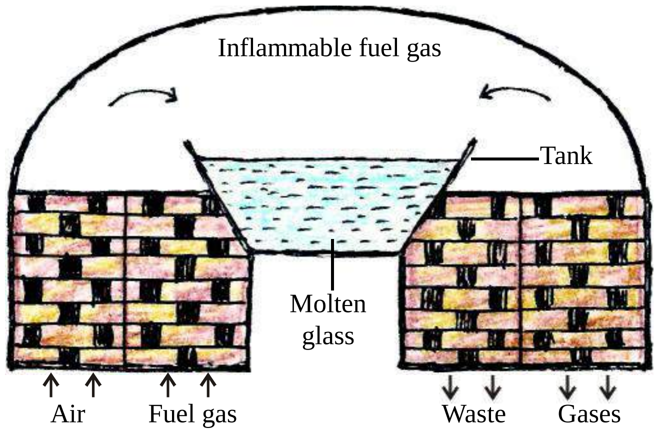
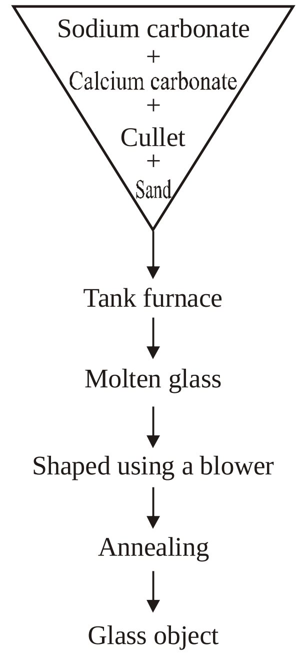


Figure-3: Manufacture of glass in tank furnace



Flow chart-2: Steps for making glass

$$Na_2CO_3 + SiO_2 \longrightarrow Na_2SiO_3 + CO_2\uparrow$$

$$CaCO_3 + SiO_2 \longrightarrow CaSiO_3 + CO_2\uparrow$$

$$Na_2SiO_3 + CaSiO_3 + 4SiO_2 \longrightarrow \underset{glass}{Na_2O.CaO.6SiO_2}$$

Experienced craftsmen can shape this molten glass into desired shapes and objects using a blower. These days this is done in big factories where machines use moulds and the process takes less time and costs less. Glass can crack and break if cooled suddenly during production. To prevent this, glass is cooled very slowly and the process is called annealing.

Questions

1. Why is gypsum added to cement?
2. Why are cullets used in glass manufacture?
3. The melting point of glass is not fixed, why?

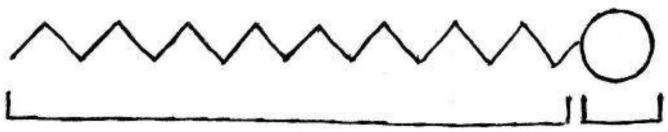
17.9 Soaps and detergents

Activity-1

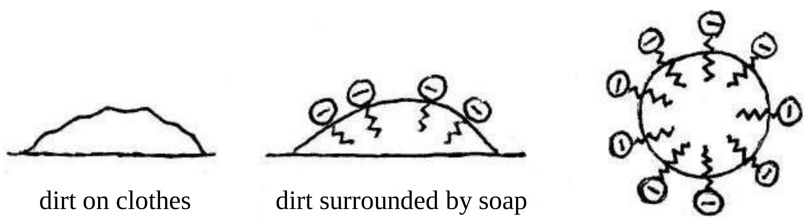
- Take two test tubes and label them as 'A' and 'B' respectively.
- Take 10 mL of distilled or soft water in each test tube.
- To each test tube, add 4 drops of cooking oil.
- Add a few drops of soap solution to test tube 'B'.
- Shake both the test tubes vigorously for the same time duration.
- Look for separate water and oil layers in both the test tubes immediately after you stop shaking them. Do you see anything?
- Leave the test tubes undisturbed. Did the layer of oil separate out from the water? In which test tube did it separate out first?

This activity shows the role of soap in cleaning.Usually, dirt is oily in nature and we know that oil does not dissolve in water. The molecules of soap are sodium or potassium salts of long chain carboxylic acids and are denoted by RCOOM. When soap is dissolved in water, it ionizes into $RCOO^-$ and metal, M^+ ions. The $RCOO^-$ ion has two parts. One is R which is a long hydrocarbon chain that forms the tail of the carboxylate ion and gets attached to the oil molecules. The second part is COO^- which forms the head and is soluble in water (figure-4a).

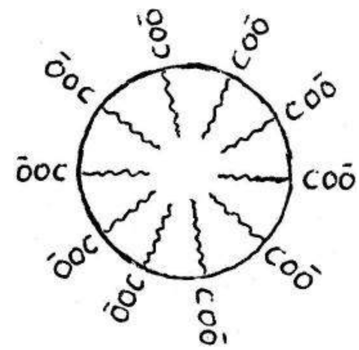
When clothes are soaked in soap solution, then the negatively charged part of soap surrounds the oil (dirt). A sphere is formed around the oil drop in such a way that the end with the hydrocarbon chain (tail) is inside the sphere and the COO^- end is on the outer part of the sphere. Thus, the soap molecules form micelles (figure-4b). The micelles get distributed in water forming a colloid which is removed when we rub the cloth and rinse with water (figure-4c).



4 (a): parts of carboxylate ion



4 (b): COO^- ion arrangement



4 (b): action of soap in removal of dirt

Figure-4 (a), (b) and (c): Detergent micelle

Activity-2

- Take about 10 mL of distilled water and 10 mL of hard water in two separate test tubes.
- Add a few drops of soap solution to both.
- Shake the test tubes vigorously for an equal period of time and observe the amount of foam formed.
- In which test tube do you get more foam?
- In which test tube do you observe a white curdy precipitate?
- What can you conclude from this activity?

Note for the teacher: *If hard water is not available in your locality, prepare some hard water by dissolving magnesium hydrogencarbonate/chloride/sulphate in water.*

In this chapter, we have already discussed hardness of water. To clean objects using hard water, we can use another class of compounds called detergents. Detergents are salts of sulphonic acids having along carbon chain. The charged ends of these compounds do not form insoluble precipitates with the calcium and magnesium ions in present hard water. Thus, they remain effective in hard water. Detergents are usually used to make shampoos and other products for cleaning fabrics.

Activity-3

- In two separate test tubes, take about 10 mL hard water each.
- Add five drops of soap solution to one and five drops of detergent solution to the other.
- Shake both test tubes for the same period.
- Do both test tubes have the same amount of foam?
- In which test tube is a curdy solid formed?
- What can you conclude from this activity?

In this activity, we compared the cleansing action of soap and detergent in hard water. Some detergents are non-biodegradable and thus increase water pollution; they should be used in moderation.

Questions

1. Can you use detergents to determine if a given sample of water is hard or not?
2. When washing clothes, after applying soap we either scrub with a brush or beat clothes over a stone or beat them with a stick. Why do we need to scrub clothes to clean them?

Keywords

Efflorescence, bleaching powder, clinker, micelle, gypsum, solid to touch, supercooled liquid, detergent, cullets, temporary and permanent hardness, annealing

What we have learnt

- Water is capable of dissolving more substances than any other solvent and therefore it is also known as universal solvent.
- The presence of dissolved salts (hydrogencarbonates or suphates or carbonates) of magnesium or calcium causes hardness of water.
- Common salt is iodized by adding potassium iodate to it.
- Baking soda is produced by Solvay ammonia process using sodium chloride as one of the raw materials.

- When washing soda crystals are left in open air, each crystal loses nine water molecules and gets converted into a white powder of sodium carbonate monohydrate;this property is known as efflorescence.
- Plaster of Paris on mixing with water hardens into gypsum.
- Bleaching powder is used in bleaching. This property is due to the chlorine gas produced by it.
- Cement is mostly a mixture of silicates and aluminates of calcium which hardens when it comes in contact with water.
- Glass is a mixture of metal silicates and therefore does not have a fixed composition or chemical formula.
- Soaps are sodium or potassium salts of long chain carboxylic acids.
- Detergents are usually salts of long carbon chain sulphonic acids.

Exercises

1. Choose the correct option:

   (i) The chemical formula of baking soda is:

   (a) $NaHSO_4$ (b) Na_2CO_3

   (c) $NaHCO_3$ (d) $Na_2CO_3.10H_2O$

   (ii) The chemical substance that is used for disinfecting drinking water to make it free of germs is:

   (a) $CaCl_2$ (b) $CaOCl_2$

   (c) $FeCl_3$ (d) $MgCl_2$

   (iii) Glass is a

   (a) Liquid (b) Solid

   (c) Transparent carbon polymer (d) Super-cooled liquid

   (iv) Plaster of Paris hardens by

   (a) Losing $CaCl_2$ (b) Releasing CO_2

   (c) Absorbing water (d) Releasing water

2. Match words in column A with the correct options in column B

Column A	**Column B**
Bleaching powder	super-cooled liquid
Baking soda	clinker
Washing soda	preservative
Sodium chloride	Bleaching agent
	Glass manufacture
	antacid

3. What is hard water? What is soft water?
4. What are the factors that cause hardness of water? How many types of hardness are there?
5. How do animals and plants, living in lakes and ponds in snowy regions, survive during winter?
6. What is baking powder? How does it make cakes soft and spongy?
7. What is the process of making Plaster of Paris? Why is it stored in air-tight containers?
8. What is the chemical name for washing soda? Name the three main raw materials used to produce washing soda by the Solvay ammonia process.
9. A compound of calcium, which is a white powder having a yellow tinge, is used in the textile industry and as a disinfectant.
    (i) Name the compound.
    (ii) Which gas is released when the compound is left out in open air? Give the balanced equation for this reaction.
10. A compound of sodium, 'X', is a white powder and an important component of baking powder. When 'X' is heated, a gas 'Y' is produced that turns lime water milky.
    (i) Write the chemical equation for the reaction which takes place on heating.
    (ii) Why is 'X' used as an antacid?
11. Describe the steps in the process of glass manufacture under each of the following headings:
    (i) Necessary materials
    (ii) Substances that give or impart colour to glass
    (iii) The chemical reaction taking place in tank furnace
12. Write the different steps involved in cement production.
13. How are soap-micelles formed? Describe.

CHAPTER 18

ENERGY: FORMS AND SOURCES

18.1 What is energy?

We use energy to carry out different tasks. In order to complete a task, we need to do some work. We need to work harder to lift a heavy object and it requires more energy.

We have already talked about work and energy in class 9th. We saw that there is a direct relation between work and energy. More energy is required in order to perform more work. The more energy you have, the more work you will be able to do.

The term 'Energy' was introduced 200 years ago by a British scientist, Thomas Young. Young derived the term 'energy' from the Greek word 'evegyeia energia' which means internal energy. According to Young, work is inherent in energy. We can use this energy to perform some work. Even our bodies have energy but in limited quantity. The more work we do, the more energy will be consumed and we will feel tired. We need food to supply us energy.

Thomas Young

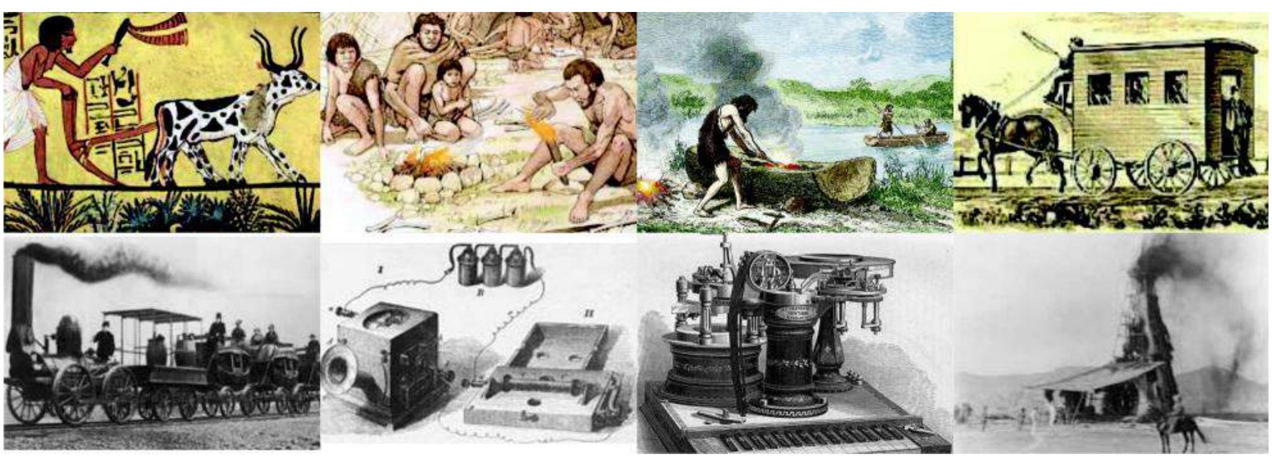


Figure-1

Human Beings and Energy

We tend to associate the term 'work' with living human beings. When human beings were cave dwellers, they used to primarily use the chemical energy present in their bodies. Then people acquired new knowledge. They started harnessing energy from their domestic animals. They learnt how to use the flow of water in rivers to sail boats. They also started using fire as a source of energy by burning woods and animal fat. First, people used fire to get warm during winters and as a source of light at night-time. Then, people started using fire to cook food and to prepare pots of metals, glass or clay. So now they were using the energy, not just from living sources like human-beings or animals but also from non-living sources.

Steam engine was invented in 1700. Different kinds of steam engines were developed and for the first time chemical energy of fuel could be converted into kinetic energy. Some steam engines were used to run machines in industries, some were used for sailing ships across seas and oceans, and some were used to pull locomotives on land.

Coal replaced wood as a fuel. In 1800, chemical energy obtained from combustible fuels was used to turn wire-wheels between the poles of two magnets. In this experiment, the dynamic energy of magnets was used to produce an electric current. Electric current was used in telegraphs and telephones. All the motors in the world run on electricity.

In around 1800 people started digging oil-wells. Oil could be easily transported from one place to another via pipes. At the end of the nineteenth century, petrol-engines were invented. There were used in cars, trucks, buses, ships, aeroplanes etc. Petrol is now also used to produce electricity and in heating homes in colder climates.

There are some other sources of energy apart from oil and coal. We have nuclear energy; energy obtained from the flow of water and wind; energy due to tidal waves (high/low tides) of sea are possible sources of energy. The energy hidden in the earth's core can also be used. Many needs can be fulfilled by solar energy.

In this chapter we will talk about these sources of energy and learn about different types of energy. We will also see what kind of energy can be obtained from a particular source of energy.

18.2 Types and forms of energy

Every day we come across various forms of energy. For example, you have breakfast (chemical energy) in the morning; go to school on a bicycle (mechanical energy); a room full of light (light energy); talk to your friends and listen to them (sound energy); throw up a ball up and it comes back into your hands (gravitational energy); enjoy a fan's air (electric energy) etc.

Can you think of any other form of energy? All forms of energy can be classified into two types - kinetic energy and potential energy.

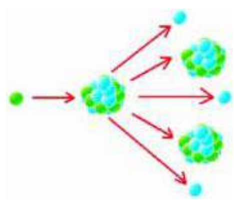
Forms of energy

Potential Energy	Kinetic Energy
Stored energy and energy by virtue of position. (Gravitational)	There is energy in motion. This energy is due to motion of waves, electrons, atoms and molecules.

Chemical Energy

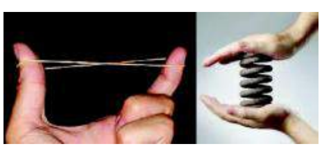
Chemical energy is the energy stored in the bonds of chemical compounds (atoms and molecules). Bio-mass, petroleum, natural gas, propane, coal are some examples of reservoirs of chemical energy.

Nuclear Energy



The energy stored in the nucleus of atoms is called nuclear energy. It holds together the atom. The nucleus of uranium atoms is an example of nuclear energy.

Stored Kinetic Energy



The energy stored in objects due to applied force is called stored kinetic energy. Compressed spring and elongated rubber are examples of stored kinetic energy.

Gravitational Energy

The energy of an object due to its position is gravitational energy. For example, the energy of water stored in the reservoir of a hydro-electric dam. When this water is released, it moves turbines and is converted to kinetic energy.

Radiation Energy

Radiation energy is a type of electro-magnetic energy which creates motion in transverse waves. Visible light, x-ray, gamma rays and radio waves as well as solar energy are examples of radiation energy.

Thermal Energy

Thermal energy is the internal energy of matter. This energy is generated due to the vibrations and motion of atoms and molecules in matter.

Motion Energy

Movement of an object or material from one place to another is motion. Wind and hydro-electric are all examples of motion.

Sound Energy

Sound is the movement of energy through substances in longitudinal (compression/rarefaction) waves.

Electric Energy

Lightening during storms and electricity are examples of electric energy. Electricity is the flow of moving electrons.

18.3 Energy Transformations

Motionless wind, stationary water or a stationary stone do not have the capability to move or break any object. We have seen that a non-living object is certainly in motion whenever it performs some work. A strong wind-storm can cause a tree to fall, moving water can push forward a sail-boat, and a heavy stone thrown using a catapult can damage a wall in its path.

Since moving objects result in some work therefore there must be some energy in motion. This energy is called kinetic energy. We have already learnt a little about kinetic energy in previous classes.

You may know that if two objects are moving at the same speed then the heavier amongst the two will have more energy as compared to the lighter object. If we lightly hit a nail with a hammer, it will not go as deep into the wall as compared to the hole formed when a nail is hit hard by a heavy hammer. But is it possible for an object at rest (not in motion) to perform some work?

Let us think about a stone on the top of a mountain-peak. A heavy wind can put it in motion. As it rolls down towards the ground it gains kinetic energy. The speed of a falling body keeps increasing with time. When the stone finally hits the ground, it performs some work; for example, it can form a big hole or it can shatter an object. More the height from ground of an object, the more distance it will have to fall and the more will be its potential energy.

Here, we need to understand that kinetic and potential energy are of many types and all the forms of energy (about which we learnt in previous classes or other chapters) can be classified into these two types.

Every object has some energy stored in it, but we cannot say anything about it till something happens to transform the stored energy into some other form. For example, when we fire a cracker, the chemical energy stored in it gets converted into light (energy), sound (energy), thermal energy and kinetic energy.

Try to fill the following table based on the conversion/transformation of energy from one form to another-

Table-1

Object	What is needed in order to convert the stored energy to some other form	Initial form of energy (stored in object)	The energy (stored in object) gets converted to the following forms
1. Torch Battery	Turning on switch	Chemical energy	Light and electric energy
2. Petrol			
3. Dynamite			
4. Stretched rubber band			
5. Tabla			

You can think of more examples based on the initial and final forms of energy. Try to fill the following table-

Table-2

ENERGY		Example
Initial form	**Final form**	
Potential energy	Kinetic energy	• Water falling from tank from a higher level. • •
Kinetic energy	Thermal energy	• Palms get warm on rubbing. • •
Kinetic energy	Potential energy	• Compressing a spring. • •
Kinetic energy	Electric energy	• Production of electricity using electric generator • •
Chemical energy	Light energy	• Switching on torch. • •
Kinetic energy	Sound energy, light energy, thermal energy	• Knife hitting a stone. • •
Electric energy	Thermal energy	• Iron getting warm. • •

Do you know that the energy always getting converted from one form to another in this world? Not only this, energy is always getting transferred from one object to another.

All electric appliances which we use, whether battery-operated or running on electricity, convert electric energy to some other form of energy. Most of the energy gets converted into useful energy but some amount gets wasted or converted into a form which is not useful. Irrespective of whether the transformed form of energy is useful or waste, the entire electrical energy gets converted. This is known as 'law of conservation of energy'. In other words energy can neither be created nor destroyed; it can only be transformed from one form to another.

The following table consists of some such examples of energy conversion where the electrical energy gets converted into both useful and useless forms while using electric appliances. Try to add more such examples to the table-

Table-3

S.No.	Electrical appliance	Form into which electrical energy is converted	
		Useful	**Waste**
1.	T.V.	Light and sound energy	Thermal energy in environment and T.V.
2.	Hair dryer	Kinetic and thermal energy of air molecules	Sound energy
3.	Oven	Thermal energy (food gets warm)	Thermal energy (utensils become hot), sound energy
4.	Fan	Kinetic energy	Sound energy
5.			

We cannot eliminate this loss of energy but this waste can be minimized.

You have read about tungsten bulbs in a previous chapter. These bulbs convert electric energy into light energy and thermal energy but the thermal energy is not useful. The loss of energy can be minimized using CFLs (Compact Fluorescent Lights) or LEDs (Light Emitting Diodes). LEDs are even better than CFLs because LEDs convert a higher percentage of electric energy into light energy.

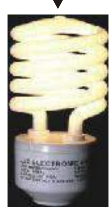
Electric energy

Tungsten bulb

90%Thermal energy

10% Light energy

Electric energy



CFLs

390%Thermal energy

70% Light energy

Electric energy

LEDs

05%Thermal energy

95% Light energy

18.4 Energy transfer

In the chapter on heat and temperature, we read about transfer of thermal energy. Thermal energy can be transferred in three ways - conduction, convection and radiation. Knowing how thermal energy is transferred from hotter objects to colder objects can help us control loss of thermal energy.

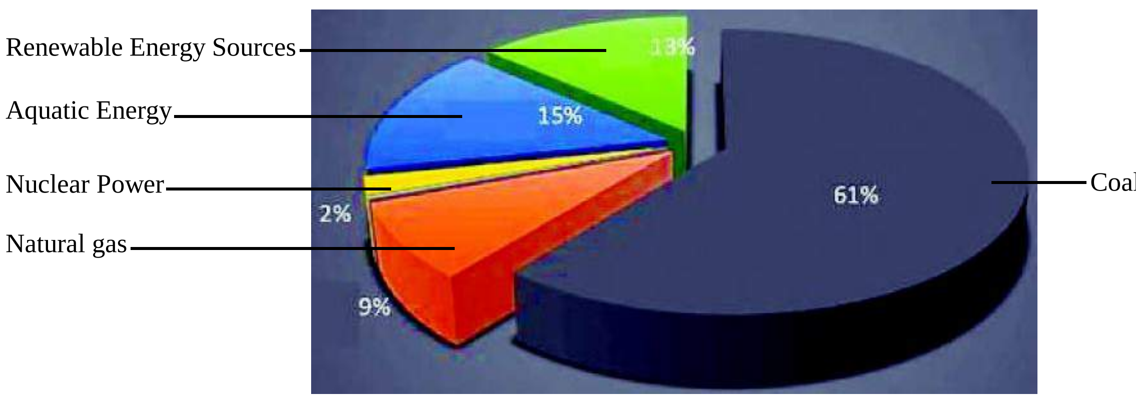
18.5 Sources of energy

No matter what form of energy we need, we first have to obtain it from some source. For example, the electrical energy in our homes could be from coal, hydro-electric power plants or nuclear fission. The chemical energy to drive vehicles can be obtained from fuels like petrol, diesel etc. These are called sources of energy.

Today, what our country need most are sources of energy which can fulfill increasing demand of electric energy.

To produce electricity, we need to convert energy from one form to another. The method could be direct conversion (which converts the energy directly to electricity) or an intermediate conversion (converting energy to some form and then converting that form to electricity).

For both of these methods different kinds of energy sources are used like fossils fuels, nuclear fission, solar energy, hydro-electric power etc.



Central Electricity mission, based on the report of the Government of India figures

Figure-2: Different sources of electricity in India

18.5.1 Conventional sources of energy

1. Fossils fuels: Coal, petroleum, LPG, kerosene, diesel etc. are fuels. There are directly used in vehicles and gas stoves. These are also used as a primary source for generating electricity. Large amount of fossil fuels are burnt every day in power stations to heat up water to produce steam which further runs the turbine to generate electricity. These appliances are called thermal appliances because these appliances generate energy by combustion of fuels which is then converted into electric energy.

These appliances convert chemical energy of fuels into thermal energy, which then gets converted into mechanical energy (kinetic energy) by rotating turbines and finally, using electric generators, this is converted into electric energy. At every step, some amount of energy is lost as it gets converted into a useless form. Power plants that run on fossil fuels usually have an efficiency of 40% which means that only forty percent of the energy of fossil fuels gets converted into electrical energy.

There are some other disadvantages of burning fossils fuel. Oxides of carbon, nitrogen and sulphur are released into the atmosphere on burning fossils fuel and they cause acid rain which pollutes water and can harm monuments.

2. Hydro-electric power plants: Another conventional source of energy is the kinetic energy of flowing water or the potential energy of water at a height. Hydro power plants convert the potential energy of falling water into electricity. The water falls on a turbine which spins and activates an electric generator which then produces electricity.

In order to produce hydel electricity, high-rise dams are constructed on the river to obstruct the flow of water and thereby collect water in larger reservoirs. During the rainy season, water collects in these reservoirs. The stored water from the high level in the dam is carried through pipes, to the turbine, at the base of the dam. Stored water falls freely on the blades of turbine and as a result, the blade of turbine spin and with the help of a generator, electricity is generated. Hydel-electricity is a renewable source of energy because after rains, the water reservoirs get refilled. There are also several disadvantages associated with hydro-electric power plants. During the construction of dams and water reservoirs, huge amounts of agricultural land is flooded and lost and many people lose their homes and are displaced. Some ecological systems are also destroyed.

3. Bio gas: Agriculture and cattle-rearing are given great importance in our country. Cow-dung (gobar) is available in steady supply due to large number of livestock and agricultural waste in our country. Cow-dung cakes are burnt directly and used as fuels in many rural areas but a large part of energy is lost in this process. Also these fuels do not produce much heat on burning and a lot of smoke is given out when they are burnt. Therefore, technological inputs to improve the efficiency of these fuels are necessary.

When wood is burnt in a limited supply of oxygen, water and volatile materials present in it get removed and charcoal is left behind as the residue. Charcoal burns without flames, is comparatively smokeless and has higher heat generation efficiency.

Cow-dung, various plant materials like the residue after harvesting the crops, vegetable waste and sewage are decomposed in the absence of oxygen to give bio-gas. Bio-gas is a mixture of methane, carbon dioxide, hydrogen and hydrogen sulphide.

Bio-gas plant has a dome-like mixing-tank built with bricks in which a slurry of cow-dung and water is made. The slurry is fed into the digester which is a sealed chamber in which there is no oxygen. Anaerobic micro-organisms that do not require oxygen decompose or break down complex compounds of the cow-dung slurry. It takes a few days for the decomposition process to be complete and generate bio-gas. The bio-gas is stored in the gas tank above the digester from which they are drawn through pipes for use. Bio-gas is an excellent fuel as it contains up to 75% methane. It burns without smoke and leaves no residue. Bio-gas is also used for lighting.

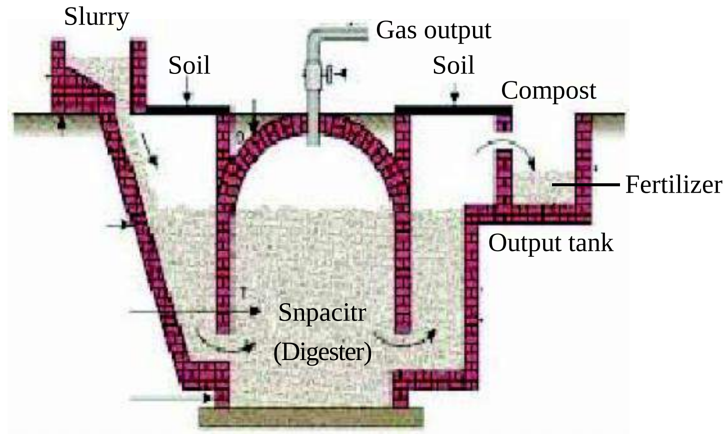
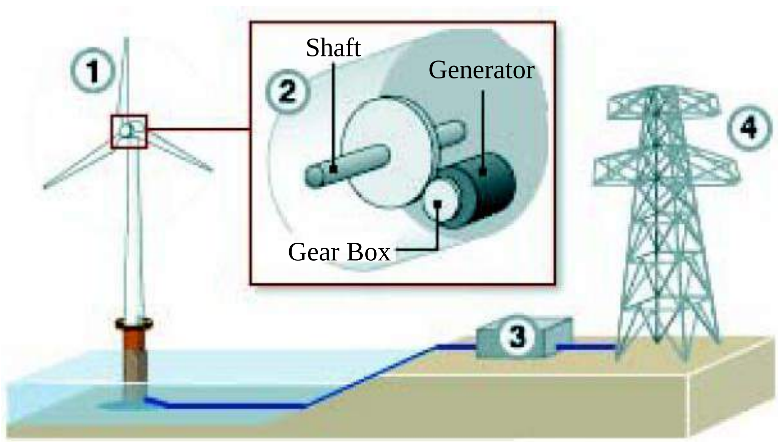


Figure-3

4. Wind Energy: We saw in a previous chapter how unequal heating of the landmass and water bodies by solar radiation generates air movement and causes winds to blow. This kinetic energy of the wind can be harnessed by windmills to do mechanical work. For example, in a water-lifting pump, the rotatory motion of windmill is utilised to lift water from a well. Today, wind energy is also used to generate electricity.

To generate electricity, the rotatory motion of the windmill is used to turn the turbine of the electric generator. A number of windmills are erected over a large area, which is known as wind energy farm. Wind energy is renewable source of energy. But, wind energy farms can be established only where the speed of wind is higher than 15 km/h to maintain the required speed of the turbine.



1. Wind causes the wind-mill turbine to rotate.
2. The shaft activates the generator which produces electricity.
3. Transformer transforms electricity at high potential.
4. Electricity grid transmits electricity.

Figure-4

18.5.2 Alternate sources of energy

Our demands for energy are increasing everyday due to progress in technologies. It is necessary to develop new techniques for the efficient uses of energy sources and keep on researching for new sources of energy.

1. Solar energy: India is fortunate to receive solar energy for greater part of the year. By solar energy, we mean the light and heat energy which falls on the earth. Sun is a huge source of energy. Solar energy is very different from the conventional sources of energy. Electric energy can be generated by direct conversion of solar energy.

Solar heating devices: The devices which can store solar energy are called solar heating devices.

Procedure:

- Take two conical flasks and paint one white and the other black. Fill both with water.
- Place the conical flasks in direct sunlight for half an hour to one hour.
- Touch the conical flasks. Which one is hotter? You could also measure the temperature of the water in the two conical flasks with a thermometer.
- Can you think of ways in which this finding could be used in your daily life?

Solar cooker: Solar cooker is a device which is used to cook food using the radiation heat energy of the sun. Solar cooker box is made up of wood box or some other insulating material. The inner body of a solar cooker is painted black. The food to be cooked is put into metal pots, whose outsides are painted black. Then the metal pots are put inside the solar cooker box which is covered using a glass sheet.

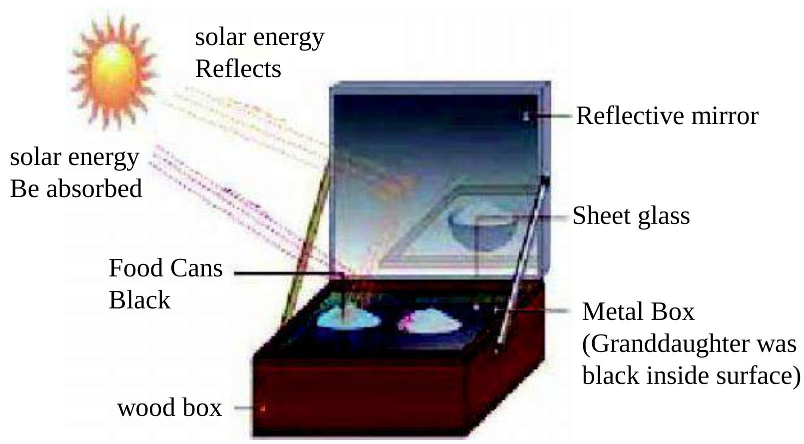


Figure-5

Once the heat waves of sun enter the box, the glass cover does not allow them to escape out of box easily. This way, maximum energy of the heat waves is captured inside the box due to which the temperature of solar cooker box increases to 100-140° C in 2-3 hours. This heat is used to cook edible foods like, rice, pulses and vegetables inside the black pots.

Solar Cells

It is easy to see that these devices are useful only at certain times during the day. This limitation of using solar energy is overcome by using solar cells that convert solar energy into electricity. A typical cell develops a voltage of 0.5-1 V and can produce about 0.7 W of electricity when exposed to the Sun. A large number of solar cells are, combined in an arrangement called solar cell panel that can deliver enough electricity for practical use.

Figure-6

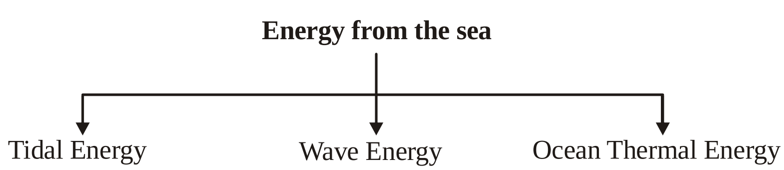
The principal advantages associated with solar cells are that they have no moving parts, require little maintenance and work quite satisfactorily without the use of any focussing device. Another advantage is that they can be set up in remote and inaccessible areas or very sparsely inhabited areas in which laying of a power transmission line may be expensive and not commercially viable.

Silicon, which is used for making solar cells, is abundant in nature but availability of the special grade silicon for making solar cells is limited. The entire process of manufacture is still very expensive, silver used for interconnection of the cells in the panel further adds to the cost. In spite of the high cost and low efficiency, solar cells are used for many scientific and technological applications.

- Artificial satellites and space probes like Mars orbiters use solar cells as the main source of energy.
- Radio or wireless transmission systems or TV relay stations in remote locations use solar cell panels.
- Traffic signals, calculators and many toys are fitted with solar cells. The solar cell panels are mounted on specially designed inclined roof tops so that more solar energy is incident over it.

  The domestic use of solar cells is, however, limited due to its high cost.

2. Energy from the sea



(a) Tidal energy: Due to the gravitational pull of mainly the moon on the spinning earth, the level of water in the sea rises and falls. The difference in sea-levels during high and low tides gives us tidal energy. Tidal energy is harnessed by constructing a dam across a narrow opening to the sea. A turbine fixed at the opening of the dam converts tidal energy to electricity.

(b) Wave energy: Similarly, the kinetic energy possessed by huge waves near the seashore can be trapped in a similar manner to generate electricity. The waves are generated by strong winds blowing across the sea.

(c) Ocean thermal energy: The water at the surface of the sea or ocean is heated by the Sun while the water in deeper sections is relatively cold. This difference in temperature is exploited to obtain energy in ocean-thermal-energy conversion plants.

3. Geothermal energy: Due to geological changes, molten rocks formed in the deeper hot regions of earth's crust are pushed upward and trapped in certain regions called 'hot spots'. When underground water comes in contact with the hot spot, steam is generated. Sometimes hot water from that region finds outlets at the surface. Such outlets are known as hot springs. Sometimes the steam gets trapped in rocks and its pressure increases. This steam is routed through a pipe to a turbine, the turbine spins and activates a generator and produces electricity. The cost of production would not be much, but there are very few commercially viable sites where such energy can be exploited. There are number of power plants based on geothermal energy operational in New Zealand and United States of America.

4. Nuclear energy: We have already learnt that the nucleus of an atom consists of neutrons and protons, and electrons are orbit around the nucleus. Scientists have discovered that the nucleus inside the atoms are a huge source of energy, therefore this energy is called nuclear energy. Nuclear energy could be obtained (produced) using two following reactions.

(a) Nuclear fission (b) Nuclear fusion

4 (a) Nuclear fission: Nuclear fission is a reaction the nucleus of a heavy atom (such as uranium, plutonium or thorium), when bombarded with low-energy neutrons, can be split apart into lighter nuclei. If the mass of the original nucleus is just a little more than the sum of the masses of the individual products after bombardment, a huge quantity of energy is released. The fission of an atom of uranium, for example, produces 10 million times the energy produced by the combustion of an atom of carbon from coal. In a nuclear reactor designed for electric power generation, such nuclear 'fuel' can be part of a self-sustaining fission chain reaction that releases energy at a controlled rate. The released energy can be used to produce steam and further generate electricity.

Chain Reaction: When 92U235 is bombarded by slowly moving neutrons, each uranium nucleus breaks into two almost equal parts and gives rise to huge amount of energy and three neutrons. Under favorable conditions, these neutrons can further divide other uranium nuclei. In this way, a fission chain is initiated which once started continues till all the Uranium nuclei have undergone fission. This process of fission of nucleus is called chain reaction.

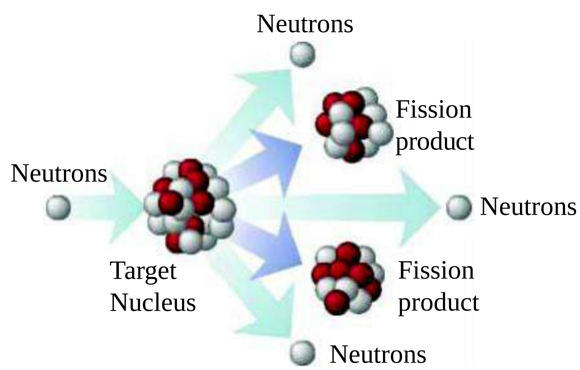


Figure-7

Chain reactions are of two types:

1. Uncontrolled chain reaction 2. Controlled chain reaction

4.a.1 Uncontrolled chain reaction: When U-235 bombarded by slowly moving neutrons, it results in formation of three new neutrons. Each of these three neutrons can again cause the fission of more U-235 nuclei and produce more neutrons. This fission process proceeds at a very fast rate and the atoms of the entire sample undergo fission in a very short time. A huge amount of energy is released in this reaction and results in a huge explosion. This reaction is used in nuclear bombs.

4.a.2 Controlled chain reaction: Nuclear energy is also used for constructive purposes. To obtain controlled amount of energy, artificial means are used to ensure that only one out of the three neutrons produced can further carry out the fission reaction. In this way, the rate of nuclear fission remains constant and the reaction is slowed down. Nuclear reactors make use of controlled fission reactions for energy production.

One major hazard of nuclear power generation is the storage and disposal of spent or used fuels - the uranium still decaying into harmful subatomic particles (radiations). Improper nuclear-waste storage and disposal result in environmental contamination. Further, there is a risk of accidental leakage of nuclear radiation. The high cost of installation of a nuclear power plant, high risk of environmental contamination and limited availability of uranium makes large-scale use of nuclear energy prohibitive.

4.b Nuclear Fusion: Currently all commercial nuclear reactors are based on nuclear fission. But there is another possibility of nuclear energy generation by a safer process called nuclear fusion. Fusion means joining lighter nuclei to make a heavier nucleus, most commonly hydrogen or hydrogen isotopes to create helium.

$$ {}_{1}^{2}H + {}_{1}^{2}H \xrightarrow[\text{fusion}]{\text{nuclear}} {}_{2}^{4}He + \text{energy} $$

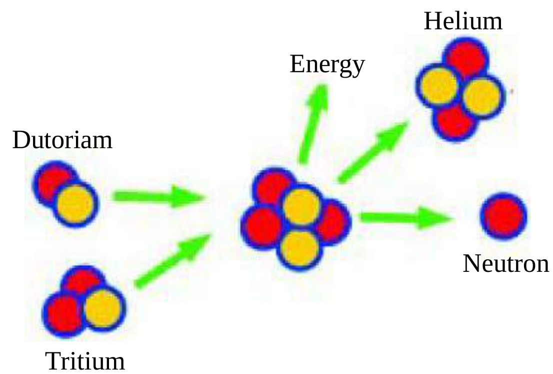


Figure-8

It releases a tremendous amount of energy, according to the Einstein equation, as the mass of the product is little less than the sum of the masses of the original individual nuclei.

Such nuclear fusion reactions are the source of energy in the Sun and other stars. It takes considerable energy to force the nuclei to fuse. The conditions needed for this process are extreme - millions of degrees of temperature and millions of Pascals of pressure.

Benefits of nuclear energy: 1. A small amount of U-235 can produce huge quantities of energy.

2. The reaction does not require oxygen.

Harmful effects of nuclear energy: The reaction produces radioactive substances which can cause great harm.

18.6 CREDA

CREDA stands for Chhattisgarh state Renewable Energy Development Agency and this is an enterprise under the department of energy of Chhattisgarh government,

Following are the objectives behind formation of CREDA:

1. To conserve energy - this means to ensure proper utilization of the energy sources and save energy.

2. To increase the use of non-conventional sources of energy in order to decrease the dependency on conventional sources.
3. Since the energy obtained from non-conventional sources of energy is environment friendly, therefore CREDA works to motivate people towards using these energy sources such as solar energy, wind energy and biomass energy.

The working models of conventional sources of energy for example, hydal power, wind power, solar energy power (solar car, solar hut, solar-boat) and biogas plants are displayed for demonstration purpose at Chhattisgarh energy education park (Raipur) managed by CREDA.

In daily life, we should take care of the following points to ensure proper utilization of energy-

1. People should be encouraged to use non-conventional sources of energy.
2. Pressure cookers should be used for cooking food.
3. Appliances which can be operated using solar energy like solar cooker, solar heaters, solar panels etc. should be used.
4. Biogas as a fuel should be promoted is rural areas.
5. To save valuable fuels like petrol, cycles should be used to travel short distances.

What we have learnt

- The law of conservation of energy is followed when energy gets converted/ transformed from one form to another.
- Energy has many forms. (There are various forms of energy).
- The process of burning of fuel is called combustion.
- The temperature of solar cooker box increases to 100-140° C in 2-3 hours.
- Bio gas is a mixture of methane, carbon dioxide, hydrogen and hydrogen sulphide where the main component is methane.
- Nuclear energy can be obtained using two nuclear processes - (i) Nuclear fusion (ii) Nuclear fission.
- CREDA stands for Chhattisgarh state Renewable Energy Development Agency, an enterprise under the department of energy of Chhattisgarh government.
- Solar cells directly convert solar energy to electric energy.
- Wind energy is used for doing mechanical work or to generate electricity.
- Flowing water is a source of hydel-energy, and it is used in production of hydro-electricity.

- The microbial decomposition of the dung of cows and other similar domestic animals is used to produce biogas.
- Coal, petroleum and natural gases all are fossils fuels.

Keywords

Hydel-power energy, tidal energy, wave energy, ocean thermal energy, geothermal energy, biogas, nuclear energy, nuclear fission, nuclear fusion, chain reaction, hydrogen bomb, fossil fuels, CREDA.

Exercise:

1. Choose the correct option:

   (i) Most of the energy sources used by us utilize solar energy. Which energy source out of following is not derived from solar energy:

   (a) Geo thermal energy (b) Wind energy

   (c) Nuclear energy (d) Bio mass

   (ii) Biogas is a mixture of following gases-

   (a) Nitrogen, Helium, Hydrogen (b) Oxygen, Nitrogen, Hydrogen

   (c) Ethane, Oxygen, Hydrogen (d) Methane, Carbon dioxide, Hydrogen

   (iii) Nuclear fission is a reaction in which-

   (a) Two light nuclei combine

   (b) Breaking of a heavy nucleus into light nuclei.

   (c) Both of the above. (d) None of the above.

   (iv) Fossil fuels are-

   (a) Coal, petroleum, natural gas (b) Biogas, wave energy, nuclear energy.

   (c) Tidal energy, hydel power energy.

   (d) Wave energy, ocean thermal energy, geo thermal energy.

   (v) Solar cell is a device which converts-

   (a) Electric energy into kinetic energy (b) Solar energy into potential energy

   (c) Solar energy into electric energy (d) Solar energy into nuclear energy

2. Fill in the blanks-
   - (i) We cannot use solar heaters on a .... day to heat water.
   - (ii) Lighting a torch is conversion of chemical energy into .... energy.
   - (iii) The energy generated due to oceans is ....
   - (iv) A solar cooker converts .... energy into .... energy.
3. Explain the mechanism of solar cooker with the help of a labeled diagram,.
4. Explain why-
   - (i) The inside of a solar cooker box is painted black.
   - (ii) The solar cooker box is covered with a glass-sheet.
   - (iii) Plane mirror reflectors are used inside the solar cookers
5. Name the device which converts solar energy into electric energy.
6. Apart from cattle-dung, which other material can be put inside a biogas plant?
7. Explain any two differences between nuclear fusion and nuclear fission.
8. On what basis we can classify the sources of energy into renewable and non-renewable.
9. Write two sources of energy which you think are renewable. Give reasons for your choices.
10. Write down the benefits of use of solar energy.
11. What are limitations of wind energy?
12. What do you understand by conversion of energy?

Examination Scheme

(Class-X)

Time : 3 hours **Total Marks : 25**

1.	Any three experiments (One each compulsorily from chemistry, physics and biology)	15 marks (5+5+5)
2.	Oral questions (viva) related to the experiments	02 marks
3.	Lab Records	03 marks
4.	Projects (work done during the session)	05 marks
	Total	25 marks

Division of marks in biology

1.	Essential apparatus	01 marks
2.	Procedure, labeled diagram	02 marks
3.	Presentation	01 marks
4.	Results, precautions	01 marks
	Total	05 marks

Division of marks in physics and chemistry

1.	Essential apparatus	01 marks
2.	Theory and equations, labeled diagram	01 marks
3.	Observations, calculation	02 marks
4.	Results, precautions	01 marks
	Total	05 marks

Experiments

Biology

S.No.	Title
1.	Comparative study of atmospheric carbon dioxide and that which is released during respiration.
2.	Testing the effect of saliva on starch.
3.	Identifying the gas released during photosynthesis.
4.	Identifying male and female reproductive organs in the given flower.

Chemistry

S.No.	Title
1.	Study of neutralization reaction.
2.	Study the effect of air and moisture on iron.
3.	Identifying washing soda and baking soda from given chemical samples.
4.	Study esterification reaction between alcohols and alkanoic acids.

Physics

S.No.	Title
1.	Experimentally compare Celsius and Fahrenheit scale and verify the relation between them.
2.	Verify Ohm's law.
3.	Establishing laws of reflection using a plane mirror.
4.	Establishing laws of refraction or finding the refractive index of rectangular glass slab.
5.	Finding the focal length of a concave mirror using one-pin method.
6.	Drawing magnetic force lines by aligning the North Pole of a bar magnet with geographic north.
7.	Drawing magnetic force lines by aligning the North Pole of a bar magnet with geographic south and finding neutral point.

Practical Work

Biology

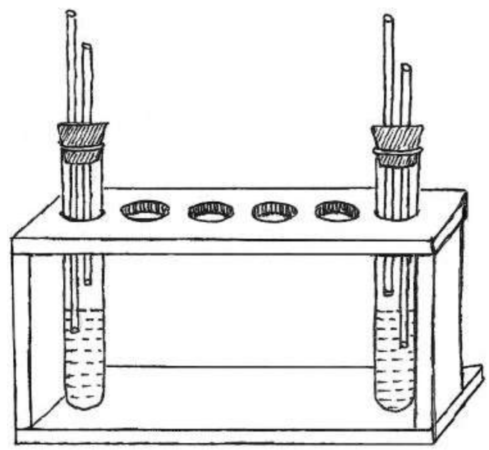
Practical work Life Process: Nutrition, Respiration, Transport, Excretion Respiration

Aim: To make a comparative study of carbon dioxide in exhaled air during breathing and atmospheric air.

Materials Required: Two boiling tubes, a test tube stand, lime water(freshly prepared),two straws/ empty refill (nib removed)/two glass tubes, rubber corks with two holes, a little wheat dough/plasticine, watch

Method:

1. Arrange the apparatus as given in the figure. Use plasticine or wheat dough to fix the straw/refill of glass tube into the cork so that the apparatus is air tight.
2. Label the two boiling tubes as A and B respectively.
3. Fill lime water in the experimental set up to the height shown in the figure.
4. Blow into boiling -tube A. Suck air from B.



5. Note the time taken for lime water to turn milky in A and in B.

Observation: You would find that lime water turns milky faster in A than in B. We know that presence of CO_2 tested in this way. Your observation indicates that there was more CO_2 in exhaled air than in inhaled air(or atmospheric air) as more CO_2 would turn lime water milky sooner.

Result: It may thus be concluded that CO_2 in exhaled air is more than that in atmospheric air.

Precautions:

1. If you keep on blowing air in lime water the milkiness would disappear. So stop blowing as soon as the lime water turns milky.
2. The straws/glass tubes should be dipped in lime water as shown in figure.
3. Wash apparatus before and after use.

Instruction: Use freshly prepared lime water by dissolving a tube of lime(can be acquired from betel leaf/paan shops) in about 150 ml of distilled water. Keep the solution for about an hour; decant the clear liquid and use as lime water.

Practical work Life Process: Nutrition, Respiration, Transport, Excretion Respiration

Aim: To observe the effect of saliva on starch

Materials required: Two beakers, two test tubes, a test tube stand, a teaspoon full of wheat flour, distilled water, dropperand iodine solution(preferably tincture iodine).

Procedure: Add half a teaspoon of wheat flour to half a beaker(around 125 ml) of distilled water mix well to prepare a solution. Now take a little of this solution in a test tube add a few drops of tincture iodine and see if it turns blue black or not that is gives confirmatory test for presence of starch . In case it doesn't, add more of wheat flour till you get a confirmatory test for starch. Now start your experiment with this solution.

Take two test tubes and label them as A and B respectively. Keep them in a test tube stand. Add 20-25 drops of wheat flour solution to both test tubes.

Now to test tube A add a similar amount of your saliva. Do not add anything to test tube B. Leave the set ups for over an hour.

Add iodine solution to both test tubes A and B. Observe which one shows presence of starch.

The teacher may ask following questions to infer.

Questions:

1. What happened after adding iodine to both test-tubes A and B?
2. Why do you think this may have happened?
3. What do you think is the effect of saliva on wheat flour solution?

Result: Saliva helps in breakdown of starch to other compounds that do not test positive for starch test with iodine. Salivary amylase in saliva is mainly responsible for the process of breakdown.

Precautions:

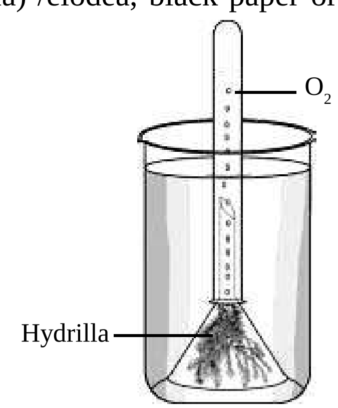
1. Add same amount of wheat flour solution to both test tubes.
2. Wash your mouth thoroughly before adding saliva to test tube A the amount.

Practical work Life Process: Nutrition, Respiration, Transport, Excretion Respiration

Aim: To observe the effect of sunlight on plants and to test the gas released.

Materials Required: Two beakers, two funnels, two test-tubes, (Cheela) /elodea, black paper or cloth,incense sticks and match box.

Procedure: Arrange two sets of the experimental set up as shown in the figure. The set ups have to be arranged under water (use the bucket full of water for the same). Ensure that the test-tube as well as funnel are full of water at the start of your experiment. Cover one set up with black paper and keep it in shade (ensure that it gets minimum heat and light) Let this be labeled as B. Keep the other set up,



labeled as A in sunlight. Leave the set ups as such for a minimum of 3-4 hours. Keep observing from time to time. You would find bubbles rising up and gas collecting in the test-tube. Once the test tube of the set up kept in sunlight is around half filled with gas, take the whole set up under water and remove the test tube and close its mouth with your thumb. Ensure that the gas does not escape. Now bring the test tube out of water, keep a burning incense stick ready and as soon as you remove your thumb, insert the incense stick into the test-tube. Did the incense stick start burning more brightly? Which gas do you think was collected in the test-tube? In which of the set ups, A or B was the collection of this gas more?

Observation:

1. More gas was collected in A. This showed that light was necessary for collection of the gas.
2. The gas present was oxygen. Presence of which is tested by using a burning incense stick /a burning splinter.

Result: We find that Oxygen is evolved in the presence of sunlight.

Precautions:

1. The set up kept in shade should be covered with black paper/ cloth such that entry of light may be minimized.

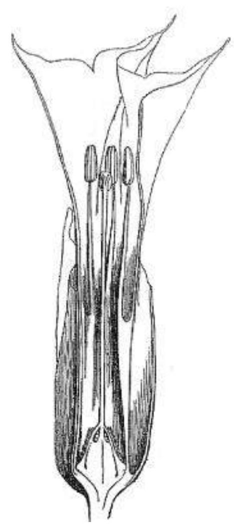
   Set up has to be arranged under water carefully such that there are no water bubbles in the set up initially..
2. Burning incense stick has to be inserted into test-tube quickly.

Practical work Life Process: Growth, Development and Reproduction

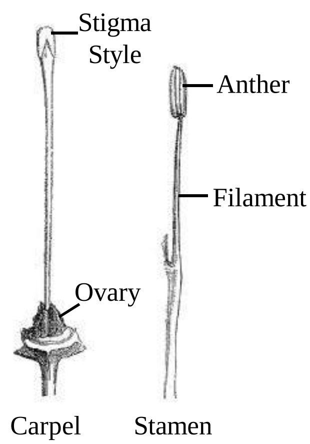
Aim: To observe reproductive parts in a flower

Materials Required: A flower of dhatura or railway creeper, slide, brush, forceps, needle, petridish/ watch glass/bowl, coverslip, hand lens, glycerine.

Dhatura Flower



Male and female reproductive parts



Procedure: Take the flower in your hand and open it up (refer to the section of practical work for figure). Now observe the female and male reproductive parts. Figure in this section shows a Dhatura flower and the male and female reproductive organs in it.

You may observe these organs as under-

You would have to remove the outer whorls as shown in the figure.

(i) Androecium: This is the male reproductive organ of a flower, composed of all the stamens present in the flower. Each stamen has a head formed of anther bearing pollen in pollen sacs and a thin connector called filament that attaches the anther to a petal, thalamus(top part of stalk of flower) etc. The anther of Dhatura appears as arrow heads with fine powdery structures on it called as pollen.Pollens are structures that pass on to the stigma of the female reproductive part. The process of transfer of pollen from anther to stigma is called as pollination. If recognized on stigma they germinate to reach the ovule where the fusion of male and female nuclei takes place. Plants may be self- pollinated when pollen of a flower reaches the stigma of the same flower or other flower on the same plant. Cross pollination occurs when pollen from flower on one plant reaches stigma of flower on another plant and is recognized there.

(ii) Gynoecium: The female reproductive organ of a flower is composed of all the carpels. A carpel is mainly composed of three parts called as stigma, style and ovary (see the figure).

Ovary: This is the lowest part of a carpel where ovules or female reproductive cells or gametes are present. Ovules after fertilization develop into seeds that can give rise to future generation of the plant.

Take longitudinal and transverse sections of the ovary, stain with safranin, wash excess stain with water, prepare slides of the same and observe under the microscope. Note your observation in your copy.

Precaution:

1. Use blade or cutter carefully during section cutting.
2. Wash excess stain before preparing a slide. Do not allow air bubbles to accumulate under the coverslip.

Chemistry

Experiment (Acid, Base and Salt)

Objective : Study of neutralization reaction

Essential apparatus: Test tubes, test tube stand, dropper, dilute hydrochloric acid, dilute sodium hydroxide and phenolphthalein

Theory : Acids and alkalis react with one another to form salt and water and this reaction is known as neutralization.

Acid + Alkali ⟶ Salt + Water

$HCl(aq) + NaOH(aq) \longrightarrow NaCl(aq) + H_2O(l)$

When all acid molecules have reacted with the alkali then the solution becomes neutral. An indicator is used to detect neutralization point. In this experiment, if phenolphthalein is used as indicator then it will be colourless in acidic medium and pink in basic medium.

Procedure : Take 20 drops of dilute hydrochloric in a test tube and add 1-2 drops of phenolphthalein to it. With the help of a dropper, add dilute sodium chloride drop by drop to the above solution while continuously shaking the test tube. Keep adding sodium hydroxide till the colour of solution in the test tube become light pink. Calculate the number of drops of dilute sodium hydroxide solution added and note the reading in the observation table. Repeat this process two more times.

Observation Table

S.No.	Drops of dilute hydrochloric acid taken	Drops of dilute sodium hydroxide solution needed for neutralization
1.	20 drops	....
2.	20 drops	....
3.	20 drops	....

Conclusions : Neutralization of 20 drops of dilute hydrochloric acid required ....drops of dilute sodium hydroxide solution.

Precautions :

1. Test tube should be clean and dry.
2. All solutions should be prepared in distilled water.
3. Clean the dropper with water each time before use.

Experiment (Metals and metallurgy)

Objective : Study of the effect of air and moisture on iron

Essential apparatus: 3 Test tubes, test tube stand, awl-pins, cotton, 3 balloons

Theory : Presence of factors such as air and moisture is necessary for rusting of iron.In this process, the surface of iron acts like an electrochemical cell. One part of the surface acts as anode and another part acts as the cathode. Moisture (or humidity) - which contains dissolved oxygen, carbon dioxide - acts as an electrolyte. The electrochemical process of rusting of iron can be shown as follows:

At the anode: Fe goes into the solution as Fe2+

$$Fe(s) \longrightarrow Fe^{2+} + 2e^-$$

At the cathode: In the presence of oxygen, these electrons are taken up water molecules to form OH- ions.

$$2H_2O + O_2 + 4e^- \longrightarrow 4OH^-$$

The Fe2+ ions formed on the anode react with the OH- to form Fe(OH)2(s). This iron hydroxide reacts with the oxygen in the atmosphere in the presence of moisture to give hydrated iron oxide.

$$2Fe(OH)_2 + ½\, O_2(aq) + H_2O \longrightarrow Fe_2O_3.xH_2O(s)$$

This hydrated iron oxide is known as rust.

Procedure : Take three test tubes and label them 'A', 'B' and 'C' respectively. Put 3-4 awl-pins in each test tube. Add enough water in test tube 'A' so that the pins are submerged. Moisten a piece of cotton and put it in lowest part of test tube 'B'. Leave awl-pins in test tube 'C' untouched. Now make the test tubes air-tight by placing balloons on their mouths. Put the test tubes in a test tube stand and place them in a hot place (or sunlight) and observe after 3-4 hours.

Observation table

S.No.	Test tube	Observation prior to putting in sunlight	Observation after 3-4 hours in the sunlight	Conclusion
1.	Test tube 'A'	Awl-pin submerged in water		
2.	Test tube 'B'	Awl-pin and moist cotton		
3.	Test tube 'C'	Awl-pin and air		

Conclusions : The necessary conditions for rusting of iron are …………..and …………….

Precautions :

1. This experiment should be carried out in the summers or winter. Presence of excess moisture during the rainy season will give to error in results.
2. Awl-pins should be completely clean. If rust is present on the, clean thoroughly with sandpaper before use.
3. Ensure that the test tube is completely dry and has no trace of moisture.
4. Balloons should be tightly and properly placed on the mouths of the test tubes.

Experiment (Chemistry in Daily Life)

Objective : Identifying baking soda or washing soda from given chemical samples.

Essential apparatus: sodium carbonate (washing soda) or sodium hydrogencarbonate (baking soda), sodium chloride, red litmus paper, lime water (freshly made), dilute hydrochloric acid, 4 test tubes, one boiling tube, test tube stand,

Theory : Washing soda ($Na_2CO_3.10H_2O$) and baking soda ($NaHCO_3$) are both white solids. Their aqueous solutions are alkaline and turn red litmus blue. Carbonates and hydrogencarbonates react with dilute acids to release carbon dioxide gas which turns lime water milky.

$$Na_2CO_3(s) + 2HCl(aq) \longrightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$$

$$NaHCO_3(s) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(l) + CO_2(g)$$

$$\underset{\textit{Lime water}}{Ca(OH)_2(aq)} + CO_2(g) \longrightarrow \underset{\textit{milky}}{CaCO_3(s)} + H_2O(l)$$

When excess of CO_2 is passed through lime water then calcium hydrogencarbonate is formed. It dissolves in water to give a colorless solution.

$$CaCO_3(s) + H_2O(l) + CO_2(g) \longrightarrow Ca(HCO_3)_2(aq)$$

Procedure :

1. In three test tubes, separately take a pinch of substance from each of the three given samples. Label the test tubes 'A', 'B' and 'C'.
2. Add 5 mL distilled water to each of the test tubes. Gently shake the test tubes.
3. Using a glass rod put a drop of solution 'A' on red litmus paper. Clean the glass rod with distilled water and do the same for samples 'B' and 'C'. Note the change of colour of litmus paper in all three cases.
4. Add 1 mL dilute hydrochloric acid to each of the test tubes. Did you observe slight bubbling in any of them? If yes, then test the sample which bubbled as described below.
5. To test using lime water, take the bubbling solution in a boiling tube and set up the apparatus as shown in figure-1.
6. Using a thistle funnel add dilute hydrochloric acid drop by drop to the boiling tube.

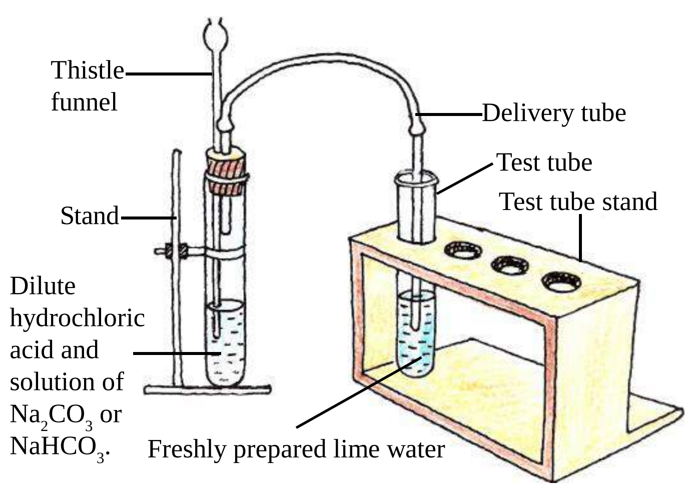


Figure-1: Identification of carbon dioxide gas using lime water

7. Pass the gas formed through freshly prepared lime water. Did the lime water turn milky? If yes, then it shows the presence of carbon dioxide.

8. Continue to pass the gas through lime water. Did it become colourless? If yes, then it confirms that the gas released is carbon dioxide.

Observation table

S.No.	**Solution of sampl**	**Red litmus paper changes to blue or does not show any change**	**Gas released with slight bubbling on addition of dilute hydrochloric acid**	**Lime water turns milky or not**
1.	'A'			
2.	'B'			
3.	'C'			

Conclusions : Washing soda/ Baking soda were identified from among the given samples based on observations with litmus paper and lime water.

The sample in test tube ……………is baking soda/ washing soda.

Precautions :

1. Dilute hydrochloric acid should be added drop by drop otherwise a rapid reaction may take place and the reaction mixture could mix with the lime water.
2. While using washing soda and dilute hydrochloric acid, ensure that the samples do not touch your skin as they may harm you.
3. Use freshly prepared lime water to test for carbon dioxide.

Experiment (Derivatives of Hydrocarbons)

Objective : Study of esterification reaction between an alcohol and alkanoic acid.

Essential apparatus: 5 mL ethanoic acid, 5 mL ethanol, a few drops of concentrated sulphric acid, distilled water, 1 g sodium hydrogencarbonate, thermometer (-10°C to 100°C), test tubes, measuring cylinder (10 mL), 250 mL beaker, burner, tripod stand, wire gauze

Theory : When an alkanoic acid is heated with an alcohol in the presence of concentrated sulphuric acid, water and an ester is formed as product. The reaction is known as esterification, for example when ethanoic acid reacts with ethanol then ethyl ethanoate (ester) and water are produced. Esters have a distinct fruity smell which is different from the smell of acids and alcohols.

$$\underset{\text{Ethanoic acid}}{CH_3COOH} + \underset{\text{ethanol}}{CH_3CH_2OH} \xrightarrow[\text{On warming}]{\text{Conc. } H_2SO_4} \underset{\text{ethyl ethanoate}}{CH_3COOCH_2CH_3} + H_2O$$

Procedure : 1. Take 5 mL acetic acid in a clean test tube and add 4-5 drops concentrated sulphuric acid to it.

2. Add 5 mL ethanol to the test tube.

3. Take 150 mL water in a beaker and warm it to 60oC. Remove the heating apparatus (spirit lamp) once the water is warm.

4. Place the test tube in the warm water for about 5 minutes so that the reaction mixture also becomes warm. This is known as heating in water bath (figure-2).

5. Keep shaking the test tube from time to time.

6. Pour the reaction mixture in the beaker containing the solution of sodium hydrogencarbonate in water. Doing so will cause the unreacted ethanoic acid to react with sodium hydrogen carbonate. Do you see any bubbles?

7. Try to feel the difference in smells of ethanoic acid, ester and ethanol.

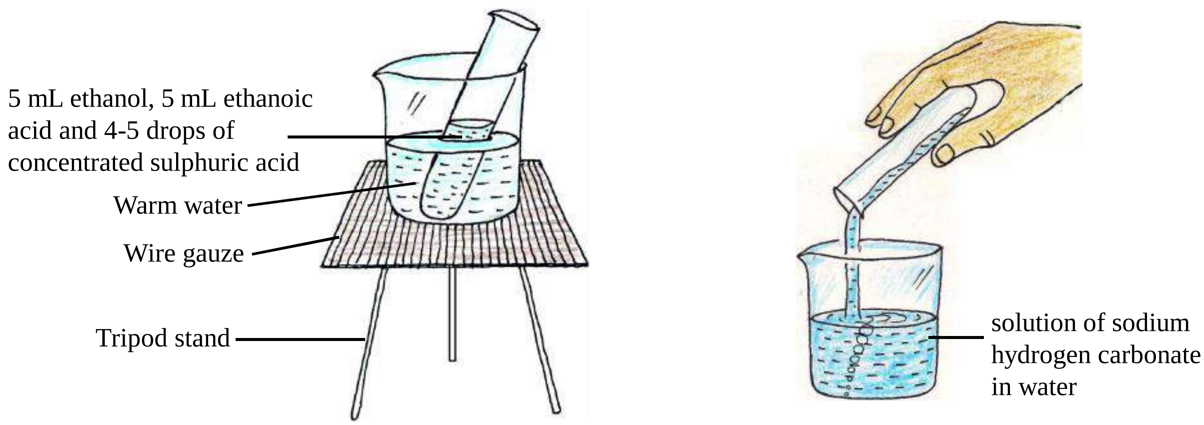


Figure-2: Reaction between an alcohol and alkanoic acid

Conclusions : Write about the difference in smell of ethanoic acid, ester and ethanol.

An ester is formed when the -OH group of an alcohol is replaced by -OR group (where -R denotes an alkyl group). Concentrated H_2SO_4 is used as a dehydrating agent in this reaction.

Precautions : 1. Be careful while using concentrated H_2SO_4.

2. Carbonic compounds vaporize easily and a water bath should be used for heating inflammable compounds such as alcohols. Never heat alcohol directly over a spirit lamp.

Physics
Some instruments used in experiments

1. Clinical Thermometer - The thermometer used by doctors to measure body temperature of patients is known as clinical thermometer.

Structure - It is a small thermometer. As shown in the figure there is a bulb which contains mercury. The capillary tube has a kink near the bulb which prevents the mercury from flowing back into the bulb. It has a glass stem on which readings are marked from 95°F to 110°F. Since human body temperature fluctuates between 95°F to 110°F, therefore this range is used in clinical thermometers. Normal body temperature, for a healthy person, is shown by a red arrow at 98.4°F.

Use - To use the thermometer, it is first washed with water and then given a quick jerk to bring down the level of mercury in the glass tem. After this, on coming in contact with the patient's body the mercury starts rising. Once the mercury becomes stable, the reading is noted. To use again, the entire process is repeated. Due to kink in the stem, the mercury does not come back on its own. To read the thermometer it should be held horizontally, parallel to our eyes so that the reading is visible.

Why mercury is used in thermometers?

1. Mercury expands uniformly with increase in temperature.
2. It does not stick to the walls of the glass tube.
3. Its specific heat is negligible therefore it needs minimal heat to show increase in temperature.
4. It has a freezing point of -38.83°C and boiling point of 356.7°C which gives a very big range to measure temperatures.
5. It shows uniform volume expansion therefore, it is convenient to mark readings.
6. It is very bright and reflective, so it is easy to read accurately.
7. It has very low vapour pressure so the impurities present are negligible and mercury is mostly pure.

These days, doctors use digital thermometers based on electronic principles. You will read more about them later.

2. Using a multimeter

You may have seen this instrument with nearly all technicians. Ammeter, voltmeter and ohmmeter are all combined in one instrument. This means that we can measure direct current (DC), alternating current (AC) and resistance using this instrument. It has a red needle and a black needle, called probes, which are used to connect the multimeter to the electric circuit.

The method of connecting the multimeter to the circuit depends on the range of values which have to be measured. If we want to use it as an ammeter to measure current then it should be connected in series in the circuit. If potential has to be measured then it should be connected in parallel fashion in the circuit.

Voltmeters and ammeters have two ends; a red end which is the positive pole and a black end which is the negative pole. Similarly, multimeter also has two probes and the negative end is known as the common point. The black probe is always fitted in the common point. Where the red probe is fitted depends on what is to be measured.

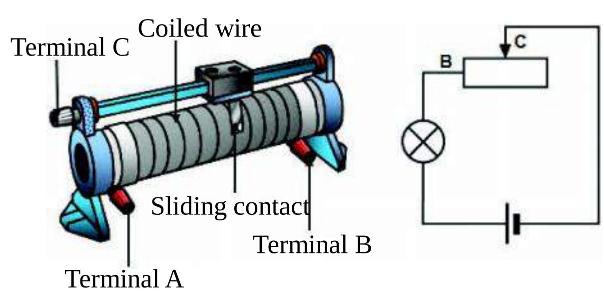
(A) Measuring electric currents - Multimeter has more than one range to measure any values. For example, the multimeter shown in the figure can measure DC in the following range: 2000 mA, 20 mA, 200 mA, 10 A. Choose any one range to fix the scale of multimeter which means that after we set a range, the multimeter will be able to measure values only between the maximum and minimum of the range.

If we have no idea about how much current is flowing through the circuit then take the biggest range in the beginning. If the current is low and we are not able to measure it accurately then move to a lower range.

(B) Measuring voltage/potential - It can measure both AC and DC voltage. The multimeter shown in the figure can measure DC voltage in the following range: 1000V, 200V, 20V, 2000 mV, 200 mV and also to measure AC voltage at 750 V and 200 V.

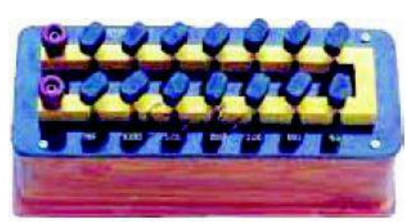
(C) Measuring resistance - The multimeter shown in the figure can measure in the range: 2000 kohms, 200 kohms, 20 kohms, 2000 ohms and 200 ohms.

3. Rheostat - It is made of an insulating material like ceramic shaped into a hollow cylinder core around which a high specific resistance wire like Manganin or Constantine is coiled as shown in the figure. The ends of wire are known as terminal A and terminal B.



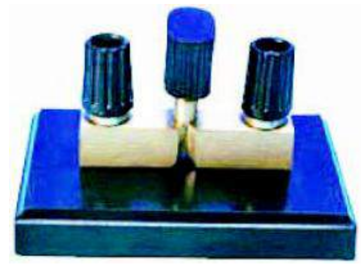
It contains a metal rod on which a bar of conducting material is attached. Rheostat is used to change the value of electric current flowing through the circuit. The values of total resistance and maximum current that can flow through it are engraved on the coil.

4. Resistance box - In this brass pieces or knobs are placed in two rows on an ebonite box. There is some empty space between any two knobs. The first and last knobs have connecting screws on them. Standard resistors are present beneath each knob.



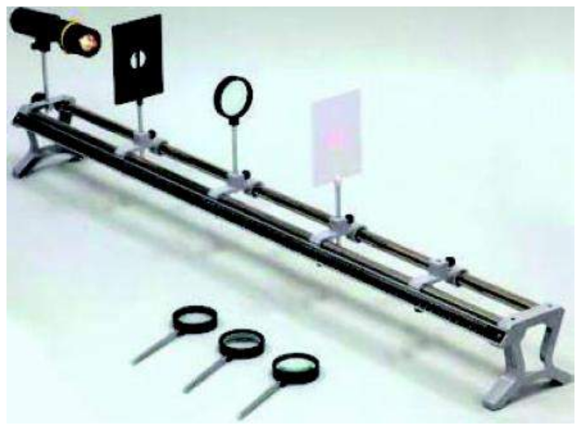
Standard resistors are made of materials like Manganin, Eureko etc. Each end of the wire is connected to one resistor. The space between the brass knobs is plugged with brass pieces. For safety, the metal coils are placed in a wooden box. The resistance under each knob is indicated outside on the box. The box has resistances of 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000 ohms or 0.1, 0.2, 0.5, 1, 2, 5, 10 ohms. In most boxes infinity symbol (∞) is indicated on the knobs to which the wires are joined. In reality, these knobs are not connected by any wire.

5. One-way plug key - Is shown in the figure. In this key, two brass plugs appropriately spaced are attached to an ebonite surface. A brass plug which has a connecting screw is placed in the space.



When we wish that electric current should flow through the circuit, the third plug is inserted and it is removed to stop the flow. This key is universally used in electricity related experiments and functions like an on/off switch.

6. Optical bench - it is used in light related experiments. It is 1 m or longer bench made of steel or wood. On one side of the bench, a cm scale is marked and an inch scale is marked on the other side.



Different stands are attached to the bench on which mirrors and lenses can be fixed using a pin. This pin can be moved up and down as needed. The bench can be made to lie flat or inclined using a screw below it.

Experiment (Heat and temperature)

Objective : Experimentally compare Celsius and Fahrenheit scale and verify the relation between them.

Essential Apparatus: Beaker, Celsius and Fahrenheit thermometers, tripod, stand, stirrer, wire etc.

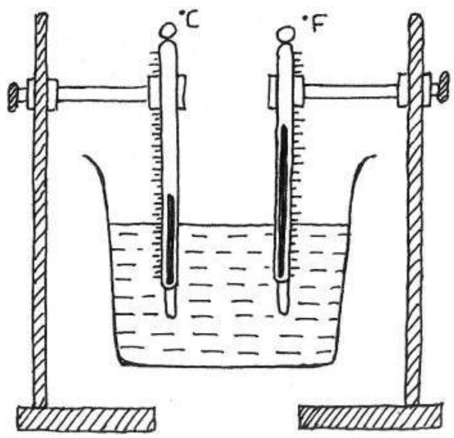
Theory : If we wish to convert the temperature from Celsius scale to and Fahrenheit scale then the relation (conversion formula) is as follows:

$$\frac{C}{5} = \frac{F - 32}{9}$$

$$C = \frac{5}{9} \times (F - 32)$$

Procedure :

1. Find the least count of the given Celsius and Fahrenheit thermometers.
2. Note the room temperature on Celsius and Fahrenheit thermometers. Use t1 to indicate the Celsius scale and t2 for Fahrenheit scale. While noting the temperature, be careful that your eyes are parallel to the highest point of the thermometer.



3. Now fill a small beaker about two-thirds with water and heat it (using a spirit lamp). Insert the two thermometers in the beaker as shown in the figure so that their bulbs are submerged completely. Make sure that your thermometers do not touch the bottom of the beaker. When the water starts boiling then agitate it using a stirrer so that the temperature becomes uniform throughout the water. Take the readings on the two thermometers; they show the boiling point of water.
4. Remove the lamp and allow the water to cool.
5. After the water has cooled a little, again agitate it with the stirrer and take **readings on the thermometer. Do this 3-4 times.**

Observation table : Least count of Celsius (centigrade) scale = 1°C

Least count of Fahrenheit scale = 1°F

S.No.		Celsius scale reading, t_1°C	Fahrenheit scale reading, t_2°C	$t_3 = \frac{9}{5}\left(t_1 + 32\right)$
1.	Room temperature	22	72	71.6
2.	Water temperature	99	210	210.2
3.				
4.				
5.				
6.				

Calculations : For each reading t_1 on the Celsius scale, we will calculate the corresponding t_3 using the formula given below and write it in the observation table.

$$t_3 = \frac{9}{5} \quad t_1 + 32$$

Results : (i) It is clear from the observation table that the boiling point of water = 99°C=210°F

(ii) For each observation, the value of t_3 is nearly same, and thus the following formula is verified.

$$\frac{C}{5} = \frac{F - 32}{9}$$

Precautions :

1. While taking the temperature of steam, the thermometer bulbs should not be in water but should be in the steam.
2. While taking the temperature of boiling water, the thermometer bulbs should be submerged in water.
3. Use the stirrer to agitate the water before taking the readings.
4. Both thermometers should be vertical.
5. Thermometer should not touch the beaker walls.
6. While taking the reading, our eyes should be parallel to the reading point.

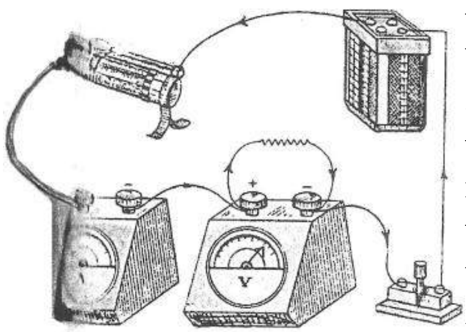
Experiment (Electric currents and circuits)

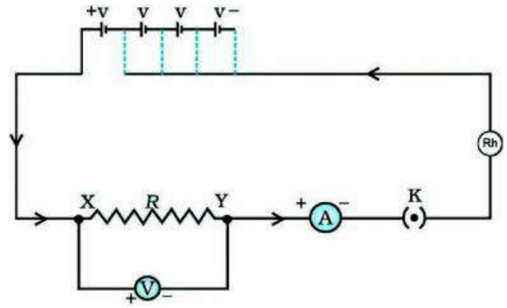
Objective : Verification of Ohm's Law.

Essential Apparatus: Resistor wires, cells, key, ammeter, voltmeter, connecting wires, variable resistor.

Theory : According to Ohm's law, provided that there is no change in physical state of the conductor, there is a linear relationship between the voltage drop (V) across its two ends and the current (I) flowing through it. This means that V = IR where R is the resistance of the conductor.

Procedure : 1. Find complete the circuit as shown in the figure. To do this we will connect the battery, resistor wires, ammeter, key and variable resistor in series and connect the voltmeter in parallel to the resistor wire. Make sure that the positive end of the battery is connected to positive ends of the ammeter and voltmeter.





2. Note the least count of the voltmeter and ammeter.
3. Now place the plug in the key and with the help of rheostat control the current flowing through the ammeter. We know that ammeter measure current and voltmeter the potential drop so let us note the respective readings.
4. use the rheostat to change the current and take several more readings for current and corresponding voltage.
5. Take 4-5 readings for current and voltage.

Observations : Least count of ammeter = 0.1 V

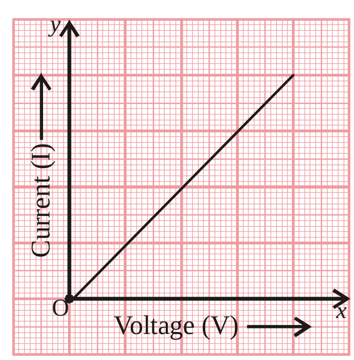
Least count of voltmeter = 0.1 A

S.No.	**Ammeter reading (I)**	**Voltmeter reading (V)**	$\frac{V}{I}$ **resistance in ohms**
1.			
2.			
3.			
4.			
5.			

Average resistance R = ...

Results : The ratio of voltage and current is constant. Therefore, we may conclude that the potential drop across the resistance wire is proportional to the current flowing through it.

Graph : Plot between V and I



Precautions : 1. Ammeter should always be joined in series in the circuit.

2. Voltmeter should always be joined in parallel in the circuit.
3. Do not constantly pass current through the conductor.
4. All screws should be tightened.
5. Do not pass very high currents through the conductor.

Experiment (Light: Reflection and refraction from a plane surface)

Objective : Verification of laws of reflection using a plane mirror.

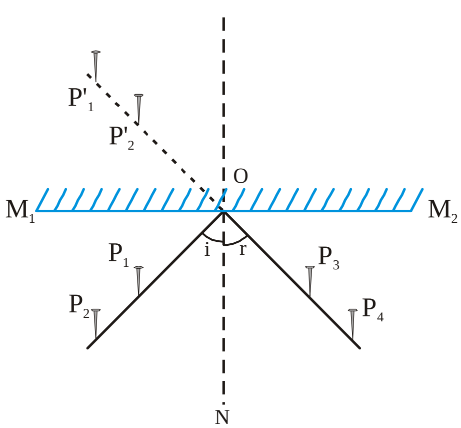
Essential Apparatus: A plane mirror fixed vertically in a plastic/ wooden frame, drawing board, drawing paper (White), a foot-rule, a pencil, pins, push pins, a protactor, etc

Principle : When a ray of light is incident on a reflecting surface then it travels back in the original medium after falling on the surface. This phenomenon is called reflection of light and it follows certain laws.

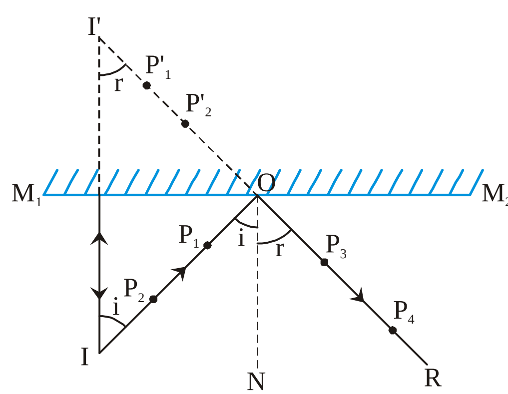
1. The incident ray, the reflected ray, and the normal to point of incidence all lie in the same plane.
2. The angle of incidence is equal to the angle of reflection.

Procedure :

1. Fix the white drawing paper on the drawing board using board pins.
2. Place the plane mirror vertically on the paper and use it to draw line M_1M_2.
3. On the midpoint O of M_1M_2 draw ON perpendicular to M_1M_2.
4. Draw a ray IO which makes an angle of $\angle 30°$ with the normal ON. This is the incident ray.
5. Place a plane mirror vertically along M_1M_2 and fix two all pins P_1 and P_2 on IO.
6. From the other side of the normal, see the images of pins P_1 and P_2 and fix two other pins P_3 and P_4 vertically so that pins P_3, P_4 and images of P_1 and P_2 appear collinear at their lower ends.
7. Now remove the pins and the mirror. Join the dots made by P_3 and P_4 and obtain the reflected ray RO.
8. Measure the angle of reflection $\angle$RON using a protactor.
9. Find the corresponding angle of reflection for different angles of incidence such as 30°, 35°, 40°, 45°, etc.



Reflection from a plane mirror



angle of incidence = angle of reflection

Observations

S.No.	Angle of incidence ĎION = i	Angle of reflection ĎRON = r
1.	30°	30°
2.		
3.		
4.		
5.		

Results : 1. The incident ray, the reflected ray, and the normal to point of incidence all lie in the same plane.

2. The angle of incidence is equal to the angle of reflection.

Precautions : 1. Plane mirror should be vertical.

2. Pins should be kept vertical.
3. Distance between the two pins should be 3-4 cm..
4. Plane mirror should be clean.
5. The lower ends of the pins should be used for checking.
6. Mirror should not be shifted from the fixed line.

Experiment (Light: Reflection and refraction from a plane surface)

Objective : Finding the refractive index of a rectangular glass slab or establishing the laws of refraction

Essential Apparatus: Glass-slab, drawing-board, white drawing paper, pencil, board pins, Protractor and scale.

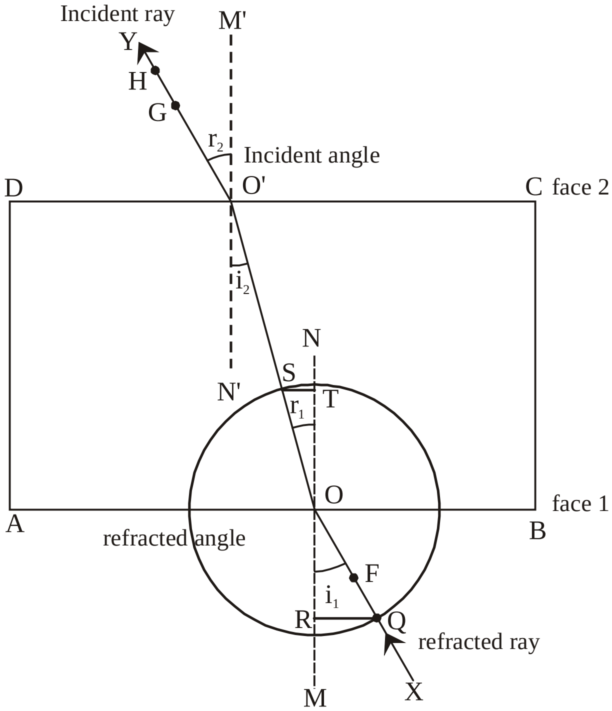
Principle : When light ray passes from a less dense to a more dense substance, it bends towards the normal and when it passes from denser to less dense medium it bends away from the normal. This is known as refraction and it follows the following laws:

1. The incident ray, the refracted ray, and the normal to point of incidence all lie in the same plane.
2. The ratio of sine of angle of incidence to the sine of the angle of refraction is constant and it is known as the refractive index of the second medium with respect to the first.

$$ {}_a«_g = \frac{\sin i}{\sin r} $$

The refractive index of glass with respect to air = $ {}_a«_g = \dfrac{\text{length of perpendicular in air (QR)}}{\text{length of perpendicular in air (ST)}} $

Procedure : 1. Fix the white drawing paper on the drawing board using board pins.



2. Place the rectangular slab on the paper and draw its outline ABCD.
3. On any point O of AB, draw NM⊥AB. From O, draw a ray XO forming angle i with NM.
4. Place the slab properly and fix two pins E and F on XO. From the other side DC of the slab, try to see the image of the pins.
5. Fix two pins G and H upright so that images of E and F and pins G and H become collinear at their lower ends
6. Now remove the slab and the pins and draw emergent ray YO' passing through marks of G and H, which intersects DC at O'. Join OO'.
7. Keeping O at the centre, draw a circle of any radii which intersects OX at Q and OO' at S.
8. Draw QR⊥N_1O and ST⊥ON_2. Measure QR and ST.
9. Repeat at least 5 times for different values of i.
10. Calculate the refractive index for each reading and then find average refractive index value.

Observations

S.No.	length of perpendicular in air, QR	length of perpendicular in glass, ST	refractive index « $= \frac{QR}{ST}$
1.	.... cm.	.... cm.	
2.	.... cm.	.... cm.	
3.-	.... cm.	.... cm.	
4.	.... cm.	.... cm.	
5.	.... cm.	.... cm.	

Results : The refractive index of glass with respect to air is

Precautions : 1. Correct measurements should be indicated on the paper on the basis of the glass-slab.

2. Pins should be fixed vertically.
3. The images of first two pins and the remaining two pins should be in the same line.

4. Perpendiculars should be drawn carefully.
5. Angles should be properly measured.

Experiment (Light: Reflection and refraction from a curved surface)

Objective : Finding the focal length of a concave mirror using one-pin method.

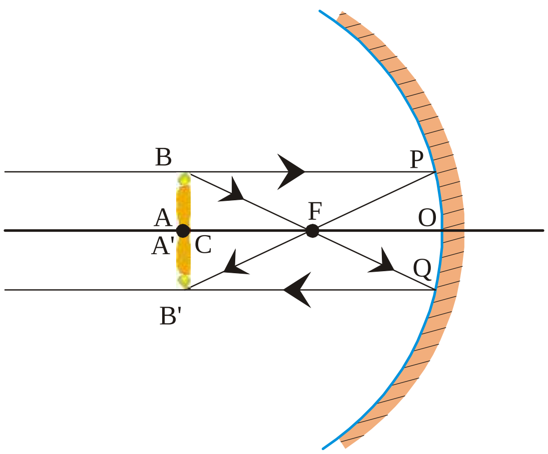
Essential Apparatus: light bench, concave mirror, pins etc.

Principle : When an object is placed at the centre of curvature of a concave mirror, a real image of same size is formed at the same place as the object. When distance between object and mirror is equal to radius of curvature, then focal length-

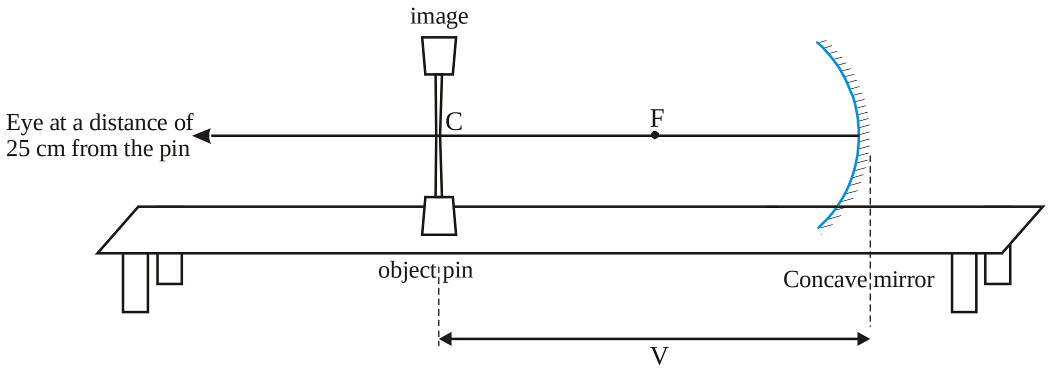
$$f = \frac{R}{2} \left(\text{focal length} = \frac{\text{radius of curvature}}{2} \right)$$

Procedure :

1. Fix the concave mirror vertically on one stand of the light bench and fix the bench horizontally flat.



2. On another clamp of the bench, fix a pin such that the tip of the pin is at the center of the mirror.
3. Move the pin along the bench in front of the mirror until a real inverted image of the pin is seen somewhere in front of the mirror. Adjust till there is no parallax between the pin and image.
4. Find the positions of the mirror and pin, the difference between the two will give the radius of curvature.
5. Repeat at least 4-5 times and take readings.



Finding focal length using one pin method

Observation table

S.No.	Position of mirror, M	Position of pin, P	Radius of curvature of mirror R = M - P
1.	.... cm	.... cm	.... cm
2.	.... cm	.... cm	.... cm
3.	.... cm	.... cm	.... cm
4.	.... cm	.... cm	.... cm

Average radius of curvature R = ……………………cm

Calculations : focal length $= \frac{\text{radius of curvature}}{2}$, focal length $f = \frac{R}{2} =$ ....cm

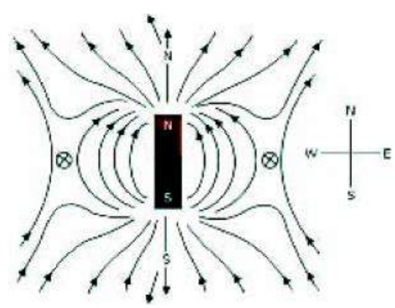
Results : The focal length of the concave mirror is = …………..cm

Precautions :
1. Pin and mirror should be aligned.
2. Parallax should be eliminated between object pin and its image.
3. The optical bench should be aligned flat horizontally before experiment.
4. Mirror should be clean and the room should have proper light.

Experiment (Magnetic effects of current)

Objective : Drawing magnetic force lines by aligning the North Pole of a bar magnet with geographic north (N→N).

Essential Apparatus: bar magnet, drawing-board, white drawing paper, board pins, compass etc.



Principle : The magnetic field lines due to a bar magnet are closed loops in which the tangent drawn at any point gives the direction of field at that point. The points where the magnetic force is zero are known as neutral points.

Procedure :
1. Fix the white drawing paper flat on the drawing board using board pins.
2. Place the compass on the paper and mark north-south direction on it. Draw a line joining the two points. Align the north pole of the bar magnet with the geographical north and trace the outline of the magnet on paper.
3. Place the compass at North pole of the magnet and make a dot next to the needle showing the direction the compass arrow points.
4. Move the compass so that the base of the arrow is at the dot you've just made. Now make a new mark where the tip of the arrow is pointing this time. Keep doing this until you reach the other end of the magnet. A curved line is obtained by joining the dots; this is the magnetic field line.

Similarly, draw several more magnetic lines of force each having arrows showing the direction from north to south. At the center of the lines, you will obtain a curved quadrilateral perpendicular to the axis. The neutral point lies in this quadrilateral.

5. Find the distance from the middle of the magnet to the neutral point.

Observations :

1. The distance from the mid-point of the magnet to the first neutral point is ….cm (this is average).
2. The distance from the mid-point of the magnet to the second neutral point is ….cm (this is average).

Results :

1. The distances of the neutral points from the mid-point of the bar magnet are nearly same. The points lie on the equatorial line of the bar magnet.
2. The field lines form a closed loop and the lines do not intersect each other at any point.

Precautions :

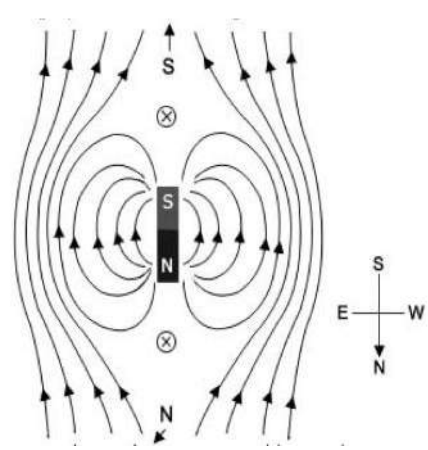
1. The drawing board and magnet should not be shifted during the experiment.
2. There should not be any other magnetic material around the experiment area.
3. Compass needle should move freely.
4. Magnet should not be very powerful.
5. More lines should be drawn near the neutral point so that it can be accurately located.

Experiment (Magnetic effects of current)

Objective : Drawing magnetic force lines by aligning the North Pole of a bar magnet with geographic south and finding neutral point (N →S).

Essential Apparatus: bar magnet, drawing-board, white drawing paper, board pins, compass etc.

Principle : Magnetic lines of force form a circular field in which the tangent drawn at any point gives the direction of field at that point. The points where the magnetic force is zero are known as neutral points. When the North pole of a bar magnet points towards the geographical south pole of the earth, the two neutral points lie on the axial line of the bar magnet such that they are equidistant from the centre of the bar magnet.



Procedure :

1. Fix the white drawing paper flat on the drawing board using board pins.
2. Place the compass on the paper and mark north-south direction on it. Draw a line joining the two points. Align the north pole of the bar magnet with the geographical south and trace the outline of the magnet on paper.
3. Place the compass at North pole of the magnet and make a dot next to the needle showing the direction the compass arrow points.
4. Move the compass so that the base of the arrow is at the dot you've just made. Now make a new mark where the tip of the arrow is pointing this time. Keep doing this until you reach the other end of the magnet. A curved line is obtained by joining the dots; this is the magnetic field line.

   Similarly, draw several more magnetic lines of force each having arrows showing the direction from north to south.
5. At the center of the lines, you will obtain a curved quadrilateral perpendicular to the axis. The neutral points lie in this quadrilateral in the direction of the axis of the magnet.
6. Find the distance from the middle of the magnet to the neutral points.

Observations :

1. The distance from the mid-point of the magnet to the first neutral point is ….cm (this is average).
2. The distance from the mid-point of the magnet to the second neutral point is ….cm (this is average).

Results :

1. The distances of the neutral points from the mid-point of the bar magnet are same. The points lie along the magnetic axis.
2. The field lines form a closed loop and the lines do not intersect each other at any point.

Precautions :

1. The drawing board and magnet should not be shifted during the experiment.
2. There should not be any other magnetic material around the experiment area.
3. Compass needle should move freely.
4. Magnet should not be very powerful.
5. More lines should be drawn near the neutral point so that it can be accurately located.

Project Work

Instructions for project work

1. Project work may be done in small groups.
2. Each child has to do three projects - one each in chemistry, physics and biology.
3. Project writing should be done in correct order. Diagrams, pictures, paper, cuttings, collections, photographs, graphs etc. should be described as required.
4. During the practical exams, it is necessary to question each child orally regarding their projects and experiments.
5. Project work can focus on a local issue.

Biology

1. Understanding the process of natural selection.
2. Understanding the living and non-living components in our environment and also the linkages between them.
3. Understanding the role of chance in heredity.

Chemistry

1. Find the pH values of aqueous solutions of different substances using pH paper.
2. Collecting information about iron ores and methods of extraction of iron in Chhattisgarh. Linking this with metal art in Chhattisgarh.
3. Collecting information about polythene usage from families in your neighbourhood and then relating this to various efforts being made to stop use of polythene.
4. Study saponification process during soap formation.

Physics

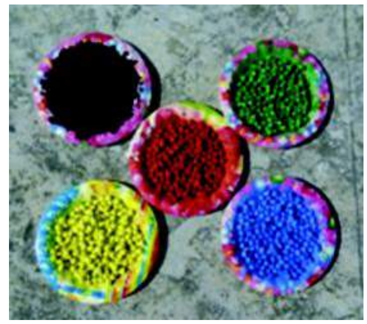
1. Making an optical instrument.
2. Producing a magnetic field by opening/closing electric circuits rapidly and continuously. By varying the intensity of magnetic field rapidly electricity can be generated.
3. Making a windmill model and demonstrating the use of wind energy in daily life.

Biology

Project work (Evolution)

Aim: To understand the process of natural selection

Materials Required: Gram (chick pea) seeds coloured separately in 5 different colours(see figure, in place of gram one may also use similar buttons of 5 different colours). Hundred gram seeds of each colour must be present. Thus a total of 500 seeds must be present. In a class of around 5 plates, string or rope and a piece of chalk is required.



Method: Allow a student to give guidelines to others to make groups each of 6 students. Two members of each group will be leaders while the rest will be birds. The students representing birds would stand around square fields. Each group should be given 12 seeds of each colour, that is a total of 60 seeds. The gram seeds represent beetles. Then each group shall be given a plate. As the game starts the 60 gram seeds would be thrown in a 1m x 1m area from where the seeds would be picked and collected in the plates.

1. Each group will mark plot of 1m by 1m area on the ground, the area marked by a group should be around 2-3 meters away from that marked by another group.
2. Try to choose such areas where the surface has grasses in some places while pebbles and stones in others.
3. The group leader of each group shall note observations in a table. Take count of gram seeds in the field and those left in the field after a round of the game. The group leaders should have a copy of the table as provided in this section(they may draw it in their copies).
4. The group leader will take a count of gram seeds in the beginning of the game and ensure that there are 12 gram seeds of each colour and a total of 60 seeds(this number has to be filled in the table in the first row). The leader shall throw the seeds over the plot as four members of the group shall stand around four sides of the plot. These represent birds. Their back should be towards the plot so that they are unaware of the distribution of the gram seeds.
5. Each of the empty plates should be kept at a distance of at least around 3-4 meters from the respective plots.
6. One student,not a member of any group, would have to signal the start of the game. The students representing birds should immediately turn collect a gram

seed and run towards the plate, put it on the plate and return to collect the next seed. After around 6 rounds the same student who signaled the start of the game will signal the stop of the game.

7. Now the group leader present near each of the plates of the respective groups should count the seeds of each colour and find out the number of seeds of each colour left on the field. They should write the numbers in the given table.
8. The group leader would now add double the number of each colour of seeds left on the field(doubling the number just represents the process of reproduction of beetles with a progeny population double as that of parents). The leader would have to sprinkle them over the respective fields. Those that are representing birds should be standing with their back towards the field so that they do not see the process(Steps 1-8 represents 1st round).
9. Repeat processes 4 to 8(this would be second round). That is we progress up to two generation of beetle population after parental generation.
10. Now students may return to their class, complete the table, analyze data obtained in the table, draw graphs and find out what had happened to the beetle population.

S.No.	**No. of seeds (representing beetles)**	**Colour**				
		Black	**Blue**	**Green**	**Yellow**	**Red**
1.	Parental generation(No. of seeds at the start of experiment)					
2.	No. of seeds left on the plate after first round					
3.	No. of seeds left on the field					
4.	No. after doubling values obtained in '3'					
5.	Total number on field (add 3 and 4.					
6.	No. of seeds on plate after second round					
7.	No. left on field					
8.	Double number left on field					
9.	Total seeds on field					

Use the numbers obtained in the last row(row 9) for graphical representation.

1. Did the relative number of each colour change a lot after the first round?
2. What happened after the second round?
3. Do you think that in both the generation the choice of selection of seeds was same?
4. Which colour of seeds were most in the fields?

5. Which colour of seeds was least or absent?
6. What would happen if you continued with your game up to 3rd ,4th or further generations?
7. Continue playing to check your hypothesis.
8. What was your experience after playing the game?
9. What do you think may be the reason for your observation?

Consolidation: Discuss the process of natural selection as observed in the game and differentiate between artificial selection and natural selection. State that natural selection is a non-intentional process, continuously going on in nature.

Project work (Our Environment -Energy flow in ecosystems)

Aim: To use transact method to find out interrelationships in ecosystem

Materials required: four wooden sticks to mark four corners of 1m X 1m square area. A length of strong thread to outline the chosen area, a spade or hoe to dig soil, copy, pencil, rubber, sharpener , hand-lens

Procedure: Select an area around your house or school. It could be a part of a garden or a grassy field. The area should be such that you could observe it regularly (at least twice daily, both in the morning and evening) for 5 days. Mark a one meter by one meter area here. Observe carefully, do you find any insects, frog, bird or any other organism in the marked area? Write the name of the group of insects and the number of them that you observe there (as for example grass 20, ants 28 etc.). Dig the soil as well to count organisms. Try to keep counts such that you count a particular organism once only. If there are any trees, herbs, bushes etc. count them under the group of plants.

Note your observations every day. Write the date, morning and evening half and details to be able to take counts daily.

Questions:

- What are the biotic and abiotic factors in your area?
- What are the biotic and abiotic factors in your area?
- Could you observe any food chain or food web in the marked area? Give an example.
- Could you observe any food web or food chain in the whole garden? Give an example.
- What are the differences in abiotic factors of morning and evening hours?

Now calculate the average number of organisms observed per day in the area from the total organisms observed in 5 days(as for example if total number of ants were 50 those observed per day were 10 and this number multiplied by the area gives you and approximate number of ant population in that area).

- Do you think the organisms in the area have enough resources for their survival?
- What do you think will happen if there aren't enough resources for survival? Elaborate your answer.

Projcet work (Life Processes: Growth, development and reproduction)

Aim: Study development and rate of growth in mustard plants

Materials required: Copy, scale, a length of thread(around 1m), pencil, pen, sharpener, rubber, hand-lens, a medium sized pot filled with soil, mustard seeds, cup.

Procedure: Take a few mustard seeds and sow them in a medium sized pot. Note this day as day 1.Water the pot every day with around a cup of water. Observe the pot and see when the plants grow out of the soil. Note the day. Keep observing till the plants are around 30cm in length.

Note your observations carefully.

1. How many days after sowing the seed did you find the plants growing out?
2. When did you find a pair of leaves growing on the plants?
3. When did the next pair of leaves grow?
4. Was there any change in the first pair of leaves as the plant grew taller?
5. In how many days did the plants grow to nearly 30 cm in height?
6. Find out the approximate rate of growth of mustard plants(Hint: divide plant length by number of days after sowing).

Projcet work (Heredity: Parent to offspring)

Aim: Tossing coins to understand probability and how it may be applied to the process of heredity.

Materials required: two similar coins either of one rupee/two rupees/ 5 rupees, marker pen(preferably black), paper, pencil

Instruction: Draw table 3 as given in chapter 15 on paper.

Procedure:

1. Start the game of tossing coins by using two similar coins(one rupee/two rupees/5 rupees). Mark one of the coins on both sides with a dot using the black marker pen. Mark it in such a manner that the head and tail marks are not covered. This is coin 'A'. The one without marks is coin 'B'.
2. Now toss both coins together and note your observation in the table with tally marks for example if both fall with head side up then one tally marks to be put under section HH, with a head on 'A' coin and tail on 'B' put tally mark under HT, tail on 'A' and head on 'B' put a tally mark under TH and so on.

3. Toss coins at least 500 to 1000 times
4. Find out the percentage probability of getting two heads; two tails; head on A and tail on B; tail on A and head on B.
5. Consider HH and TT as alternative traits of a character(say HH represents tallness and TT represents dwarfness).
6. Take the help of Chapter 15 especially section 15.2.4.

Questions:

1. Suggest how Mendel may have used probability to predict inheritance of characters from one generation to the next?
2. What do you think would happen if a single coin was tossed? What is the probability of getting a head? Why do you think Mendel may have suggested that characters are passed on from one generation to next as at least a pair of traits?
3. How do you think mathematical calculation of probability may have helped Mendel to arrive at his proposed laws of inheritance?

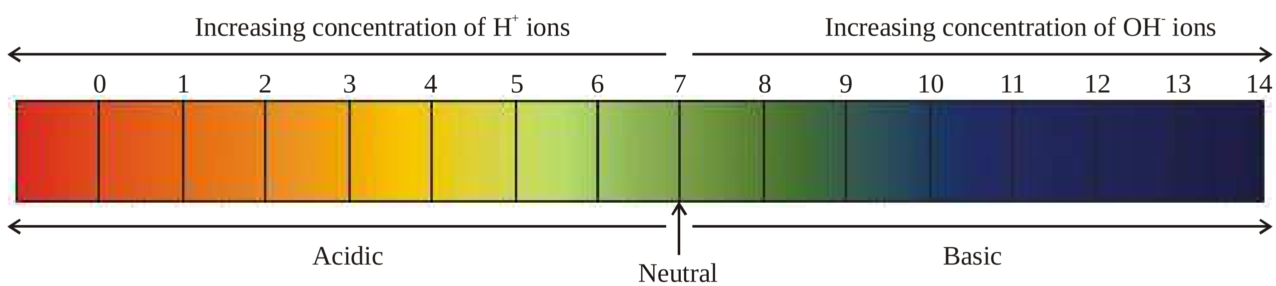
Chemistry

Project work (Acids, Bases and Salts)

Objective : Find the pH values of aqueous solutions of different substances using pH paper.

Essential Apparatus: Different test solutions as follows: 1) solution of soil in water 2) fruit juice 3) milk 4) solutions of different substances, test tubes, test tube stand, pH paper, glass rod or droppers.

Theory : pH is a measure of the acidic or basic nature of a dilute solution. pH scale tells us the concentration of H+ ions in a given solution. pH is divided on a scale of 0 to 14. At 25°C (298K), the pH of a neutral solution is 7. Value of less than 7 on the pH scale shows acidic nature and that of more than 7 shows basic nature. Usually, pH paper is used to find the approximate pH value of any solution. It indicates different pH values through different colours.



Procedure : (Note- all solutions should be made in distilled water. A dropper or glass rod used with any one solution should be thoroughly cleaned before with water before using again.)

1. Take clean test tubes in a test tube stand.
2. To make solutions of solid substances, add a pinch to about 10 mL of water. Use liquid substances like fruit juice as they are.
3. Take different strips of pH paper. Using a dropper or glass rod, put one or two drops of the different solutions on different strips of pH paper.
4. Match the colour obtained with the pH paper chart to determine the pH of each solution.
5. To find the pH of fruit juice, squeeze out a few drops on pH paper and note the pH.

Observation Table :

S. No.	test solution	approximate pH value
1.	solution of soil	
2.	fruit juice	
3.	milk	
4.		
5.		
6.		
7.		
8.		
9.		
10.		

Conclusions : Identify the nature (acidic, basic, neutral) of different solutions and write the conclusions.

Project work (Metals and metallurgy)

Objective : Collecting information about iron ores and methods of extraction of iron in Chhattisgarh. Linking this with metal art in Chhattisgarh.

Theory : Ores are found in large quantities in Chhattisgarh and our state holds an important place in the country in terms of iron production. The ores are found in different types of rocks. Ores are also formed due to soil compaction and other factors. Through this project, we will be able to understand that iron ore-

1. Is found in which types of rocks in Chhattisgarh.

2. What are the methods of extraction used?
3. How is the iron used in the field of metal art?

Procedure : 1. Groups of students should be formed by the teacher.

2. During project work, each group should collect information from their surroundings around the following questions:

- Where in Chhattisgarh is iron ore found?
- What were the local methods of iron extraction used previously and what are the current methods?
- What is the history of iron metal art in Chhattisgarh?
- What is the chemistry behind metal art?
- What are the traditional alloys of Chhattisgarh?
- Make a list of objects made of different alloys found in and around your home or school.
- How to different cultures connect to metal art and how is the art connected to local context?

Prepare the project report according the answers given to your questions.

Project work (Derivatives of hydrocarbon)

Objective : Collecting information about polythene usage from families in your neighbourhood and then relating this to various efforts being made to stop use of polythene.

Theory : People continue to use objects made of polythene even today. What was used instead of polythene 40-50 years ago before its invention? Is the decomposition and recycling process for paper and polythene similar?

Since polythene is inert to most chemicals therefore it keeps collecting as waste and does not decompose. In this situation, the polythene dumped in garbage is either burnt to destroy it or recycled to make secondary products. Both these processes effect our environment. Through this project, reflect on the following questions:

1. Why has polythene been banned in our state and country?
2. What efforts are being made to stop the use of polythene?
3. What products are formed during combustion of polythene and how do they effect the environment?
4. Which objects are formed by recycling of polythene?

Procedure : 1. Groups of students should be formed by the teacher.

2. During project work, each group should make a questionnaire to interview members of four families in their locality. After the interview, prepare a project report.

3. If articles from newspaper or magazines have been used or any other material has been used during report preparation, its list should be prepared by each group.
4. If new information or new questions came up during project work they should be shared with the teacher and other groups and included in the report.
5. Also include any efforts made by student groups to increase community awareness on the issue.
6. ach group can prepare posters, small skits, songs etc. in an effort to increase community awareness on the issue.

Project work (Chemistry in daily life)

Objective : Study saponification process during soap manufacture.

Necessary material and chemicals: sodium hydroxide, vegetable oil (for example 20 mL castor oil), 10 g common salt, distilled water, red and blue litmus papers, two 250 mL beakers, two test tubes, a glass rod, 50 mL measuring cylinder and a knife.

Theory : when an oil or fat is reacted with sodium hydroxide then a sodium salt of the acidic oil (soap) and glycerol are formed. This is known as saponification.

$$
\begin{array}{llllll}
CH_2OCOC_{17}H_{35} & & & & CH_2OH & \\
| & & & & | & \\
CHOCOC_{17}H_{35} & + & 3NaOH(aq) & \longrightarrow & CHOH & + \; 3C_{17}H_{35}COONa \\
| & & & & | & \\
CH_2OCOC_{17}H_{35} & & & & CH_2OH & \\
\textit{Triglyceride} & & \textit{sodium hydroxide} & & \textit{glycerol} & \textit{soap}
\end{array}
$$

This is an exothermic reaction which means that heat is released during formation of soap.

Procedure :

1. Take 20 mL castor oil in a 250 mL beaker.
2. In distilled water, prepare a 20 % solution of sodium hydroxide (10g NaOH in 40 g of water) and add 20 mL of this solution to the castor oil.
3. Dip red and blue litmus paper in the reaction mixture to test its nature. Did you notice any change in colour of any of the litmus papers. Note your observations.
4. Touch the external beaker wall - is it hot or cold?
5. Add 5 - 10 g common salt to the mixture and continuously stir the mixture with a glass rod till soap starts forming.

6. Leave the reaction mixture undisturbed for a day so that the soap solidifies and hardens.
7. Remove the soap cake and cut into desired shape and size.
8. If castor oil is not available, use any other vegetable oil.
9. Scent and colour can also be added to the soap.

Observations : 1. On dipping in the reaction mixture, the colour of red litmus paper is …….. and that of blue litmus paper is …………

2. The temperature of reaction mixture ……………(rises/ falls) on adding sodium hydroxide to the oil.

Conclusions : On the basis of your observations of litmus paper, decide whether soap is acidic or alkaline. Also tell whether saponification is exothermic or endothermic.

Glycerol is formed as a second product during saponification. Soap is salt of oil acid and is its precipitate.

Precautions : 1. Stir the reaction mixture carefully so that it does not spill out of the beaker.

Physics

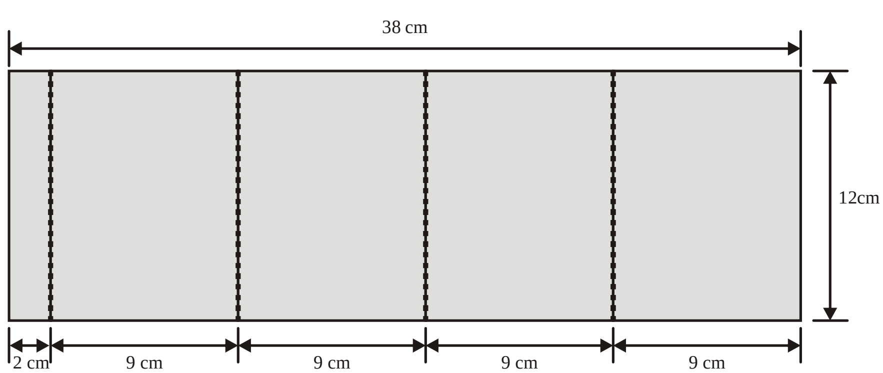
Project Work (Light: Reflection and refraction)

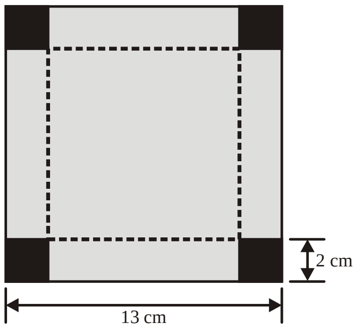
Objective : Making an optical instrument.

Theory : Pinhole camera, microscope and telescopes also are based on the principle that "light travels in straight line".

Procedure : You need stiff black paper to make two special types of boxes.

For the first box, cut a 38 cm long and 12 cm wide strip of black paper. As shown in the figure, fold the strip at four places at a distance of 9 cm from each other. You will be left with a 2cm wide strip at one end. Put glue on it and stick it to the opposite end. You now have a window box where both sides are open.

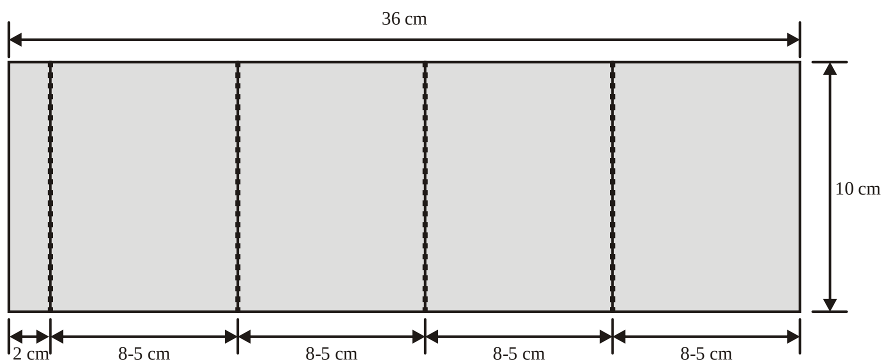




Now, cut a square of 13 cm side from the black paper. Cut a 2 cm square from each of its sides as shown in the figure. Fold along the dotted line and stick this to one end of the first box to form its base.

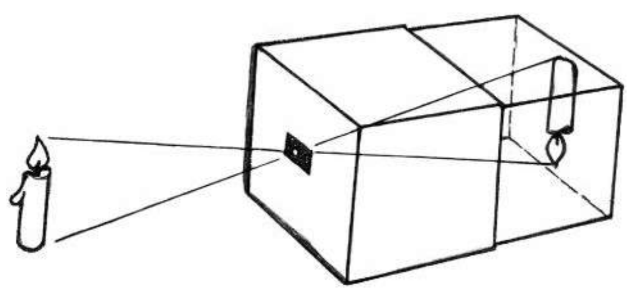
Your first box is ready. Make a small hole on its base using an awl-pin.

For the second box, cut a 36 cm long and 10 cm wide strip of black paper. As shown in the figure, fold the strip at four places at a distance of 8.5 cm from each other. Now glue it to the opposite end, as described for the first box. Stick white paper carefully on one end of this box. Put an oil-drop on the white paper to make it slightly semi-transparent. This is your screen box.



Make your own pinhole camera

Take the two boxes. Put the curtain box inside the window box - your pinhole camera is ready. Put a lighted candle in front of the hole of the camera and see from the other end.

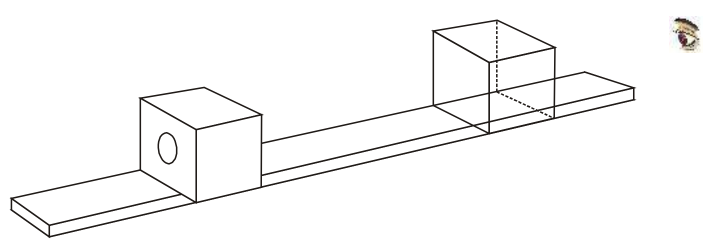


What do you see on the screen? Move the screen box forwards and backwards and note what happens to the candle image each time. Does shifting the screen cause any change in the image?

How do you think this image was formed? Look at the picture and think of the answer.

Through the camera, look at an object which has a lot of light falling on it, for example, a tree or a building. Now look at your camera screen. If light is falling on the camera, cover it with your hands.

Make your own binoculars



To make binoculars you'll need to fix a thick convex lens as well as a think convex lens to the box. To do this, cut a 3 cm circular hold in the screen and stick the thin lens to it. Keep the thick lens near your eye and the thin lens 40 cm away from it. Move the thin lens forwards and backwards. At one point, a far-off object will appear close. Look at far-off objects (houses, trees etc.) with your instrument; how do they appear?

Making a microscope

Take a fat lens in your hand and look at the letters in your textbook. First the letters appear very big but when you start to move the lens away they become smaller and then appear inverted.

Keeping the thick lens in the final position, place the thin lens in front of your eyes and look at the letters. You can lower the lenses to make the image clearer.

Do the letters look big?

How is the image, right side up or inverted?

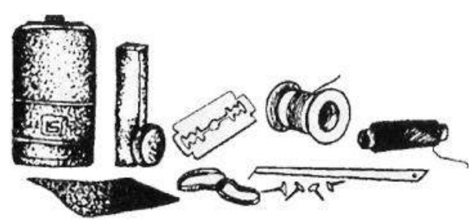
Project work (Magnetic effects of current)

Objective : Producing a magnetic field by opening/closing electric circuits rapidly and continuously. By varying the intensity of magnetic field rapidly electricity can be generated.

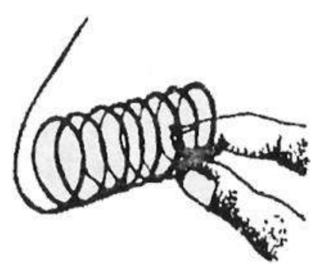
Theory : Different objects around us like fans, tape records, electric bells, etc. function when a magnetic field is produced in an electric field.

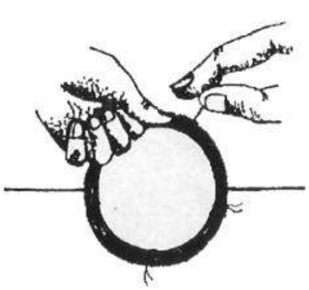
Necessary Apparatus:

1. 24 gauge copper wire used in motor rewinding, about 1 m long. This is usually available in electrical shops. This does not have plastic cover, only an enamel coating.
2. Torch cell
3. Circular magnet or bar magnet.
4. Blade or sand paper
5. Stove pin
6. Cycle tube cut into bands
7. Nail
8. String



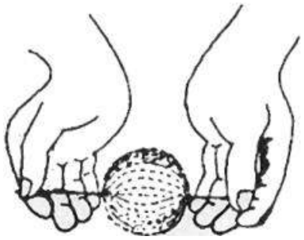
Procedure : First coil the wire tightly around the cell to form a coil.



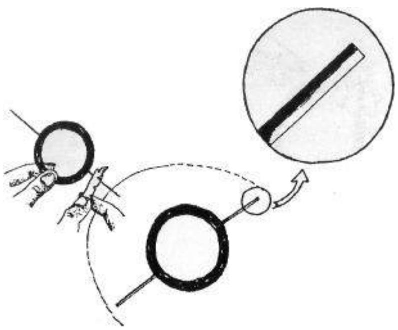


To ensure that the coil does not open when it removed from around the cell, tie it with string at a few places. Or you use tape or bend the open ends.

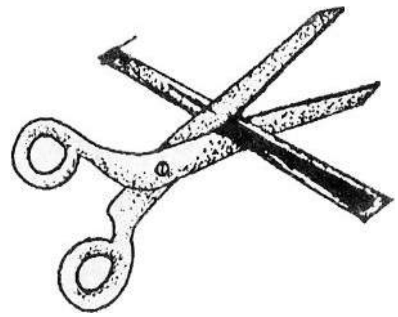
Since this coil is the most important aspect of the experiment, make it very carefully. Both ends of the coil should line on the lie passing through the center of the coil.



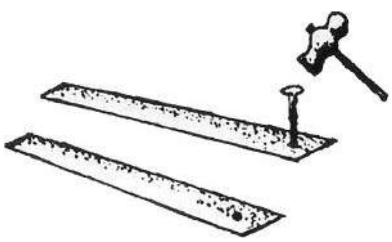
If the coil is properly aligned on this axis, it will move freely and smoothly. To test the balance, you can use your fingers and turn it as shown in the figure. If it moves easily and for a long time then it is ready. If for some reason, weight is more on one side you will immediately see that the coil is not spinning properly and jerks and stops.



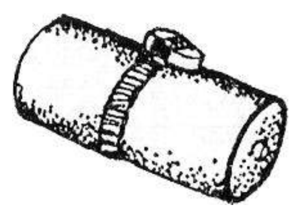
Now you will have to sand away the enamel from the upper half of each end of the coil. Do it carefully and do not remove the paint completely. Rub only from one side as shown in figure. If you remove the paint completely, the motor will not run. You should have copper on half of the wire and paint on other half.



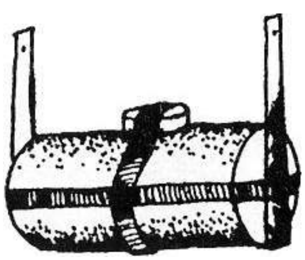
In this way, by keeping half of the part insulated and other conducting, we have prepared a method to close and open the circuit quickly, as was mentioned in the objective.



Once your coil is ready, cut the stove pin into two equal parts. Using a nail, make small holes on the ends of both the pieces.

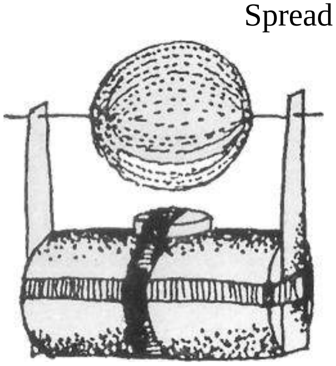


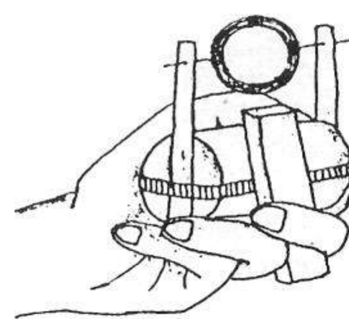
If you are able to find circular magnets, attach them to the cell with the cycle tube bands. Actually, using a bar magnet or circular magnet we have to ensure that only one pole is towards the coil.



Put another cycle tube band around the cell. Use this to fix the stove pins to the two ends of the cell, the positive end and the negative end. They should be touching because only them will the circuit be complete.

Spread the pins a little and fix the coil in the holes in them.





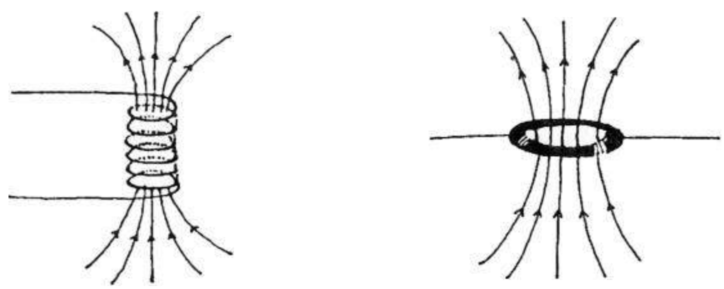
Check each part of the circuit carefully and gently push the coil. Did it start spinning?

If the coil stops spinning, push it in the other direction.

If the motor does not work even now, then you will have to recheck the following - balance of coil, have the ends been correctly sanded or has the enamel been completely removed, connections are correct, is there any rust, is the coil very far from the magnet etc. If the motor starts working properly we can do many activities with it.

- You can fix a picture to the coil to understand persistence of vision.
- You can see what happens if we change radius of coil, number of turns, shape of coil etc. How do they affect the rate of spinning and its direction?
- If you turn over the motor, you will observe something interesting.

Once the motor is made, let us try to understand why the coil spins and how the motor works.

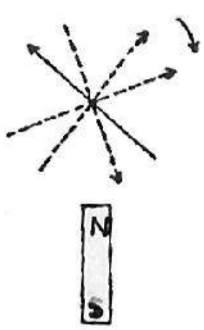


When current passes through any coil then it forms a magnetic field whose effect is similar to that of a bar magnet.

This means that whenever the clean part of the coil i.e. the conductor comes in contact with the stove pin then electric current passes through the coil and it starts behaving like a magnet.

This means that we have a still, flat magnet on the bottom and a freely moving bar magnet (in this case, the coil) over it which on spinning behave half the time like a magnet and like a rod the other half of the time.

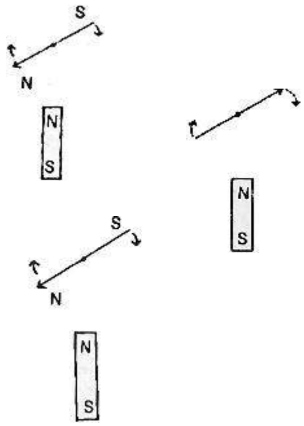
When the clean part of the coil comes in contact with the stove pin, then electric current flows and the coil behaves like a magnet. The other half of the time, when enamel part is in contact with the stove pins there is no flow of current and the coil is not a magnet.



What happens when we gently push the coil and set it in motion? Let us understand through some diagrams.

Suppose the clean part of the coil comes in contact with the stove pin, then electric current flows and the coil behaves like a magnet. Then the like pole of the magnet below the coil will be repelled and pushed and the opposite poles will be attracted towards each other and the coil will spin.

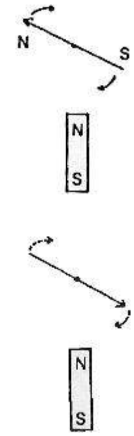
This is the same situation, N is repelled and S is attracted.



Once half-spin is complete, then enamel comes in contact with the stove pin and electric current stops flowing. But because of the earlier motion, the coil continues to spin.

Although the current is not flowing yet the soil is spinning due to inertia because of which the conducting portion again comes in contact with the stove pin, circuit closes and current flows again pushing the coil.

This process continues, the coil spins and this is our motor.



Project work (Energy: Sources and Forms)

Objective : Making a windmill model and demonstrating the use of wind energy in daily life.

Material : tin sheet, tin cutter, cycle spoke, stand, pump to remove kerosene oil, scale, protractor, water, container etc.

Principle : Flowing air is called wind. Due to kinetic energy, wind is capable to work. When wind comes in contact with windmill blades, a force is applied on them which causes the wheel to rotate. By using the constant motion of the rotating fans, wind energy can be produced.

Procedure :

1. Cut a big circle from the tin sheet using tin cutter.
2. Divide the perimeter into six equal parts $\left(\frac{360^\circ}{6} = 60^\circ\right)$ and cut each part a little way from the perimeter to the center (do not cut completely).
3. Bend and fold one side of each part as shown in the figure. This is the wheel of the windmill.

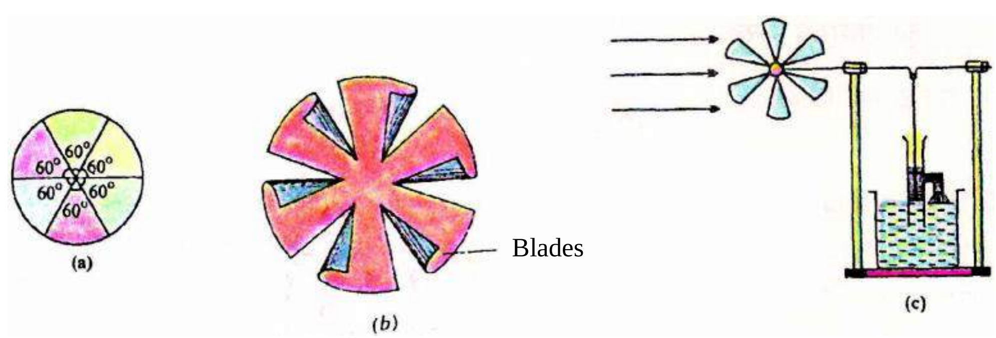
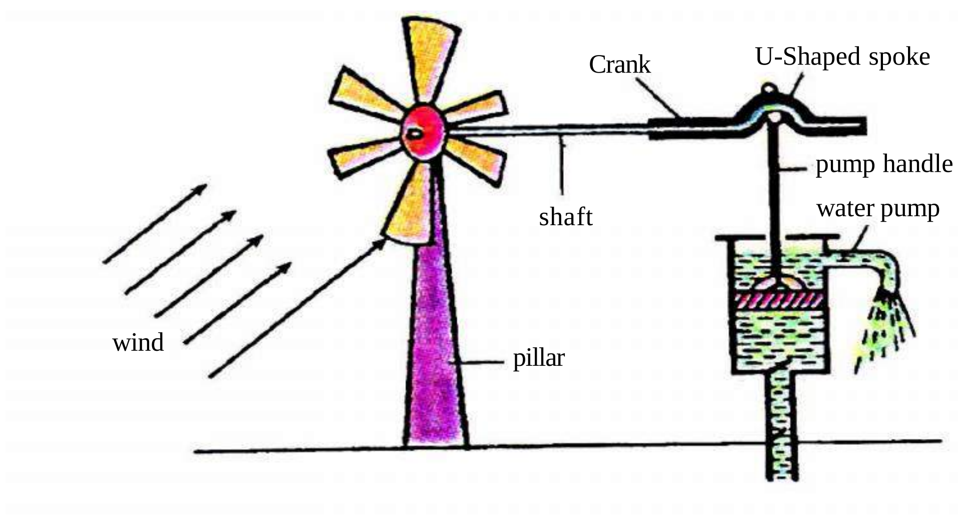


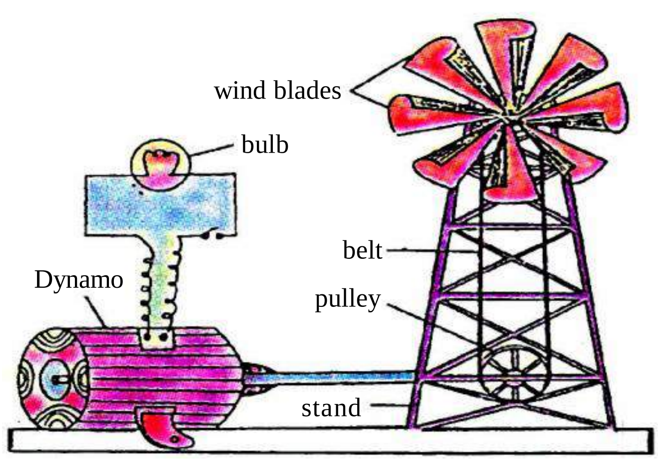
Figure - water pumped up be a windmill

4. Now bend the cycle spoke into U shape from the centre as shown in the figure.
5. Attach the pump handle to this U-shaped spoke.
6. Fix the cycle spoke into a stand as shown in the figure.
7. On one end of the spoke attach the windmill in such a manner that the spoke also moves along with the windmill.
8. Dip the pump into a water container containing water so that the water removal part is outside.
9. Now place the windmill in front of a wind source so that the wheel is in front of the source.

Observations : When the blades of the windmill rotate in the wind, the windmill spins moving the spoke as well as the pump handle with it. This pumps out water. This set-up is used to draw water from wells and also underground water (figure).



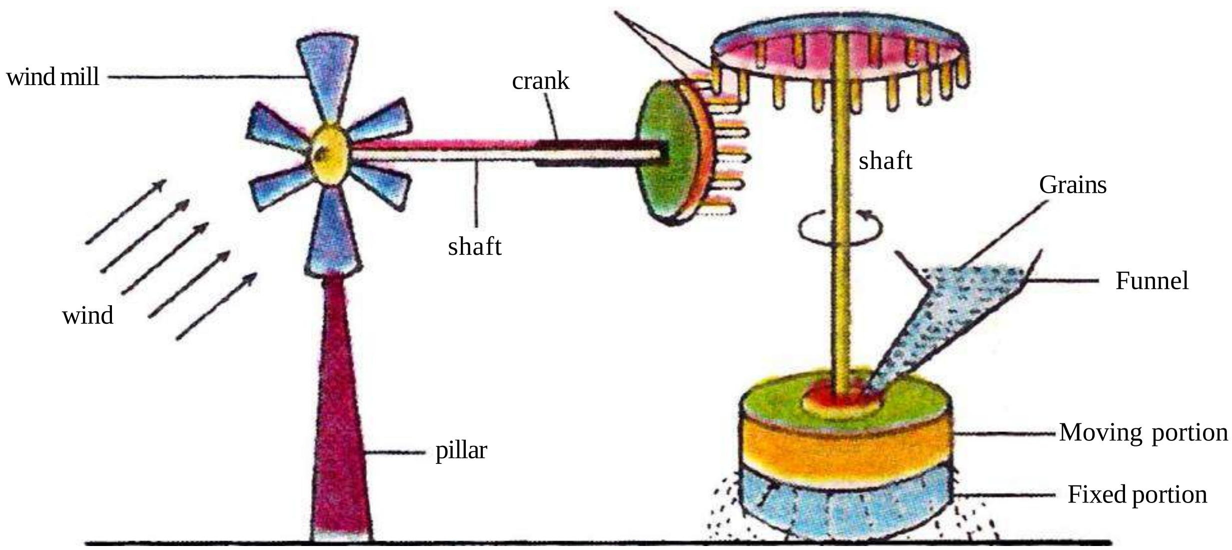
Tips : 1. If there is no wind, then use a table fan as wind source. Windmill does not work in low speed wind conditions.



2. If a dynamo is attached with the spoke using a belt (as per the figure) then even electricity can be produced.

Similarly, windmills are used for grinding wheat.

Results : This model of the windmill proves that the kinetic energy of wind can be converted into different other forms of energy and utilized in our daily life.



Precautions :
1. The blades of the windmill should be in the same direction as the direction of wind.
2. Pump should be light.
3. The fans of the windmills should be light and hollow.
4. Windmills should be placed in areas where there the wind flows at high speeds.

Benefits :
1. It conserves conventional energy sources like coal and oil.
2. It may help us overcome energy crisis in the future.
3. There is no environment pollution.
4. The energy obtained can be transformed into other forms.
5. On large scale, it can be used to produce electrical energy as has been done in Gujarat state.

Limitations :

1. We cannot use it continuously.
2. It is not effective in areas where the speed of wind is low.
3. It can convert 60-70 % of wind energy into work.
4. If winds are not available, it can't be used.
5. To set up windmills requires large areas.

Answer key

Chapter -1 Evolution

1. (i) (a) (ii) (b) (iii) (a) (iv) (a)

2. (i) Biological Species
(ii) Variation
(iii) Variation/specific character/Beneficial variation

Chapter -2 Acids, Bases and Salts

1. (i) (a) (ii) (b) (iii) (c) (iv) (d) (v) C
(vi) C (vii) C

Chapter - 3 Heat and Temperature

1. (i) (b) (ii) (a) (iii) (a) (iv) (d)

2. (i) Energy (ii) Temperature Difference (iii) Solid (iv) Medium (v) No

6. (i) –10°C (ii) 212 °F (iii) –261°C

Chapter - 4 Periodic Classification of Elements

1. (i) (d) (ii) (b) (iii) (b) (iv) (c) (v) (a)

Chapter -5 Our Environment: Energy Flow in the Ecosystem

1. (i) (a) (ii) (c) (iii) (b) (iv) (b) (v) (c)
(vi) (a) (vii) (b)

Chapter -6 Electric current and circuit

1. (i) (c) (ii) (b) (iii) (b) (iv) (d) (v) (b)

2. (i) Different (ii) Different (iii) Unit (iv) Tungsten
(v) Resistivity

Chapter -7 Life Processes : Nutrition, Transport, Respiration, Excretion

1. (i) (b) (ii) (b) (iii) (b) (iv) (a) (v) (b)

Cheapter -8 Life Processes : Control and Coordination

1. (i) (d) (ii) (d) (iii) (a) (iv) (b) (v) (b)

Chapter -9 Metals and Metallurgy

1. (i) (c) (ii) (b) (iii) (c) (iv) (c) (v) (b)

2. (i) Displacement (ii) Haematite (iii) Homogenous (iv) Calcination

Chapter -10	**Light: Reflection & Refraction From Plane Surfaces**											
1.	(i)	(c)	(ii)	(d)	(iii)	(c)	(iv)	(b)				
2.	(i)	Size of Body		(ii)	Snell's law		(iii)	Zero				
	(iv)	Total Internal Reflection										
Chapter -11	**Chemistry Of Non-Metals**											
1.	(i)	(b)	(ii)	(a)	(iii)	(d)	(iv)	(c)	(v)	(b)		
2.	(i)	Florine	(ii)	Less	(iii)	Right	(iv)	Hydrogen				
Chapter -12	**Magnetic Effects Of Electric Current**											
1.	(i)	(b)	(ii)	(c)	(iii)	(b)	(iv)	(d)	(v)	(a)		
2.	(i)	Generator		(ii)	Electric motor		(iii)	Induce current				
	(iv)	Moving Force										
Chapter -13	**Light: Reflection & Refraction From Spherical Surface**											
1.	(i)	(a)	(ii)	(a)	(iii)	(a)	(iv)	(a)	(v)	(a)	(vi)	(c)
2.	(i)	Small and Virtual			(ii)	Centre of curvature			(iii) 20 c.m.		(iv)	4D
Chapter -14	**Life Processes: Reproduction, Growth and Development**											
1.	(i)	(d)	(ii)	(c)	(iii)	(d)						
Chapter -15	**Heredity: From Parents to Offsprings**											
1.	(i)	(d)	(ii)	(c)	(iii)	(b)						
Chapter -16	**Derivatives of Hydrocarbons**											
1.	(i)	(a)	(ii)	(c)	(iii)	(b)	(iv)	(a)				
Chapter -17	**Chemistry in Daily Life**											
1.	(i)	(c)	(ii)	(b)	(iii)	(d)	(iv)	(c)				
2.	(i)	(d)	(ii)	(f)	(iii)	(e)	(iv)	(c)				
Chapter -18	**Energy: Forms and Sources**											
1.	(i)	(c)	(ii)	(d)	(iii)	(a)	(iv)	(a)	(v)	(c)		
2.	(i)	Rain	(ii)	Electric Energy								
	(iii)	1. Wave Energy,			2. Tidal Energy,			3. Ocean Thermal Energy,				
		4. Light Energy,			5. Heat Energy							