SCIENCE

(Theory & Practical)

Class-9

2019-20

State Council of Educational Research and Training, Chhattisgarh, Raipur

For Free Distribution

Publishing year	:	**2019**
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Preface

According to National Curriculum Framework 2005, good science education is one which is honest towards the student, towards life and towards science. This perspective acted as the guiding principle in the construction of class 9 science syllabus and development of the textbooks.

We tried to keep in mind not just the content but also the different ways of teaching-learning science. Teaching of science, to a large extent, depends on whether we are able to link the different topics to the experiences and context of the child so that long-term learning takes place. But this does not mean that topics and content development has been neglected. Various facts, principles, theories and phenomenonhave been used to understand concepts and this, in fact, is the foundation of science. The different validities (cognitive, content, process, historical, environmental and ethical) described in the position paper on science teaching (NCERT) have been kept in mind in the textbook.

During the writing process, our writers struggled with theories and concepts that are not directly related to the context of the child. Therefore, opportunities for the students to estimate, try them out, reach conclusions were constructed through activities and projects. We request our teachers to not only actively participate in these activities but also devise more such moments so that this textbook proves more useful for the students, teachers and the community.

During the entire process, we have especially focused on giving the students' time to experiment, discuss and explore, and have tried to ensure that they do not feel mentally burdened.

The textbook has been written by teachers, teacher educators and members of associated organizations.

The Council wishes to acknowledge all those who were directly or indirectly involved in the textbook development process. Vidya Bhawan Society (Udaipur), Eklavya (Bhopal) and Azim Premji foundation made significant contributions to the textbook and we are grateful to them. Your suggestions will help us improve this book and they are always welcome.

Director

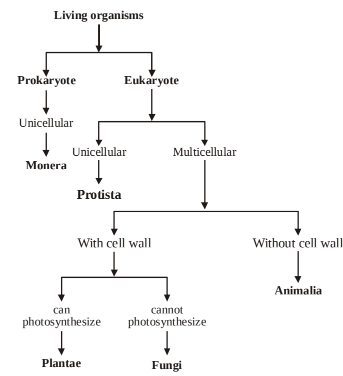
State Council of Educational Research and Training

Raipur, Chhattisgarh

Content

Chapter 1

Biodiversity and Classification



1.1 Biodiversity

We see different groups of organisms all around us sharing similarities and differences. For example, groups of animals include those like horses, dogs, cats etc. while plants would include neem, banyan, jamun, pomegranate, etc. If we compare the properties of each group, we would find that members of a group share more similarities amongst themselves than with members of other groups.

The members of these groups may be further grouped under even smaller groups such as groups of horses or dogs or cats or neem tree, dhatura, etc. If we compare the characters of each of these smaller groups, we would find that, the members share several similar properties which clearly separate them from the other smaller groups. These properties are found in the members of the group independent of the habitats around the world they might be living in. All the properties are specific to a group and the group that shares maximum similarities is usually called "species". Let us take the example of man: human species consists of groups that are present all over the world and have same characters like well-developed brain, sparsely distributed body hair, etc. We may say that these properties are specific to humans and separates them from members of other groups.

- Discuss with your friends whether members of same species always share the same properties?

So far, we have discussed the similarities of members of the same species. Let us now study them and see whether we may also find some differences.

Activity-1

Observing neem plants

Collect two nearly similar neem plants from your surroundings. Observe them carefully and fill the following table-

Table 1

S.No.	Name of Plant	Length of Stem	Number of of Leaves	Shape and Size of Leaves	Colour of Leaves	Edge of Leaves	Venation
1	Neem plant -1						
2	Neem plant- 2						

- What differences did you observe in the similar looking neem plants?

Activity - 2

Observing Humans

This activity may be done in a group of at least 10 children. All information as in the table should be collected and noted.

Table 2

S.No.	Name of Student	Height	Weight	Length of Pointer Finger	Thumb Print	Palm	
						Length	Breadth

- Which of these properties were similar (at least in some individuals)?
- Which of these were different in all individuals?
- Could you find any two individuals of your class whose properties were exactly the same?

You will find that the thumb imprints of all your classmates differ. Thus, we may say that the thumb imprint is a specific character of an individual.

We can say on the basis of the above activities that species have similar as well as different characters. These differences are called "variations".Variations help us to identify individuals of a species. Due to these variations, we find different varieties of organisms in a particular area.The variety of organisms present in a particular area comprises the biodiversity of that area.

We shall need a schema of study, if we start by taking diversity as a basis to make a systematic and detailed study of all substances and organisms on earth (See page 281).

Let us try to understand this schema with the help of some examples.

1.2 Grouping and Classification

Activity- 3

We observe several types of things around us daily and categorize them differently to use them in different ways. For example, things used in the kitchen, things used for play, etc. You have been given a list of different things. Categorize them on the basis of their properties.

Plastic scale, book, pen, test-tube, wooden block, lens, plane mirror, piece of glass, piece of plastic, rubber ball, cricket bat, rope, needle, wooden scale, pencil.

Table 3

S.No.	Name of Group	Things that fall under the group
1.	Wooden things	
2.	Cuboidal things	
3.		
4.		
5.		

- What are the different properties that you kept in your mind to form groups?
- In which group could you keep maximum objects together?
- On the basis of which specific property could you form a group with minimum of the given things?

You may have observed that certain properties are similar within a group. This property is considered as the character of the group. We could use a rubber ball, a cricket bat, a rope and a plane mirror to play. So, 'things used for play' could be a character of the group according to which they could be kept under the same group.

We choose several bases to identify the characteristic features of the things mentioned in the previous section. These could be shape of the thing, material of which the thing is made, its use, etc. In a similar manner, we can identify other bases using some other properties. Thus, the process of categorizing on the basis of a characteristic feature shared similarly by the members of a group is called as "grouping". In the process of grouping, an object can be present in two or more groups as it could have characteristic features related to two or more groups.

Another process of grouping of the things of the same list has been given here.

Plastic scale, book, pen, test-tube, wooden block, lens, plane mirror, piece of glass, piece of plastic, rubber ball, cricket bat, rope, needle, wooden scale, pencil

Things made of wood
Wooden block, wooden scale, cricket bat, pencil, book

Things not made of wood
Plastic scale, pen, test-tube, lens, plane mirror, piece of glass, piece of plastic, rubber ball, rope, needle,

Things made of glass
Test-tube, lens, plane mirror, piece of glass

Things not made of glass
Plastic scale, pen, piece of plastic, rubber ball, rope, needle,

Fig. 1: Classification of things

A special way of grouping has been followed here. At each level, grouping has been done on the basis of presence or absence of a character in such a way that members of one group do not belong to the other.Things are grouped into separate classes that are discrete while members of the same class share similar characteristic features. This form of grouping is called "classification".

Grouping and classification are used in all areas, whether they are the grouping or classification of elements, solutions, forces or living organisms. In this chapter, we shall study about grouping and classification by taking living organisms as examples. We shall come across other examples in the following chapters.

Now, let us try to see how different efforts towards grouping or classification had been carried out over time by observing the similarities and differences of living organisms.

1.3 Former attempts of grouping and classification

According to historical accounts we find that over a thousand years ago, Aristotle had made attempts towards grouping organisms on the basis of their habitat. Thus, he grouped organisms as those of land or water. Perhaps, other attempts had also been made towards grouping or classification; but, we have only a few records available regarding the same. We find that around the year 1686, John Ray, an English naturalist tried to classify plants on the basis of their external structures. After John Ray, it was Linnaeus who tried to classify all plants on earth. His most important contribution is: the use of some specific observable characters like the presence of male and female parts and their number to prepare a simple schema of classification. It is called as sexual system of classification. The description of this system is given in his book 'Systemae Naturae' published in the year 1735.

Linnaeus made comparative study of several specimens of plants and animals that he collected. He developed such a schema of classification where species of plants and animals could be classified separately. The knowledge that Linnaeus acquired about the structures of animals and plants had a great impact on life sciences. According to his schema, the whole living world could be divided into two categories -Plant kingdom and Animal kingdom. Linnaeus first introduced hierarchy in his system. Organisms were arranged on the basis of their characters and developmental history in a definite sequence of groups. Like -

The Linnaean hierarchy for man is

Kingdom - Animalia (Multicellular, eukaryote, nutrition starts with ingestion of food)

Phylum - Chordata (vertebral column, paired appendages)

Class - Mammalia (hair on body, external ear)

Order - Primate (opposable thumb, 5 fingers each in fore and hind palm)

Family - Hominidae (Bipedal movement)

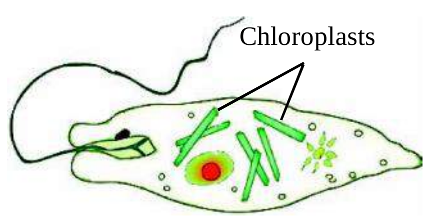
Genus - *Homo* (Well developed brain)

Species - *sapiens*

There were some limitations in the two kingdom classification system. Linnaeus classified organisms as either plants or animals, but several organisms were eventually found to express both animal and plant characters.

Do you know?

Euglena is such an organism that shows both animal and plant characters. It has chloroplasts, does not have a cell wall and acquires food both autotrophically and heterotrophically.



Euglena

Linnaeus did not have the scope to study the internal structure of cells during his time.Thus, internal cellular structures did not find any place in his classification schema. It was much later when microscopes with higher magnification power were invented that variations in internal cellular structure also formed a basis of classification.

As the knowledge of internal structures of cells increased and new organisms discovered, the basis of classification was also modified. Different ways of classification started finding way. One such schema was suggested by R.H. Whittaker in the year 1969.

Whittaker classified the whole living world into 5 kingdoms. His classification was based on the following characters -

1. The absence or presence of nuclear membrane (prokaryotic or eukaryotic)
2. Level of organization (unicellular or multicellular)
3. Process of acquiring nutrition (autotrophic or heterotrophic)

1.4 Whittaker's Classification

As compared to other former systems of classification, Whittaker's appears to be more developed. There is a better insight regarding biodiversity in this system. The entire living world has been divided into the following kingdoms:

1. Kingdom Monera
2. Kingdom Protista
3. Kingdom Fungi
4. Kingdom Animalia
5. Kingdom Plantae

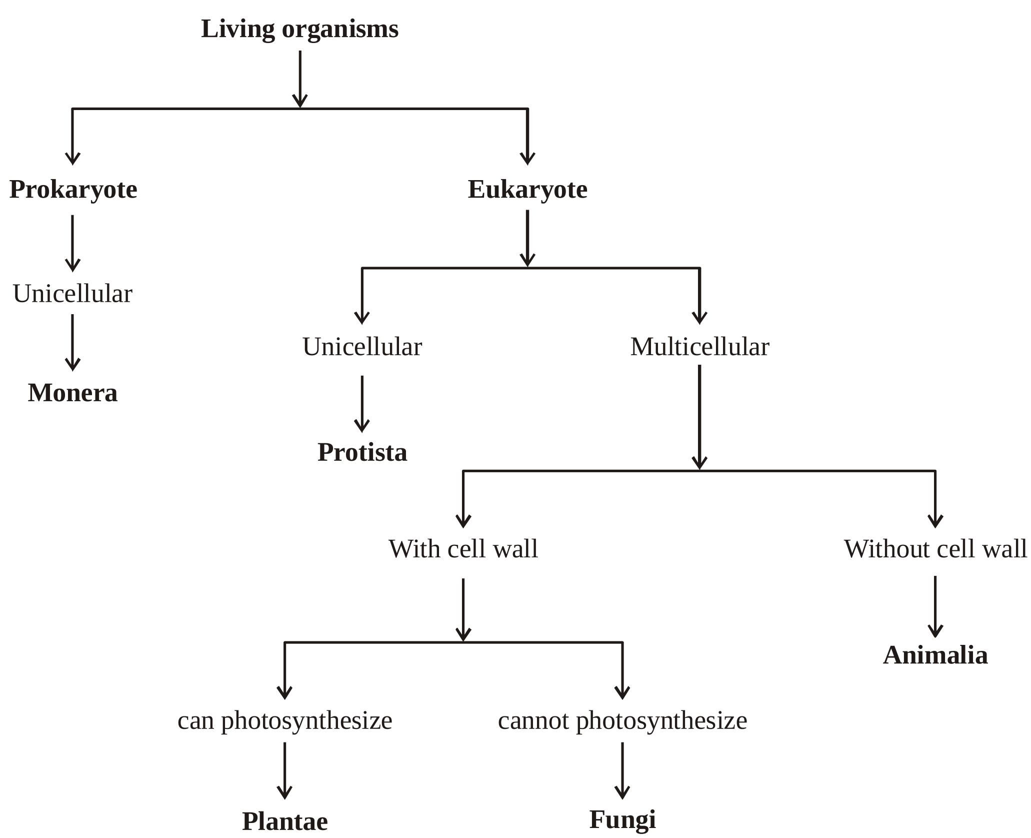


Fig. 2 : Five Kingdom Classification

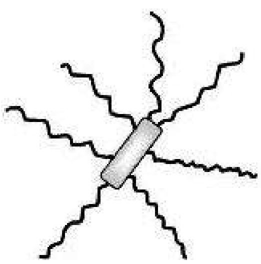
1.4.1 Kingdom Monera

1. Unicellular organisms that lack a nuclear membrane or are prokaryotes are classified under this kingdom.
2. Organisms may be autotrophic or heterotrophic.
3. Cell wall is present around the cell membrane.
4. Their cell wall is different from that of plants and is mainly made of peptidoglycan (a compound formed of protein and carbohydrate).

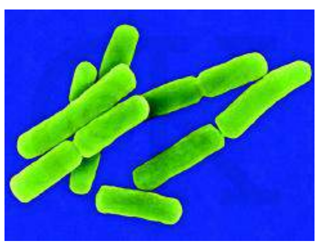
   Example: Bacteria, Cyanobacteria.

Do you know?

In a gram of fertile soil, we have around 100 crore and in a milliliter of milk we have 3000 crore of these organisms.

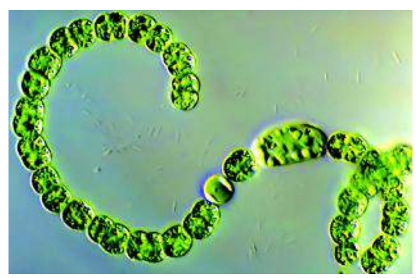


E. coli



Bacillus anthracis

(A) Bacteria



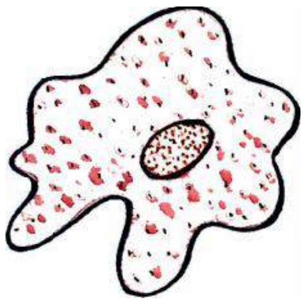
(B) Cyanobacteria (Anabaena)

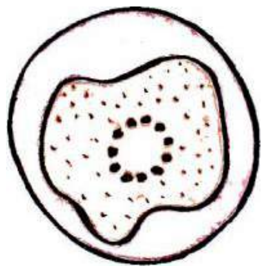
Fig. 3

1.4.2 Kingdom Protista

1. All organisms of this kingdom are unicellular with nuclear membrane around the nucleus or eukaryotic cells.
2. Organisms can be both autotrophic or heterotrophic.
3. All the life processes are carried out within the cell.

   Example: Amoeba, Paramecium, Entamoeba, Euglena.


Amoeba


Entamoeba

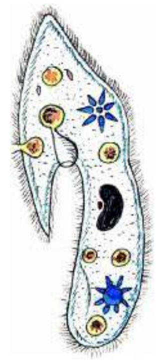

Paramecium

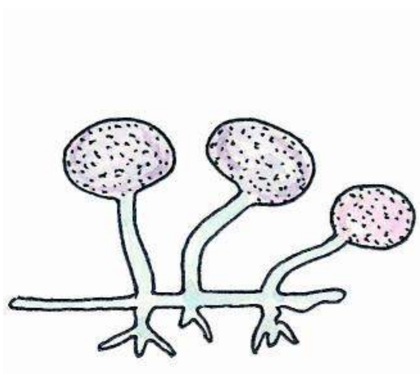
Fig. 4

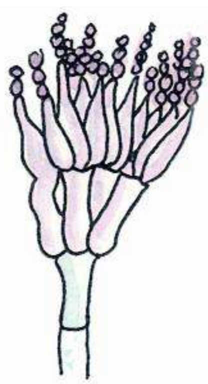
- Suggest a character on the basis of which Monerans can be distinguished from Protistants

1.4.3 Kingdom Fungi

1. Most fungi are filamentous. They form networks of filaments that are called mycelium.
2. Organisms of this kingdom are heterotrophic, unicellular or multicellular eukaryotic forms.
3. Chloroplasts are absent in their cells.

   Example: Mucor, Yeast, Agaricus (Mushroom), Rhizopus(bread mould), Aspergillus, Pennicilium


Rhizopus


Pennicilium

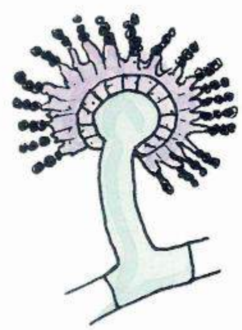

Aspergillus

Fig. 5

You may have observed some filamentous hair like structures on rotting bread, in shoes during rainy season or sometimes over pickles (that was not preserved well). These structures are fungi. Mushrooms are a kind of fungi too. Fungi may be symbiotic, parasitic or saprophytic in mode of acquiring their nutrition.

Some fungi are harmful while some are useful. Some cause diseases while some are used in the production of certain food materials like the yeast, which is used in preparing bread and beer. Some fungi are also used to produce antibiotics.

- The growth of which organisms is arrested by keeping food in the refrigerator?

Do you know?

Lichens are formed of symbiotic associations of algae and fungi. They remain so closely associated that they appear as single organisms. Fungi use the food produced by algae through photosynthesis, while algae use the moisture and minerals absorbed by the fungi. Litmus is produced from a type of lichen.

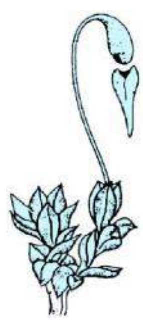
Lichen

1.4.4 Plant Kingdom

1. All organisms of plant kingdom are multicellular, eukaryotic forms.
2. Most plants have chloroplasts in their cells, that help them to photosynthesize thus they are autotrophic.
3. These have a cellulosic cell wall.

   Example: Spirogyra(Algae)*, Funaria(Moss)**, Fern***, Cycas, Date palm, Neem, Wheat

Spirogyra



Funaria

Marchantia

Fern

Cycas

Neem

Coconut palm

Cactus

Fig. 6

*Whittaker included multicellular algae in plant Kingdom. The body of algae cannot be differentiated into root, stem and leaves. During rainy seasons, we often find a shiny layer of scum along the sides of ponds and rivers and sometimes on wet floors. This layer is mainly algae. In local language this is called 'kai'.

**The body of moss can be differentiated into leafy structures and root like structures called as 'rhizoids'. Rhizoids help in drawing in water and minerals. These have been included under a group called Bryophyta. Other examples of this group are Riccia, Marchantia.

*** Try to find out ferns in your area. This belongs to the group Pteridophyta. The body of most plants of this group is like those of flowering plants; thus, their body can be differentiated into root, stem and leaves and they also have vascular tissue. These are usually non flowering plants and thus do not produce seeds. Marcellia is another example of this group.

Do you know?

Amarbel or Dodder is a member of the plant kingdom. This is a parasitic climber that wounds round a host plant. It does not contain chlorophyll. It acquires its food from the host plant. Dodder has a special type of root that helps to absorb food materials from the host plant.

Classification of flowering plants (example of the Plant Kingdom.)

Flowering Plants

- **Seeds without cover**
  - **Gymnosperm** (Cycas)
- **Seeds with a cover**
  - **Angiosperm**
    - More than one cotyledon — **Dicotyledon** (gram, pea, lentil). These have tap roots and reticulate venation in leaves
    - One cotyledon(seed leaf) — **Monocotyledon** (wheat, maize). These have adventitious roots and parallel venation in leaves

Fig. 7 : Classification of flowering plants

- Observe the leaves of some plants like mango, rice, mahua, grass, maize. What is the relation that you find in the type of root and venation of leaves?

1.4.5 Animal Kingdom

- Organisms of this kingdom are multicellular, eukaryotic, heterotrophic forms.
- These do not have a cell wall.
- These do not have chloroplasts.
- Mode of nutrition is mainly by ingestion. They have a specialized organ for intake of food. As for example butterflies have juice sucking tubes, humans have mouth, birds have beaks, etc.
- Most of the animals have specialized organs for movement (locomotion: movement in such a way that location changes).

  Example: Lion, mynah, fish, man, hydra, tapeworm, earthworm, mussel, scorpion, star-fish, etc.

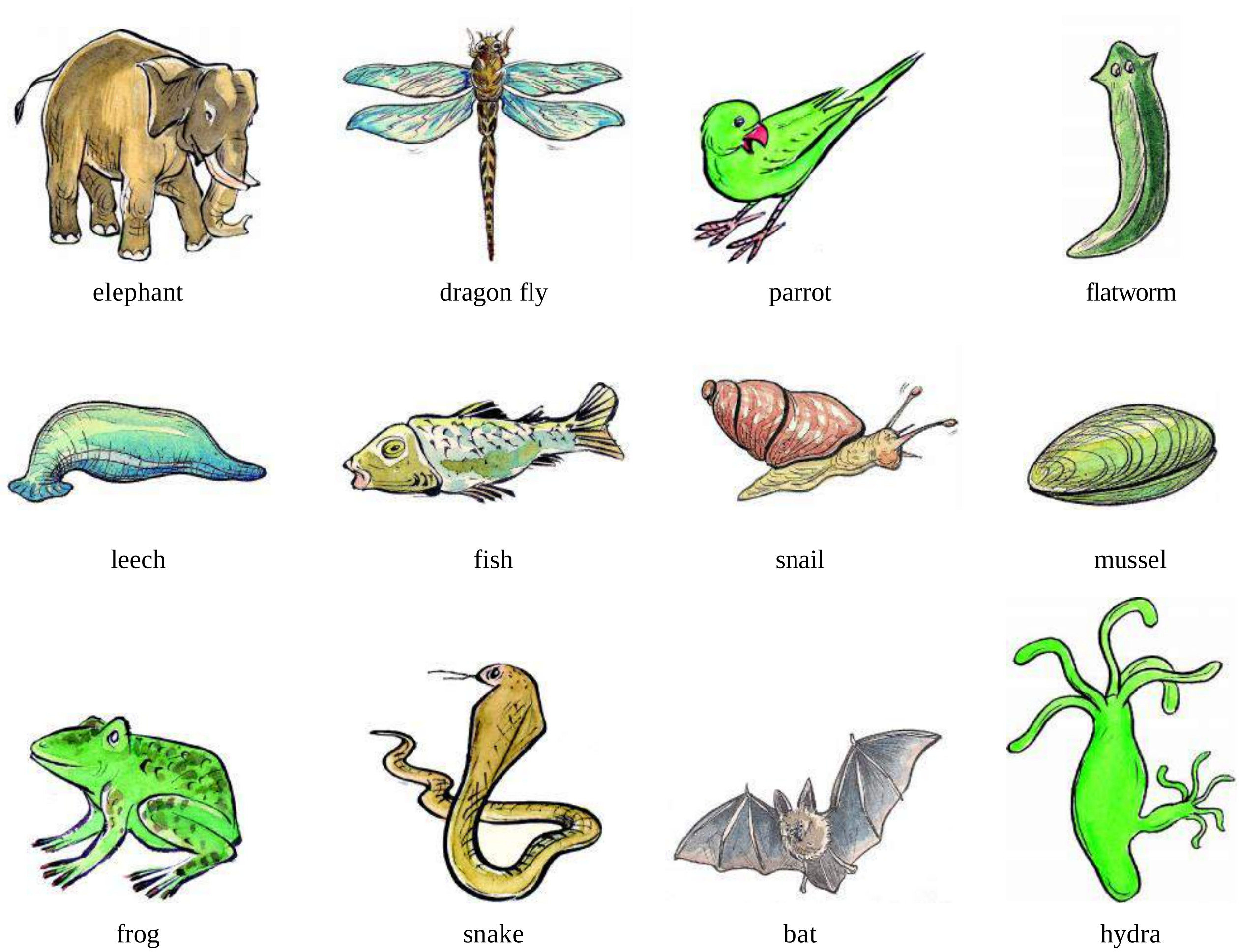


Fig. 8

Following is an example of classification of animal kingdom considering only the vertebrates

Fig. 9 : Classification of Animal kingdom

- Write a major difference between fishes and mammals.

1.5 Need and process of naming organisms

Naming is a process of assigning a proper place to an organism in the schema of classification.Thus an organism is assigned a specific name.

An object or a living organism is called by different names in different places due to the diversity in language. Like 'potato' is called as 'urullaikilanku' in Tamil, 'batata' in Marathi and aaloo in Hindi. Various names of the same object poses difficulty in identifying an object. Addressing this difficulty,Linnaeus suggested a system of naming living organisms that could be universally followed. This was a system of scientific naming according to him. According to this system, each organism would have a name comprising two words. This is the system of binomial nomenclature. In this system-

1. The first word of the name would represent the genus while the second would represent the species.
2. The first alphabet in the name of genus would be in capital letters while the rest would be in small letters. The name of species would be in small letters.
3. Both the words in of the name are either underlined or written in italics.

The scientific name of some organisms is as follows-

Organism	**-**	**Scientific name**
Frog	-	*Rana tigrina*
Lion	-	*Panthera leo*
Sparrow	-	*Passer domesticus*
Man	-	*Homo sapiens*

Certain species are wiped out from earth while certain new ones appear. This process goes on continuously in nature. Thus, no schema of classification would be successful enough in including all species of organisms at a time. Even after Whittaker, there have been several other systems suggested for classification of living organisms. Thus, it is apparent that even the five kingdom classification cannot completely include the known forms of diverse organisms present on earth now. As more and more organisms would be discovered, the scope of biodiversity would expand and the basis of classification would change along with its system.

Keywords

Variations, biodiversity, grouping, classification, characters, species, genus, nomenclature

What we have learnt

- Different types of organisms and substances are present on earth.
- Categorizing things on the basis of their similar characters is called grouping.
- Scientists have classified organisms on the basis of their similarities and differences.
- Classification helps us to distinguish between different organisms.
- Classification is essential for the study of different organisms easily, clearly and systematically.
- Linnaeus divided the whole living world into two kingdoms (Plant and Animal).
- Whittaker classified living organisms into 5 kingdoms on the basis of the following characters-
    1. Absence or presence of nuclear membrane - prokaryotic and eukaryotic.
    2. Organization of body of living organisms - unicellular or multicellular.
    3. Mechanism of nutrition - Autotrophic or heterotrophic.
- On the basis of the above characters the 5 kingdoms into which organisms are categorized are - 1.Monera 2. Protista 3. Fungi 4. Animalia 5. Plantae
- On the basis of increasing complexity of organization of the body of organisms, they have been further categorized into different classes.
- The hierarchy of organizing the classes depends upon the different characteristic features of living organisms.
- Carolus Linnaeus proposed the system of binomial nomenclature in which the first word represents genus and the next the species.
- The basis of classification and its system is bound to change due to the continuous extinction of species as well as their evolution into new forms.

Exercise

1. Choose the correct option.

    (i) In classification -

    (a) Identifying characters is not essential

    (b) Members of a class share maximum similarities

    (c) Members of a class do not have similarities

    (d) There is no basis

(ii) A dicotyledonous plant is-

(a) Onion (b) Grass

(c) Banana (d) Mustard

(iii) A character not similar to birds and fishes is-

(a) Presence of body compartments (b) Egg laying

(c) Presence of vertebrae (d) Presence of wings

2. Fill in the blanks-

(i) It is important to select a basis for grouping and ....

(ii) Prokaryotic organisms are included in .... kingdom.

(iii) .... gave the 5 kingdom classification.

3. Write two characteristic features of Kingdom Fungi that distinguish it from other kingdoms.

4. Write two differences between amphibians and reptiles.

5. Cell wall is found in organisms of kingdom fungi yet they are not included under plant kingdom. Why is it so?

6. What is the basis of keeping snake and tortoise in the same group?

7. Why do we need classification?

8. What do you understand by binomial nomenclature? How do we write the names of organisms in this system? Give at least two examples.

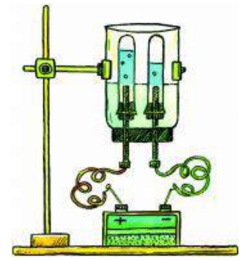
9. What are the similar characters of bats and rats?

10. What is the basis of five kingdom classification? What are the kingdoms? Write in detail about them.

11. "If the basis changes, the system of classification will also change." Justify this statement.

Chapter 2

Matter : Nature and Behaviour



Are there any similarities between light, an iron nail, the sound of a *dholak*, chairs and tables, smiles, steam, etc.? What are the similarities between them and what are the differences? Let us do an activity to try and understand this.

Activity-1

- Take a trough or bucket and fill it 3/4th with water.
- Now take a glass or glass beaker. Turn it upside-down and place it in the water as shown in Fig.1.
- Does the entire beaker get filled with water?
- Is the beaker empty?
- Now shine light on the beaker using a laser torch. (Note:*laser torch beams can harm your eyes so use it only under your teacher's guidance*).
- Are the light beams able to enter (go inside) the beaker?

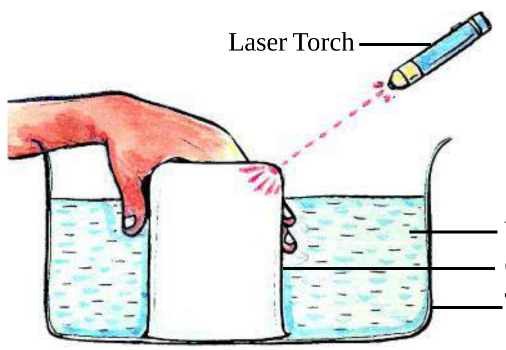


Fig. 1 : Matter occupies space

Let us try and understand why light was able to enter the beaker but water could not. What is there inside the beaker that stops water from getting inside? We know that air, water, chairs-tables, etc. occupy space. Water could not enter the beaker because air is already present in it. Air occupies space inside the beaker.

You must have noticed that a bottle filled with water is heavier than an empty bottle. The weight of an object is due to its mass. The objects described above such as iron nails, chairs & tables, steam occupy space and have mass. Whereas light, the sound of a *dholak*, smile etc. neither have mass nor occupy space. Since light does not need space it is able to enter the beaker. Anything that occupies space and has mass is called matter. Since light, the sound of a *dholak,* smile do not have this property therefore they are not matter.

Now, can you tell : Among air, water and light which can be called matter?

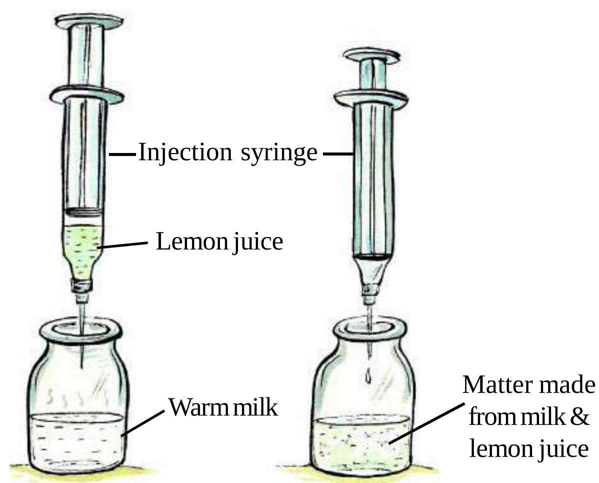
2.1 Conservation of matter

If we look at matter around us, we see that it undergo some changes. We can identify these by looking for changes in colour or in smell/odour or in state.

Let us try to understand this through an example. When we light a candle, it burns down completely after some time. Think: What has happened to the components (wax and wick) of the candle? For a long time it was believed that they get used up or destroyed in the burning process. Later, attempts were made to understand the burning of a candle and we realized that it is a chemical process where oxygen is also involved along with wax. During the process, carbon dioxide and water vapour are obtained as products but this was not known till we learnt to identify the gases being used or produced in a reaction. When the sum of the masses of all the reactants was determined it was found to be equal to the sum of the masses of all the products. This was the first time it became clear that the reactants taking part in a chemical reaction are converted into products and not destroyed.

Try this too

- Put 10 mL hot milk in a clean, injection bottle and put the cap back on the bottle.
- Take 2 mL lemon juice in an injection syringe.
- Insert the syringe in the cap of the injection bottle as shown in Fig-A. Weigh the arrangement. Make sure that there is no contact between the milk and lemon juice.
- Now press the injection piston slowly so that the lemon juice falls drop by drop into the milk.
- Observe the changes in the milk in the bottle.
- Do you think a chemical reaction has taken place here?
- Now, again weigh the entire arrangement and note the weight (Fig-B).



(A) Before reaction **(B) After reaction**
Matter cannot be destroyed

- Were there any changes in the masses of the apparatus before and after the experiment?

Note: Correct conclusions can be drawn from the experiment only if the weighing instrument is accurate and measures correctly.

In the study of many other chemical reactions, it was again found that the sum of the masses of all reactants is always equal to the sum of the masses of all the products.

This understanding was stated in the form of a law: Mass can neither be created nor destroyed during a chemical reaction. This is known as the law of conservation of matter or the law of conservation of mass. The law was formulated by Lavoisier.

Lavoisier's contribution

Attempts to understand the nature of matter had been going on for centuries. But in the absence of modern instruments, several misconceptions remained. At one time it was thought that one substance could be transformed into another. For example, when water was distilled in a glass container for a long time then fine, sand like particles were found in the container. Therefore, people thought that when water is heated for a long time it gets transformed into earth.

Antoine Laurent Lavoisier (1743-94), a French chemist, repeated the same experiment. He carefully weighed the entire glass apparatus before the experiment and also after distillation. He noticed that the mass of the apparatus was decreasing. This change was equal to the mass of the sand-like particles. He realized that the type of glass being used was slightly soluble in water. The glass would dissolve a little in water and after evaporation, its particles would remain behind. He concluded that water was not being transformed into earth. It was only after this that we could start building our modern understanding of chemical reactions.

Questions

1. Identify matter from among the following –
   water, air, chair, stone, scent of a flower, iron, thoughts.
2. 20g 'A' and 40g 'B' give 25g 'C', 15g 'D' and 20g 'E' in a reaction. Use these observations to explain the law of conservation of mass.

2.2 Matter around us

Have you ever run a magnet through sand? When we put a magnet in sand and turn it around, iron filings separate out and stick to the magnet. Similarly, when tap water kept in a container evaporates it leaves behind some white residue. Therefore, we can say that most of the matter around us exists as mixtures of two or more constituents (substances) which can be separated.

Sea-water is a mixture of different salts dissolved in water. One of the salts (sodium chloride) found in sea-water can be separated by evaporating the water. Similarly, cold-drinks are a mixture of sugar, salt and carbon dioxide in water. The components of a mixture can be separated by using physical techniques. Therefore, we can say that a mixture has more than one substance which can be separated from each-other using simple physical techniques. When we try to learn more about mixtures we find that they are of many different types.

2.3 Types of mixtures

Different types of mixtures are formed based on the nature of their components and how the components interact with each other. Let us understand this through some activities:

Activity-2

- Form your students into four groups 'A', 'B', 'C', 'D'.
- Ask group 'A' to take 100 mL of water in a beaker and add one spoonful salt to it.
- Ask group 'B' to take 100 mL of water in a beaker and add one spoonful sugar to it.
- Ask group 'C' to take 100 mL of water in a beaker and add one spoonful chalk powder to it.
- Ask group 'D' to take 100 mL of water in a beaker and add one spoonful cooking oil in it.
- Each group should stir their mixtures using a glass rod. Now leave the beakers undisturbed for some time.
- Observe all the beakers and try and answer the following questions:
    - In which of the beakers are the components mixed completely and appear uniform?
    - In which of the beakers can the constituents still be seen separately?

We see that groups 'A' and 'B' get mixtures whose components seem uniformly distributed. Such mixtures are called homogeneous mixtures.

In the mixtures obtained by groups 'C' and 'D', the constituent substances can be seen separately. Such mixtures where the constituent substances are not uniformly distributed and can be seen separately are called heterogeneous mixtures.

Let us do an activity to try and understand the properties of homogeneous and heterogeneous mixtures :

Activity-3

- Ask your students to form three groups 'A', 'B' and 'C'.
- Ask group 'A' to take 100 mL of water in a beaker and add one spoonful salt to it.
- Ask group 'B' to take 100 mL of water in a beaker and add one or two drops of either milk or ink to it.
- Ask group 'C' to take 100 mL of water in a beaker and add one spoonful chalk powder to it.
- Each group should stir their mixture well using a glass rod. In which beaker are the particles visible separately in the water?

- Using a laser torch direct a beam of light through each beaker from the side. Observe the beaker from above, that is, perpendicular to the direction of the laser beam. In which beaker(s) is the path of light visible (Fig. 2)?

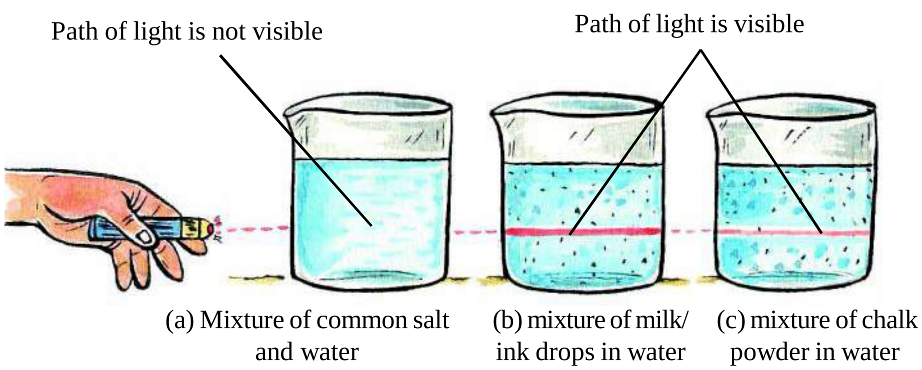


Fig. 2

- Now leave the three beakers undisturbed for 15 minutes. Then observe in which beakers the mixture is stable and in which the particles have started to settle down after some time?
- Each group should filter their mixture separately using filter paper (Fig.3). Which group has some residue left behind on their filter paper?

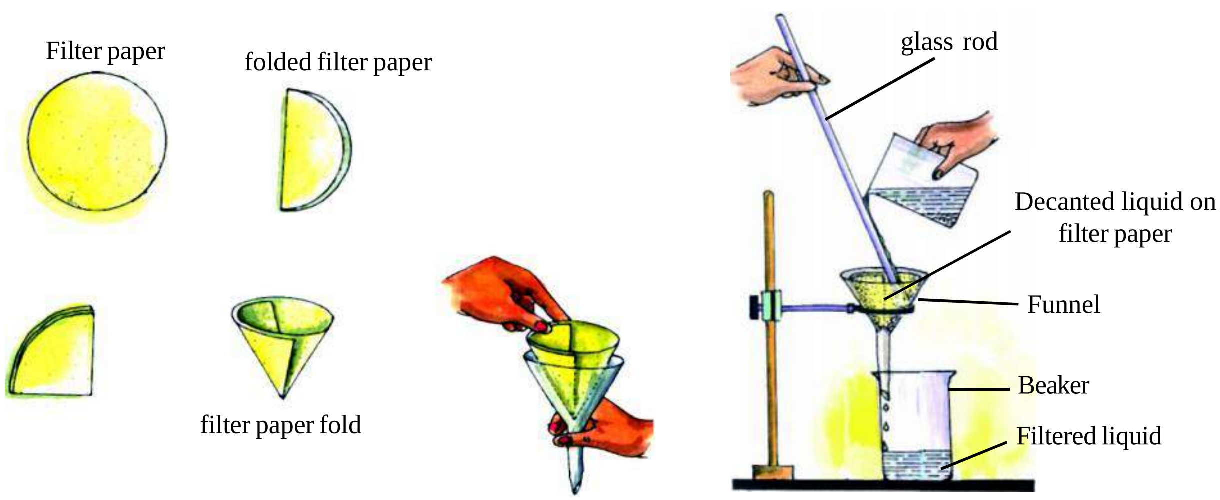


Fig. 3 : Filtration

Based on the observed properties of these three mixtures, we can say that:

- Separate particles are not visible in mixture 'A' and the path of light is also not seen. The constituent particles do not settle down at the bottom of the beaker and cannot be separated by filtration. Such mixtures are called solutions and here the constituent particles are uniformly distributed.

- In mixture 'B', separate particles are not visible. The constituent particles do not settle down at the bottom of the beaker and cannot be separated by filtration. But unlike mixture 'A', the path of laser light beam can be seen in mixture 'B'. Such types of mixtures are known as colloids.
- The constituent particles of mixture 'C' can be filtered and they settle down if left undisturbed. The particles in this mixture are so big that not only can they be seen but they also scatter a beam of light. Such mixtures are called suspensions.

We will now try to understand solutions, colloids and suspensions in some detail.

2.4 What is a solution?

We come across many solutions like soda water, lemonade, etc. in our daily lives. Usually, a solution has two parts - solute and solvent. The constituent of a solution whose quantity is more than any of the other constituents and which dissolves the other components in it is called the solvent. The constituent(s) that are in lesser quantity and which dissolve in the solvent are called solutes. Solutes and solvents can be solid, liquid, or gas. The solute and solvent particles are evenly distributed in a solution. Because of the uniform distribution of particles, if we examine any portion of a solution its properties will be same. For example, the solution of salt and water will taste the same throughout. Therefore, solutions are homogeneous mixtures.

You must have applied tincture iodine on a wound. The solution of iodine (solute) in alcohol (solvent) is known as 'tincture of iodine'. It is commonly believed that solutions are mixtures of solids, liquid, or gases dissolved in a liquid but solid and gaseous mixtures are also known. For example, alloys are solid solutions and air (nitrogen 78%, oxygen 21% and other gases in trace amounts) is a gaseous mixture.

Alloys

Alloys are homogeneous mixtures of solids. Although the constituent particles of alloys cannot be separated by physical means still we consider them as mixtures. For example, brass is a mixture of 60-80% copper and 40-20% zinc. Alloys display the properties of the metals of which they are composed.

2.4.1 Properties of a solution

- Solute and solvent together constitute a solution. A solution can have more than one solute.
- The constituents of a solution are uniformly distributed at the level of atoms and molecules. That is, its particles are very small.
- Because of very small particle size, the particles of a solution cannot be separated by filtration. Nor are the particles heavy enough to settle down.

- Because of very small particle size, they do not scatter a beam of light passing through the solution. So we do not see the path of a light beam in a solution.

2.4.2 Types of Solutions

Solutions can be categorized based on the amount of solute present in them. Let us understand this further through an activity.

Activity-4

- Take two beakers and fill them each with 100 mL water.
- In one beaker add a spoonful of sugar and in the other add a spoon of salt. Mix well using a glass rod.
- Keep adding sugar in the first beaker and salt in the second beaker with continuous stirring till no more can be dissolved.
- Were the quantities of sugar and salt that dissolved same?
- Now heat both the solutions with the help of a spirit lamp. Did the extra sugar and salt dissolve?
- Now add one spoonful sugar to the first beaker and one spoonful salt to the second beaker. Did they dissolve in the solution?

From this activity, we can conclude that at a given temperature a solvent is capable of dissolving a fixed amount of a solute and cannot dissolve more than that. If at a given temperature and for a given volume of solvent, it is not possible to dissolve any more solute, then the solution is called saturated solution. The amount of solute present in the saturated solution at this temperature is called its solubility. If the amount of solute present in a solution is less than the saturation level, it is called an unsaturated solution. In activity-4, we saw that if the saturated solution of solute at a given temperature is heated, then more solute can be dissolved in it. Now, if we cool this solution slowly then the extra solute will remain dissolved in the solution. This solution at the lower temperature where the amount of solute dissolved is more than the saturation level is called a super-saturated solution. For example, *chashni* is a supersaturated solution of sugar in water. Under appropriate conditions, the extra solute separates out as crystals.

On the basis of activity-4 we can say that different substances in a given solvent can have different solubilities at the same temperature. Can we divide solutions into concentrated and dilute solutions based on the amount of solute present? For this we need to learn about concentration of solutions. Let us understand this through an activity.

Activity-5

- Take two beakers and label them ‘A’ and ‘B’. Take 100 mL water in each beaker.
- Add ½ spoon salt to beaker ‘A’ and 2 spoonful salt to beaker ‘B’.

- Stir the contents of both beakers vigourously with a glass rod.
- The quantity of salt in beaker 'A' is less than the quantity of salt in beaker 'B'. We say that the solution in beaker 'A' is dilute as compared to the solution in beaker 'B'. The solution in beaker 'B' is concentrated as compared to solution in beaker 'A'. Concentrated and dilute are relative terms.

• Nutritional Facts g/100g	
Protein	3.0
Carbohydrate	4.7
Fat	3.0
Saturate	1.8
Trans Fat	ND
Calories K cal	58

Fig. 4 : Percent concentration of constituents of milk

We can express concentration in quantitative terms as well. The concentration of a solution is the amount of solute present in a given amount (mass or volume) of a solution.

We see many examples of concentrations being used in our daily life. For example, on a packet of milk which shows that there is 3.0 g protein, 4.7 g carbohydrate and 3.0 g fat in 100 g of milk (Fig. 4). Medicine bottles also show component concentrations in percentages.

There are several ways to describe the concentration of solution. One of them is:

$$\text{Mass percentage of a solution} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 100$$

Example-1 : Find the concentration of a solution of 40 g common salt (solute) in 520 g water (solvent).

Mass of solute (common salt) = 40 g

Mass of solvent (water) = 520 g

Mass of solution = mass of solute + mass of solvent

40 g + 520 g

= 560 g

$$\text{Mass percentage of a solution} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 100$$

$$= \frac{40}{560} \times 100 = 7.14\%$$

2.5 What is a suspension?

The mixture (chalk powder in water) obtained by group 'C' in activity-3 is an example of a suspension. Muddy water which is a mixture of soil in water is another example of suspension. Here, the solute particles do not dissolve and remain suspended in the medium (solvent). The suspended particles can be seen with the naked eye. A mixture of sand and water, *haldi* in water etc. are also examples of suspensions.

We can identify the following main properties of a suspension on the basis our observations:

- Suspensions are heterogeneous mixtures because they show different compositions in different parts.
- Their particles are so big that they can be seen with the naked eye and they can scatter a beam of light. This shows its path and also shows the particles of the mixture.
- The size of the particles in a suspension is so big that they start settling down if left undisturbed. The particles can also be separated using filter paper.

2.6 What is a colloid?

Is the mixture (milk/ink in water) obtained by group 'B' in activity-3, a solution or suspension? If it is neither, what is it?

On the basis of our observations, we can conclude that this is a type of mixture that is between suspensions and solutions. Such mixtures are called colloids. The particles of a colloid are smaller than that of a suspension. That is why they look homogeneous but are actually heterogeneous.

- The size of particles of a colloid is so small that they cannot be seen by the naked eye. They cannot be separated by filtration and do not settle down when left undisturbed. But they can be separated by using centrifugal force. You must have seen butter being separated from curd using a hand-churn. Here also, the particles are separated from a colloid using centrifugal force. If you have a centrifugation machine in your school, take some milk in a test tube and spin it for two minutes. Does the cream separate out from the milk?
- The particles of a colloid easily scatter a light beam to show the path of light rays. This effect is known as Tyndall effect (Fig. 5). The effect was discovered by the scientist, John Tyndall (1820-1893).

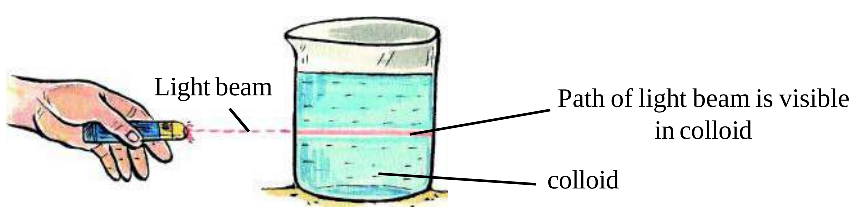


Fig. 5 : Tyndall effect

This effect can also be seen in a dark room when light enters it through a small opening. This effect is due to the scattering of light by dust and smoke particles.

- In a colloid, the solvent particles exert an unbalanced force on the solute particles. This causes the solute particles in the colloid to move in a zig-zag manner (Fig. 6). This event was studied by Robert Brown (1773-1858) in 1827 and such zig-zag motion of particles is called Brownian motion after him.

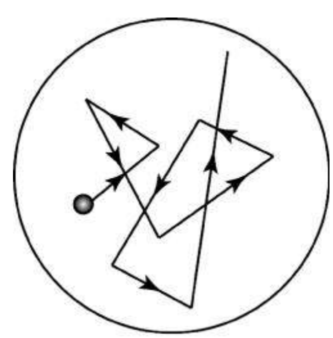


Fig. 6 : Brownian motion

Questions

1. Identify solutions, suspensions and colloids from among the given mixtures –

   salt dissolved in water, mud in water, milk in water.

2. Which amongst the following mixtures will show Tyndall effect –

   sugar in water, ink in water, starch solution, salt solution.

3. 250 g of washing soda was dissolved in 1 kg of water. Find the concentration of the solution in terms of mass percentage.

4. When we add 1-2 drops of rice water (*pasiya)* in 100 mL water, what do we get – a colloid or a suspension? Explain with reasons.

We know that mixtures are of many types and their components can be separated using different separation techniques. On separation, if we get substances that cannot be further separated using simple physical techniques then the separated substances are called pure substances.

Many new separation techniques are being developed. With the advance in separation techniques, it is possible that what we consider as a pure substance today may turn out to be a mixture. For example, for a long time in the past, air was considered as a pure substance but now we know that air is a mixture of gases. Come, let us understand pure substances in more detail.

2.7 What are the types of pure substances?

Pure substances can be classified as either elements or compounds on the basis of their chemical composition.

2.7.1 Elements

You know that elements are those substances that cannot be further broken into simpler substances by using chemical methods (heat, light, electricity or reactions with other chemical substances). Hydrogen is an element. Similarly, sodium (Na), iron (Fe), copper (Cu) etc. are also elements. Can you add more names to this list of elements? How many more names were you able to add?

Lavoisier (1743-94) was the first to give the modern definition of elements based on experiments. According to Lavoisier, element is a basic form of matter that cannot be broken down into simpler substances by chemical methods.

An element cannot be further broken into simpler substances because it is made of only one type of atoms. For example, copper is made of only copper atoms and iron is made of only iron atoms. Elements are found in solid, liquid and gaseous states.

Do you know?

- The number of elements known to us so far is more than 100. Of these, 92 are naturally occurring and the remaining are man-made.
- Most of the elements are solids.
- Two elements – mercury and bromine – are liquid at room temperature.
- The elements gallium and cesium become liquid at a temperature slightly above room temperature (300 K).
- Eleven elements are gases at room temperature.

2.7.2 Compounds

There are many substances around us that are formed by chemical reactions between two or more elements in a fixed proportion. These substances are called compounds. The properties of the compound formed after a chemical reaction is different from its constituent elements. For example, water (H_2O) is a compound which is formed by reaction between an inflammable gas, hydrogen, and oxygen gas which is needed for combustion. But water is neither combustible nor does it help in combustion. In fact, it puts out fires. Let us do an activity to find the ratio of the constituent elements in water.

Activity–6

- Do this activity under your teacher's supervision.
- Take a plastic bottle with a wide opening. Cut off its base. Fit a rubber cork with two holes on the mouth of the bottle. Insert one graphite rod in each of the holes. Set up your apparatus as shown in the figure.
- Fill the bottle about two-thirds with water and add a few drops of dilute sulphuric acid to it.
- Now place two test tubes over the graphite rods in such a way that they are completely filled with water and there are no air bubbles inside them.
- Connect the two electrodes to a 9 V battery.
- Observe the gases that start collecting in the test tubes. Is the rate of collection of gases the same in the two test tubes?
- When one of the test tubes is completely filled with the gas, that is, no water is left in it then note the level and volume of gas collected in the other test tube.

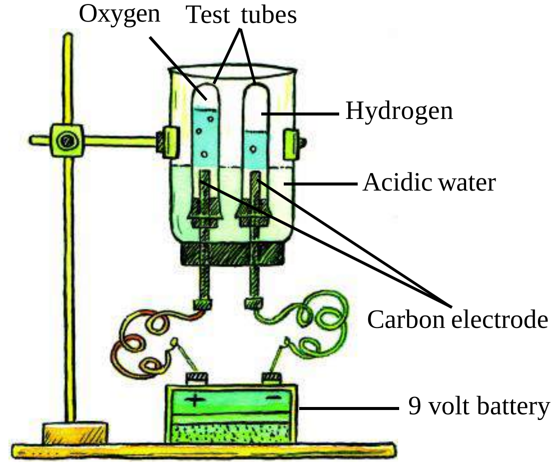


Fig. 7 : Electrolysis of water

- Is there any difference in the volumes of gas collected in the two test tubes?
- Remove the gas-filled test tube and replace it with another test tube filled with water, similar to the previous set-up. Put a lighted match-stick close to the mouth of the test tube filled with gas. Observe.
- When the second test tube get completely filled with gas, remove it. Put a lighted match-stick close to the mouth of this test tube. Observe.
- What is the ratio of the volume of the gas that helps in burning (O_2) to the volume of gas that itself burns (H_2)? What would be their ratio by volume when they combine to form water?

On the basis of the above activity, we can say that water is a compound that is formed by the chemical combination of hydrogen and oxygen in the ratio 2:1 by volume. The properties of the compound formed are different from the properties of oxygen and hydrogen. The constituents of water can be obtained by chemical methods such as electrolysis.

If we try to calculate the ratio of hydrogen to oxygen in water by mass, we find that it is always 1:8 irrespective of the source of water. This means that if 9 g of water undergoes electrolysis, we will always get 1 g hydrogen and 8 g oxygen. Similar results are obtained in case of other compounds as well. For example, on analysing carbon dioxide, the ratio of carbon to oxygen by mass was always 3:8.

Based on such experiments, Proust (1754-1826), a French chemist, gave the law of definite or constant proportions. According to this law, a compound always contains the same (fixed) proportion by mass of its two or more constituent elements. Ammonia and baking soda are some examples of compounds. The constituent elements of these compounds follow the law of constant proportions.

Questions

1. Group the following substances into elements or compounds:

   potassium, lime water, sulphur, washing soda, carbon, lead, vinegar
2. We get a white powder when we burn magnesium ribbon in air. Is this powder an element or a compound? Give reasons for your answer.
3. What is common salt – element, compound or mixture? Explain.

Keywords

Solution, colloid, suspension, homogeneous mixture, heterogeneous mixture, solvent, solute,saturated solution, unsaturated solution, supersaturated solution, concentration, solubility, Tyndall effect, Brownian motion, centrifugal force.

What we have learnt

- Matter occupies space and has mass.
- Matter can be divided into mixtures and pure substances.
- A mixture contains more than one substance mixed in any proportion and shows the properties of its constituents. Mixtures can be separated into its constituent components using appropriate separation techniques.
- When the constituent components of a mixture are uniformly distributed then it is called a homogeneous mixture and when they are non-uniformly distributed then it is called heterogeneous mixture.
- A solution is a homogeneous mixture of two or more substances. The component of a solution present in larger quantity is called the solvent, and the one present in lesser quantity, the solute.
- The concentration of a solution is the amount of solute present in a given amount of solution.
- A mixture where the solute particles are insoluble in the solvent and can be seen by the naked eye is called a suspension.
- The size of particles in a colloid is too small to be seen with the naked eye, but is big enough to scatter light and show the path of light.
- Pure substances can be elements or compounds. An element is a form of matter that cannot be broken down by chemical reactions into simpler substances. A compound is a substance composed of two or more different types of elements, chemically combined in a fixed proportion. Properties of a compound are different from its constituent elements.
- During a chemical reaction, the sum of the masses of the reactants is equal to the sum of the masses of the products. This is known as the law of conservation of mass.
- In a compound, elements are always present in a definite proportion by mass. This is known as the law of definite proportions.

Exercises

1. Choose the correct option:

   (i) Homogeneous mixture is :

   (a) iron (b) bronze

   (c) 24 carat gold (d) oxygen

(ii) Heterogeneous mixture is

(a) pure water (b) concrete

(c) solution of salt in water (d) lime (calcium oxide)

(iii) Oxygen is

(a) an element (b) a compound

(c) a heterogeneous mixture (d) a homogeneous mixture

(iv) Sugar is

(a) an element (b) a compound

(c) a heterogeneous mixture (d) a homogeneous mixture

(v) Which of the following will show Tyndall effect

(a) solution of salt in water (b) starch solution

(c) solution of baking soda in water (d) vinegar

(vi) Which of the following is not a pure substance

(a) ice (b) iron

(c) mercury (d) milk

2. Choose solutions from the given mixtures –

soil, sea water, air, soda water, mixture of glue in water, mixture of milk in water

3. Separate the following into elements, mixtures and compounds –

lemonade, rocks, copper, diamond, salt, neon gas, salad, pure water, aluminium, silver, soap, blood, carbon dioxide, sodium

4. Choose the appropriate option to fill in the blanks:

(i) An element has .... type of particles (same/different).

(ii) The scattering of light by colloid particles is called .... (Tyndall effect/ Brownian motion).

(iii) In tincture iodine solution, iodine is the .... (solvent/ solute)

(iv) The particles in a .... can be separated by filtration using filter paper. (suspension/ colloid).

(v) Particles in a .... cannot be seen with the naked eye (solution/ suspension).

5. Explain the following with examples –

   Pure substances, saturated solutions, colloid, suspension

6. Through an activity, demonstrate that the sugar dissolved in water is a solution.

7. What is the effect of temperature on the solubility of a solid in a liquid? Explain through an activity.

8. Write the differences between solutions, colloids and suspensions.

9. How will you differentiate between homogeneous and heterogeneous mixtures?

10. Seema took three solids, A, B and C and made their saturated solutions in 100 g water at different temperatures. The amounts of A, B and C used to form saturated solutions are shown in the table:

Solute	**Temperature in K**			
	293 K	313 K	333 K	353 K
a	35 g	36 g	37 g	38 g
b	32 g	62 g	106 g	167 g
c	34 g	40 g	46 g	54 g

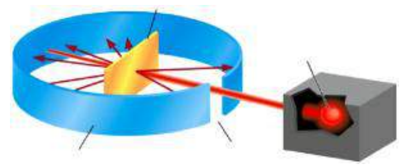
(i) What are the amounts of A, B and C needed to form saturated solutions at 293 K? What can you conclude based on this observation?

(ii) Calculate the amount of solutes A, B and C needed to form saturated solutions in 500 g water at 313 K.

(iii) Find the concentration in mass percent of A and C at 353 K.

Chapter 3

Atomic Structure



When we look around us we can see objects of different shapes, sizes, colours and textures. All these objects are made of different substances and all substances are made up of very tiny particles. Now, the question is: How small are these particles?

When we add a few drops of Dettol to a glass of water, all of it smells of Dettol. The smell can be detected even when we keep on adding more and more water. Why is it so?

Let us do an activity to understand:

Activity– 1

- Dissolve two-three crystals of potassium permanganate in 100 mL water (Fig. 1). Carefully note the colour of the solution.
- Take 10 mL of this solution and add it to 90 mL water.
- Now take out 10 of the second solution and add it to 90 mL water.
- Keep diluting the solution for 5-8 times.
- Is the final solution still coloured?

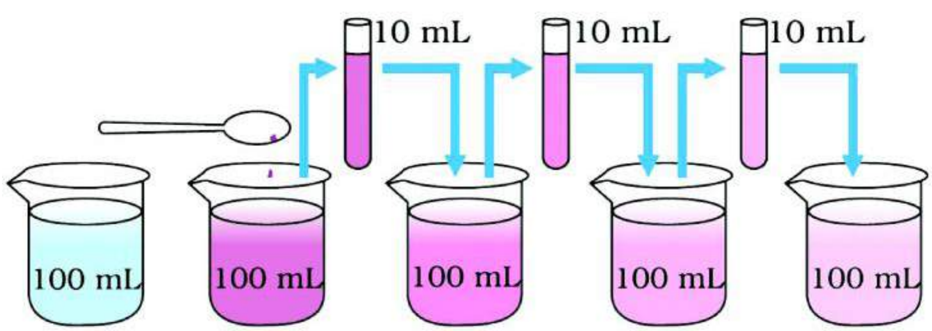


Fig. 1 : How small are the particles in matter

To detect the colour of the diluted solutions, place a piece of white paper behind the beaker and compare with a beaker of plain water.

Through this activity, we see that a few crystals of potassium permanganate are sufficient to colour a large volume of water. Just think, how many particles are there in one crystal of potassium permanganate and how small they must be.

Actually, the particles are so minute that the substance cannot have any smaller particles. These particles are of two types – atoms and molecules. Atom is a fundamental particle. Atoms join together to form molecules. People have been trying to understand the atom for several centuries. How did we reach our present understanding of the atom? Let us read more about it.

3.1 The story of the atom

The story of the attempts to understand the atom is very fascinating and begins as early as 500 BC. The Indian philosopher *Maharishi Kanad* postulated that if we go on dividing matter (*dravya*), we shall get smaller and smaller particles.Ultimately, a time will come when further division will not be possible and we will get the smallest particles which would be indivisible. An ancient Greek philosopher Leucippus and his student Democritus also thought of what would happen if we go on dividing matter and believed that a stage would come when particles obtained could not be divided further. Democritus called these indivisible particles *atoms* meaning those that cannot be split. He also said that the entire universe is made of atoms.

But we know that science is more than thinking and philosophizing. It needs different experiments, analysis, logic and theories to test ideas. Since Democritus did not have any basis for his ideas therefore his atomic theory did not become very popular. In 306 BC, an Athenian, Epicurus wrote in his book that all things around us are made of atoms. Lucretius also mentioned atoms in his poem, 'Nature of Things'. Ultimately, these opinions gained experimental validity when new techniques were developed in chemistry in the eighteenth century.

You have already read that the mass of matter remains conserved during a chemical reaction. In 1799, the French chemist Proust postulated the law of constant proportions according to which all chemical compounds are made of elements and "in a chemical compound the elements are always present in definite proportions by mass". This law was experimentally verified by many scientists and it explained the formation of many compounds. The various efforts to describe the two laws also helped in building an understanding of the atom.

John Dalton was a school teacher and scientist in Britain who explained why the different laws were true and he gave us the atomic theory. Dalton's efforts were published in the form of a book in 1808. Dalton's theory can be described as follows:

1. All matter is made of atoms.
2. Atoms are indivisible, infinitely small particles, which cannot be created or destroyed in a chemical reaction.
3. Atoms of a given element are identical in mass and chemical properties.
4. Atoms of different elements have different masses and chemical properties.

5. Atoms of different elements combine in the ratio of small whole numbers to form compounds.
6. The relative number and kinds of atoms are constant in a given compound.

Dalton's law of multiple proportions


John Dalton

Dalton saw that 3 g of carbon reacts with 4 g of oxygen to form carbon monoxide and 3 g of carbon reacts with 8 g of oxygen to form carbon dioxide. We can see that 8 g oxygen is double of 4 g oxygen. When Dalton took more such examples of elements combining in different ratios, he found that their proportions were always in simple whole number multiples which means that each time the atom is indivisible. He later published this result as law of multiple proportions. So we can say that when two elements combine to form more than one compound then the ratios of the masses of one element combining with a fixed mass of the second element are simple whole numbers. In the example given above we see 4 and 8 g oxygen combining with 3 g of carbon to give carbon monoxide and carbon dioxide respectively. So the ratio of mass of oxygen combining is 4:8 or 1:2 which is a simple, whole number ratio.

3.2 Is atom indivisible?

With the idea of an indivisible atom, chemists were able to explain chemical reactions as well as describe different laws and rules. But the concept of an indivisible atom did not last long as many experiments were conducted to understand the nature of matter which took the atomic theory into an entirely new direction.

On the one hand, the nature of the atom was being discussed and at the same time experiments were also being conducted to understand reactivity of gases. The contributions of the British physicist J.J. Thomson (1856-1940) and the German scientist Goldstein (1850-1930) in the study of gases needs to be appreciated. For example, Goldstein observed that when a sufficiently high voltage is applied across the electrodes of a glass tube filled with gas at low pressure, current flows and a stream of shiny rays are emitted from the cathode. Goldstein called these rays as cathode rays (Fig.2).

This experiment was repeated later under many different conditions. The scientist Schuster placed metallic plates on both sides of the path of cathode rays. When voltage was applied across the plates, one acted as cathode and the other as anode. He observed that when cathode rays pass through these plates, they bend (deflect) towards the positively charged plate that is, anode (Fig.3). In this way, it was confirmed that the cathode rays are made up of negatively charged particles.

Later, Thomson calculated the mass and charge on these negatively charged particles and found that the nature of the cathode ray particles was always identical and it was independent of the cathode material. He named these negatively charged particles electrons. Electron is a subatomic particle of all atoms. Thus, Thomson challenged the long-held belief that atom is indivisible. J.J. Thomson received the Nobel Prize for physics in 1906 for his discovery of electron.

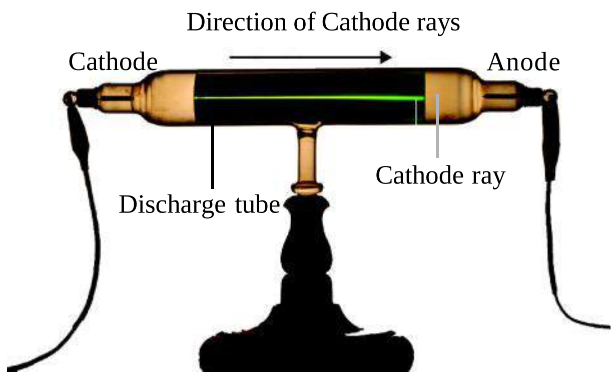


Fig. 2 : Cathode ray

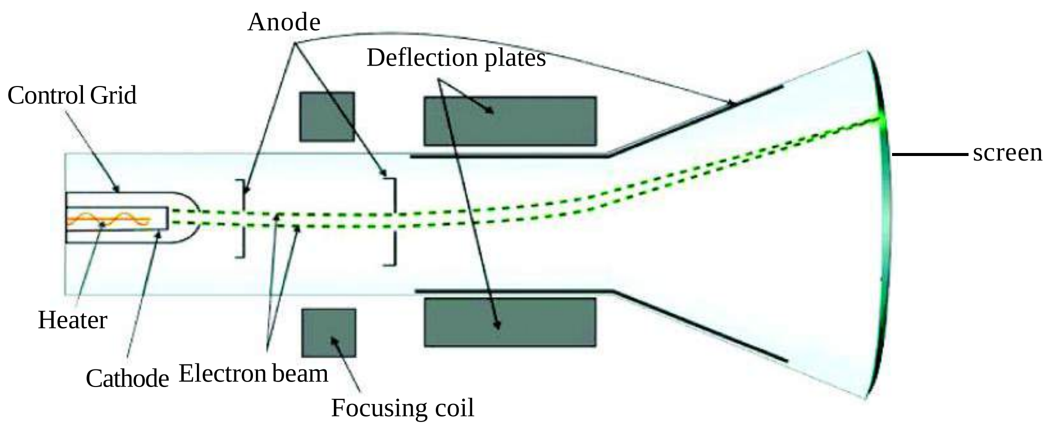


Fig. 3 : Bending of cathode rays towards the anode

3.3 Goldstein and Canal rays

Just as cathode rays were discovered, positively charged rays were also discovered by Goldstein in 1886 and were called canal or anode rays. On the basis of observations from his experiments, it was seen that canal rays were made of positively charged particles and their nature depended on the type of gas in the glass tube. Goldstein saw that the charge and mass of different anode rays were different. From this he concluded that the rays were being produced by the ionization of the gas in the glass tube. Thus, the discovery of canal rays helped establish the neutral nature of atoms, that is, atoms have positively and negatively charged particles and the charges being equal cancel each other.

3.4 Thomson's Atomic Model

J.J. Thomson gave the plum pudding model of atom. According to this model, the atom has a spherical cloud of positive charge in which the negatively charged particles are embedded in such a way that the charges are balanced. We can take the example of a watermelon to understand this model. The red portion of the watermelon is the positive cloud and the black seeds are the negatively charged electrons (Fig.4). Since the positive and negative charge in an atom is same therefore the atom is electrically neutral.

The atomic theory underwent many changes between 1908 and 1913 as more and more new information became available from different experiments. Let us read about these experiments.

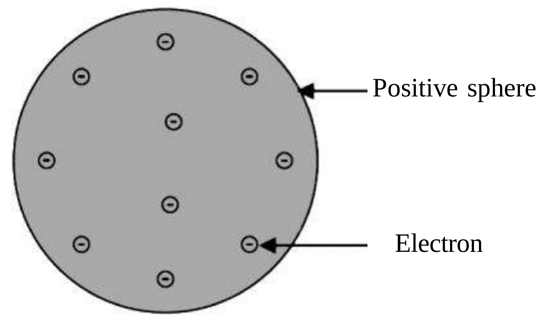
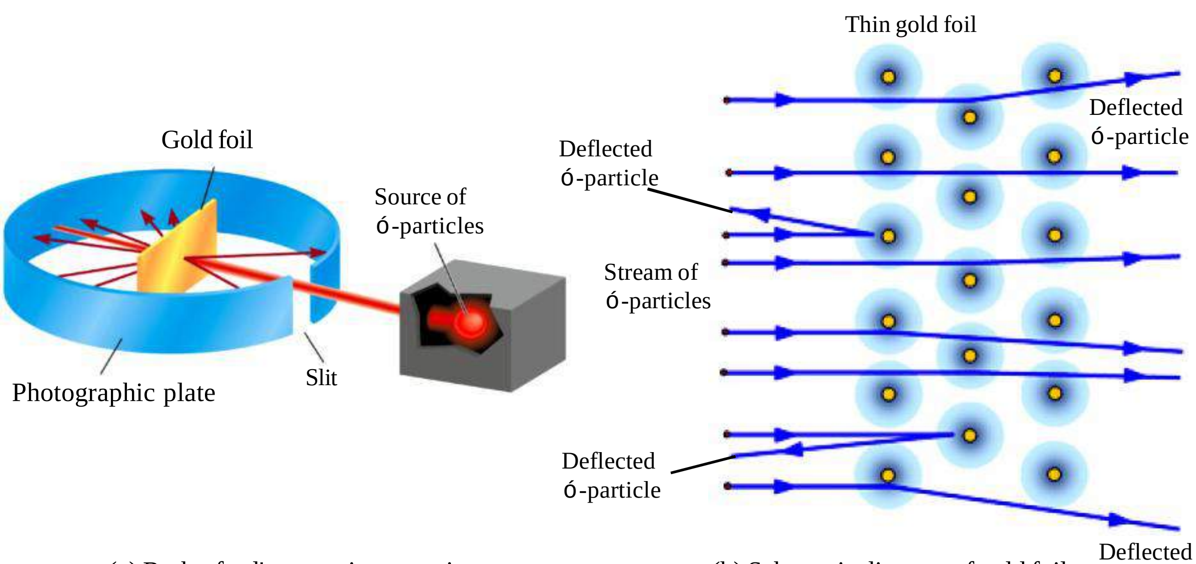


Fig. 4 : Thomson's atomic model

3.5 Alpha particle scattering experiment and Rutherford's Atomic Model

E. Rutherford and his students Geiger and Marsden carried out experiments to understand the structure of atoms. In one of the experiment, they bombarded a thin gold foil with high energy alpha particles (Fig. 5a and 5b). Alpha particles are positively charged and their mass is equal to the mass of helium atoms.



(a) Rutherford's scattering experiment (b) Schematic diagram of gold foil

Fig. 5 : Labled diagram of Rutherford's scattering experiment

According to Thomson model, the mass of each gold atom in the foil should have been spread evenly over the entire atom. Therefore, Rutherford expected that the alpha particles would change directions (deflect) only by a small angles as they passed through the foil but this did not happen. Rutherford observed that:

1. Most of the alpha particles passed straight through the gold foil without deflecting which shows that most of the space in the atom is empty.

2. Only a small fraction of the alpha particles were deflected which shows that the positive charge of the atom is concentrated in a very small volume.
3. Only 1 in 20,000 particles was deflected by 180^o and went back on the same path when it collided with the gold foil. If the alpha particle is bouncing back then it means that the mass of the atom was densely concentrated in this extremely small region and not spread out uniformly. This means that the mass of the atom was concentrated in a very small volume.

E. Rutherford (1871-1937) was from New Zealand. He is also known as the father of nuclear chemistry and received the Nobel Prize in 1908 for his discovery of the nucleus of the atom. In the alpha particle scattering experiment, he bombarded an extremely thin (100 nm thick) gold foil with high energy alpha particles and concluded from this experiment that the radius of the nucleus was 10^5 times smaller than the radius of the atom.

Rutherford

On the basis of these observations, Rutherford proposed that the positive charge and most of the mass of the atom was densely concentrated in an extremely small region. He called this very small portion of the atom nucleus. Electrons move around the nucleus in different circular paths called orbits. Thus, Rutherford came up with nuclear model of an atom on the basis of his experiments but did not describe the distribution of electrons. This was done by a Danish scientist, Niels Bohr.

Questions

1. Can the alpha particle scattering experiment be carried out by using silver foil or extremely thin foils of other elements rather than gold? Explain your answer with reasons.
2. On what basis did Thomson challenge the theory of indivisibility of atom?

3.6 How are electrons distributed in different shells (orbits)?

According to Rutherford's nuclear model, the atom can be described as having a small, positively charged nucleus around which electrons revolve in circular paths. But this model does not explain how the electrons are distributed in the atom.We know that electrons are negatively charged. Then, should similarly charged electrons be repulsed by each other or will they collide with each other? What holds together the sub-atomic particles inside the atom? Niels Bohr, along with his associate Bury, struggled with these questions and came up with a model called the Bohr-Bury scheme to distribute electrons in the atom. According to the Bohr-Bury scheme, electrons revolve in shells around the nucleus and these shells are represented by the letters K,L,M,N….

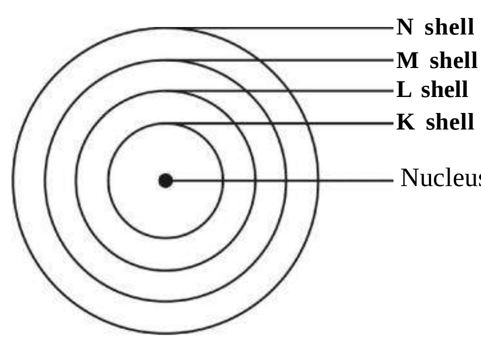


Fig. 6 : Atomic shells

The shell or orbit closest to the nucleus is called the K shell, the second shell is called L and the next shells are labelled M, N … respectively (Fig. 6).

3.7 Bohr-Bury scheme and distribution of electrons

1. The maximum number of electrons present in a shell is given by the formula $2n^2$, where 'n' is the shell number. For K shell (orbit), n=1 and for L,M, N shells n=2,3,4 respectively. The maximum number of electrons in first orbit or K-shell will be = $2 \times 1^2 = 2$ and similarly we can calculate the maximum number of electrons in other shells. The electrons present in the outermost shell are called valence electrons and this shell is called the valence shell.
2. The maximum number of electrons that can be accommodated in the outermost shell is 8 (exception is when K is the outermost shell and the maximum number of electrons is then 2).
3. Electrons are not accommodated in a given shell, unless the inner shells are filled. That is, the shells are filled in a step-wise manner.
4. Even when the capacity of the penultimate shell is more than 8, a ninth electron is placed in it only after 2 electrons have entered the last shell. For example, the atomic number of calcium is 20 but its electronic configuration is 2,8,8,2 and not 2,8,9,1.

The schematic atomic structure of the first 18 elements as per the Bohr-Bury scheme is given in Fig. 7.

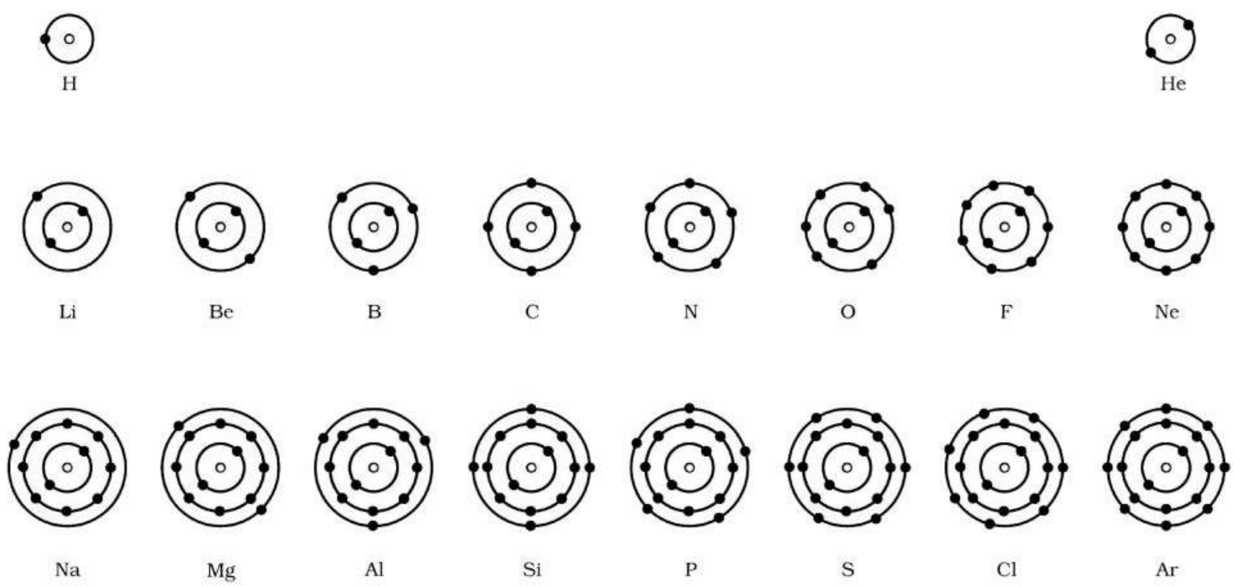


Fig. 7 : Distribution of electrons in different shells

Similarly, can you draw the atomic structures of elements having 19 and 20 electrons?

Some of the boxes in Table-1 have question marks, fill in the correct information.

Table 1 : Distributions of electrons in different shells and electronic configuration

Element	Symbol	No. of electrons	Distribution of electrons in orbits				Electronic configuration	Valence electron
			K	L	M	N		
Hydrogen	H	1	1				1	1
Lithium	Li	3	2	1			2,1	1
Carbon	C	6	2	?			?	?
Oxygen	O	8	?	?			?	?
Sodium	Na	11	2	?	1		2,8,1	?
Aluminium	Al	13	2	8	?		?	?
Phosphorus	P	15	2	8	?		?	?
Chlorine	Cl	17	?	?	?		?	?
Argon	Ar	18	2	8	8		?	?
Potassium	K	19	2	8	8	?	?	1
Calcium	Ca	20	?	?	?	2	?	?

3.8 Atomic number and mass number

The canal rays discovered by Goldstein in 1886 were positively charged. These later led to the discovery of the second subatomic particle, proton. Proton is positively charged and its charge is equal in magnitude but opposite to that on an electron. In 1932, J. Chadwick discovered a third subatomic particle, neutron. Neutron had no charge and its mass was nearly equal to that of a proton. Neutrons are present in the nucleus of all atoms, except hydrogen.

We now know that an atom has different subatomic particles, namely protons, neutrons and electrons. Protons and neutrons are present in the nucleus whereas electrons are revolving in shells outside the nucleus. In a neutral atom, the number of protons is equal to the number of electrons. The total number of protons present in an atom is known as its atomic number and is denoted by the letter Z. Usually, the mass of an atom is taken as the sum of the masses of the neutrons and protons present in its nucleus and is called mass number. The unit for mass number is u (unified mass). The subatomic particles, neutrons and protons, present in the nucleus are also called nucleons.

In general, electrons are represented by e^-, protons by p^+ and neutrons by n. An atom can be represented using its atomic symbol, mass number and atomic number, as shown below:

Mass number

Atomic symbol

Atomic number

For example, the atomic number of sodium is 11 and its mass number is 23. It is written as $^{23}_{11}Na$. The number of neutrons in lithium and calcium is 3 and 20 respectively, epict the atomic number and mass number of lithium and calcium in symbolic form.

In table-2 given below, the number of protons in the atoms of some elements and their mass numbers are given. Can you write down the number of neutrons for each?

Table 2 : Atomic number & mass number

Element	Symbol	No. of protons	Mass number	No. of neutron
Hydrogen	H	1	1	
Lithium	Li	3	6	
Carbon	C	6	12	
Oxygen	O	8	16	
Sodium	Na	11	23	
Aluminium	Al	13	27	
Phosphorus	P	15	31	
Chlorine	Cl	17	35	
Argon	Ar	18	40	
Potassium	K	19	39	
Calcium	Ca	20	40	

You may know that the nucleus is 10^5 times smaller than an atom. We also know that both neutrons and protons are present in the nucleus. Now, the size of the sodium atom is 1.86×10^{-10} m. Can you answer the following questions about the sodium atom:

1. What will be the size of its nucleus?
2. Keeping in mind the ratio of the size of the nucleus to the atomic size, how will you show a sodium atom? Can you pictorially depict a sodium atom accurately?

3.9 Isotopes, Atomic mass and Isobars

If we look at carbon in nature, it is seen that the mass number of carbon atoms in some cases is 12 and in some cases it is 14. Why is this so? Actually, carbon-12 and carbon-14 atoms have different number of neutrons. While carbon-12 has 6 neutrons, the number of neutrons in carbon-14 is 8.

In nature, a number of elements are present whose atoms have the same number of protons but different number of neutrons. The atoms of such elements, where the atomic number is same but mass numbers are different, are called isotopes of each other. For example, chlorine-35 and chlorine-37 are two isotopes of chlorine. Isotopes have many applications in our lives. For example, an isotope of cobalt is used in treating cancer, an isotope of iodine is used in goiter treatment, an isotope of uranium is used as fuel in nuclear reactors etc.

Relative atomic weight

Atomic weight is a fundamental concept in chemistry. Atomic weight is a means of establishing a relationship between the absolute weight of an element and the number of atoms present in it. Dalton knew that it was not possible to weigh a single atom so he concentrated on finding out relative atomic weights.

Since at that time hydrogen was the lightest element known, therefore he assigned one as the mass of one hydrogen atom. Because the atomic weights of atoms of other elements were calculated against the weight of the hydrogen atom therefore they were called relative atomic weights. It was also seen that oxygen reacts with more elements as compared to hydrogen so some people felt that oxygen should be made the standard. Nowadays, the atomic weights of elements are calculated against one atom of carbon-12.

We can now understand why the atomic number of most elements are not whole numbers. This is because it may have more than one isotope in nature. We can understand this through an example. Chlorine occurs in nature in two isotopic forms, chlorine-35 and chlorine-37 in the ratio of 3:1 or 75% and 25% respectively. The average atomic weight can be calculated as :

$$[(75 \times 35) + (25 \times 37)] \div 100 = 3550/100 = 35.5$$

Thus, the atomic weight of chlorine is 35.5 u.

Table 3 : Atomic weight of elements

1 H 1.008	2 He 4.003	3 Li 6.941	4 Be 9.012	5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95	19 K 39.10	20 Ca 40.02

If we consider carbon-14 (an isotope of carbon) and nitrogen-14 we find that their mass numbers are same but atomic numbers are 6 and 7 respectivly. Atoms of different elements with different atomic numbers but the same mass number, are known as isobars.

Questions

1. If the atomic number of an atom is 15 and mass number is 31 then what is the number of sub-atomic particles present in the atom?
2. If the K and L shells of an atom are full and the M shell has 2 electrons then what is the atomic number of the atom?
3. Write the electronic configuration of the following: ${}^{23}_{11}Na$, ${}^{12}_{6}C$, ${}^{35}_{17}Cl$

We learnt that a nucleus is present at the centre of the atom. Most of the mass of the atom is concentrated in the nucleus. Electrons are present around the nucleus. Attempts are continuously being made to observe the atom. You should also use the internet, books, magazines and audio-video sources to answer your questions about the atom.

Keywords

orbit or shell, atomic number, atomic weight, isotope, isobar, cathode, anode,canal ray,sub- atomic, nucleon, electron, proton, neutron, relative atomic weight, mass number, nucleus, law of multiple proportions

What we have learnt

- The early models of the atom imagined that it was indivisible.
- Dalton was the first scientist to talk about the shape and weight of an atom. In his law of multiple proportions, Dalton said that the number of atoms of an element at the end of a reaction is the same number at the beginning (that is, atom cannot be destroyed).
- According to J.J. Thomson, atom has a cloud of positive charges into which the negatively charged particles are embedded.
- Rutherford's alpha-particle scattering experiment led to the discovery of the atomic nucleus.
- Rutherford's alpha particle scattering experiment established that the atom has a very small nucleus and electrons revolve around this nucleus.
- Niels Bohr proposed that atoms have discrete shells designated as K,L,M,N…Electrons are distributed in these shells.

- The outermost shell of an atom has 8 electrons (except for helium and hydrogen atoms). The electrons present in the outermost shell are known as valence electrons.
- The number of protons present in an atom is known as the atomic number.
- The sum of the number of protons and neutrons present in the nucleus is known as the mass number.
- In a neutral atom, the number of electrons is equal to the number of protons.
- Isobars are atoms of different elements having the same mass number but different atomic numbers.
- Isotopes are atoms of the same element, which have same atomic number but different mass numbers.
- The average atomic weight depends on how many isotopes of an element are present in nature and in what percentages.

Exercises

1. Choose the correct option:

   (i) Isotopes have different:

   (a) electrons (b) protons

   (c) neutrons (d) both electrons and neutrons

   (ii) Who first included electrons in his atomic model?

   (a) Dalton (b) Thomson

   (c) Rutherford (d) Bohr

   (iii) Which of the following statements is true for $^{39}_{19}K$ atom

   (a) The atom has 39 electrons (b) The atom has 39 protons

   (c) The atom has 19 protons (d) None of the above

2. Choose the appropriate option to fill in the blanks:

   (i) All atoms of an element are .... (similar/different)

   (ii) The number of .... (electrons/neutrons) is equal to the number of protons in a neutral atom.

   (iii) $^{14}_{6}C$ and $^{14}_{7}N$ are .... (isotopes/isobars) of each other.

3. How was the atom proposed by Thomson different from the atom proposed by Dalton?

4. $^{16}_{8}O$ and $^{16}_{7}N$ are isobars. Use this example to explain isobars.
5. Bromine-79 and bromine-81 are found in nature in the ratios 50.69 and 49.31. What will be the average atomic weight of bromine?
6. Find out the number of valence electrons in $^{16}_{8}O$ and $^{14}_{7}N$.
7. Describe Bohr's atomic model.
8. Apart from oxygen-16, oxygen-17 and oxygen-18 are also known to exist in nature. Are these atoms isotopes or isobars? Explain.
9. Explain Dalton's atomic theory. What are its limitations?
10. What was the alpha particle scattering experiment carried out by Rutherford? What conclusions did he draw from this experiment regarding the structure of an atom?
11. Write the rules proposed for electron distribution under the Bohr-Bury scheme. Use the rules to write the electronic configuration of given atoms. Also give the number of neutrons present in each atom. $^{19}_{9}F$, $^{24}_{12}Mg$, $^{28}_{14}Si$, $^{31}_{15}P$, $^{35}_{17}Cl$

Chapter 4

Motion

You are familiar with the word 'Motion'. In our day-to-day life, we find several examples of motion, for example walking, running, movement of vehicles, falling of a fruit from a tree, flight of birds etc.

Fig. 1 : Example of Motion

We already know that all the things in our surroundings are always in motion and even we ourselves are not stationary at all times. Motion is a requirement for several activities and transitions and so its study as well as analysis provides answer to many fundamental questions. For instance, to understand seasonal changes it is important to know about the motion of earth around the sun. Knowing the time taken by a vehicle to reach from one position to another, also shows the understanding of motion.

Mostly we say that a body is in motion only if its position changes with time. But is it possible that for one person, the body seems to be in motion while for another the body is stationary? For example, if you are sitting in a moving train then, for you all other passengers and you yourself are at stationary. But for a person standing outside the train, you and the train, both are in motion.

If you are standing aside a road, for you all the trees around you seem to be stationary but while travelling by a bus, they appear to be in motion. Whether a body is in motion or is stationary depends on who is doing the observation and from which point. On this basis we can say that a body is said to be in motion when its position with respect to an observation point constantly changes with time. Any position can be considered as an observation point and its called as a reference point.

It is not easy to study the types of motion that we witness in our daily lives. When a person walks, along with the motion of his legs, different parts of his body like hands, head etc. also move. When a vehicle is in motion, all its different fittings are also in different motions. For example- while cycling, the motion of your legs, the motion of its pedal, the motion of the chain and the motion of tyres are all different.

Generally, different parts of a body are in a motion in different directions and the distance covered by the body can be very large compared to its size. In this situation, to study the linear motion of an object we consider following two simplifications-

1. A point is considered as a representative of the whole object and the motion of this point along a straight line is taken into consideration.
2. We choose this point such that the complete centre of mass of the object seems to be located at this point.

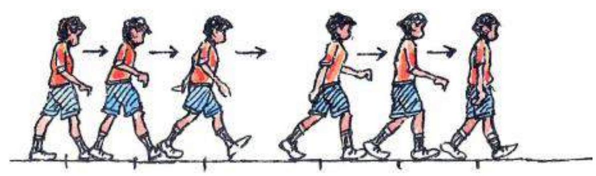


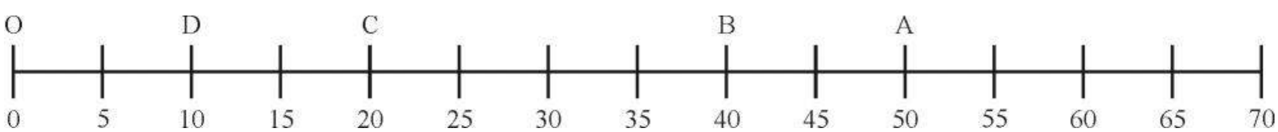
Fig. 2

The motion of a train on a straight rail track, fall of a stone from a height etc are examples of linear motion. Can you add more examples to this list?

4.1 Description of Motion

Come, let's see the changes in the position of a moving object. An object begins its motion from point O which can be considered as an initial point.

First the object moves from O to D, then D to C, and later from C to B and B to A. The length of the path from O to A covered by the object is, OA = 50 km.



Now it returns back on the same path from B to C and reaches D. The total length of the path covered by the object is

= OA + AD

= 50 + 40 = 90 km

The total length of the path covered by the object is called 'distance', which is 90 km. here. But what is the difference between the object's initial and final positions?

Initial position of object = O

Final position of object = D

Difference between initial and final positions of the object = 10 Km.

Here, the difference between the initial and final positions of an object is 10 km. This difference is called 'displacement'. Now, let's understand distance covered and displacement in more depth.

To represent the distance covered by an object we only need a numeric value. Such a quantity is called a scalar quantity. The numeric value of a quantity is its magnitude.

To represent the displacement of an object, along with magnitude we also need the direction of motion. Such a quantity is called vector quantity.

In the above example, if the object covers the distance only from O to A, then

Distance from O to A = 50 km.

Displacement from O to A = 50 km.

Thus, the magnitude of displacement and distance is equal. If the object moves from O to A and returns back to O, then the total length of the object's path is = OA + AO = 50 km. + 50 km. = 100 km. But its displacement is zero because the initial and final positions are same. Therefore, displacement can be zero, even if the distance covered is not zero. Let's understand displacement and distance through another example.

A man walks 3 m. towards east. Later, he moves 8 m. towards north and then 3 m. towards west. (Fig. 3)

It is clear that the distance covered in this case is AB + BC + CD = 3 m. + 8 m. + 3 m. = 14 m.

Magnitude of displacement = AD = 8 m. and displacement is towards north from A.

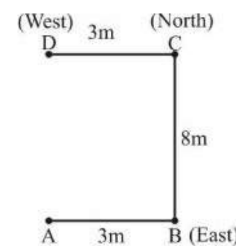


Fig. 3

4.1.1 Speed and Velocity

Activity-1

Some figures related to the motion of two buses A and B are provided in table 1:-

Table 1: Distance covered by bus A and bus B

Time	Distance covered by bus A (in km.)	Distance covered by bus B (in km.)
9.00 am	10	10
9.15 am	20	18
9.30 am	30	25
9.45 am	40	33
10.00 am	50	40
10.15 am	60	52

Observe these figures. After observation, tell-

- Is, the time interval for both the buses same?
- Which bus covers uniform distance in uniform time interval?

By observing table 1 given above we find that the time intervals for both A and B is same. Bus A covers uniform distance of 10 km. in a uniform time interval. However, bus B covers non-uniform distance in uniform time interval.

The time taken for covering a given distance (say 30 km.) is different for both the buses A and B. Bus A covers 30 km. distance in 45 minutes, while B covers the same distance in 60 minutes. Thus, we see that A moves faster while B moves slower.

To calculate the rate of motion of the bus we measure the distance travelled in a unit time by the bus. This quantity is called speed and in SI system its unit is meter/second (m/s). Another unit for speed can be kilometer/hour (km/h).

The average speed of the bus is the ratio of the total distance covered by the bus and the total time period.

$$\text{Average speed} = \frac{\text{Total distance covered}}{\text{Total Time period}}$$

Calculate the speeds of Bus A and Bus B from activity 1.

From 9:00 am to 9:15 am (in ¼ hours)

$$\text{Average speed of Bus A} = \frac{10\text{ km}}{\frac{1}{4}\text{ h}}$$

$$= 10 \times 4 \text{ km/h}$$

$$= 40 \text{ km/h}$$

Similarly,

$$\text{Average speed of Bus B} = \frac{8\text{ km}}{\frac{1}{4}\text{ h}}$$

$$= 8 \times 4 \text{ km/h}$$

$$= 32 \text{ km/h}$$

Table 2

Time Interval	**Bus A**		**Bus B**	
	Distance (km.)	**Avg. speed (km/h)**	**Distance (km.)**	**Avg. speed (km/h)**
9:00-9:15 am	10	40	8	32
9:15-9:30 am	10	?	7	28
9:30-9:45 am	10	?	8	?
9:45-10:00 am	10	?	7	?
10:00-10:15 am	10	?	12	48

The speed of Bus A is constant; therefore it is in a uniform motion. However, the speed of bus B is changing, hence it is in a non-uniform motion. Find out one example each of uniform motion and non-uniform motion from your day-to-day lives.

Lets understand speed through one example.

Example 1 : If a car covers 60 km. distance in 2 hours, what will be its speed?

Solution : Total distance = 60 km.

Time = 2 h

$$\text{Average speed} = \frac{\text{Total distance covered}}{\text{Total time period}}$$

$$= \frac{60}{2}$$

= 30 km/h

This does not mean that the car travelled the whole journey at a constant speed of 30 km/h. It is possible that it travelled with a speed more than 30 km/h for some time and also less than 30 km/h for some other time.

Example 2 : An object covers a distance of 20 m. from A to B in 10 s. It takes 6 s to return from B to A. What is the average speed of the object?

Solution : Total distance covered by the object = 20 m + 20 m = 40 m

Total time taken = 10 s+ 6 s = 16 s

$$\text{Average speed} = \frac{\text{Total distance covered}}{\text{Total time period}}$$

$$= \frac{40\text{m}}{16\text{s}} = 2.5 \text{ m/s}$$

Average speed of the object = 2.5 m/s

4.1.2 Velocity

We can represent the direction of an object along with its speed. The distance covered by an object in the given direction in a unit time is called its velocity. The change in velocity of an object depends on the change in the speed of the object, direction of motion or change in both.

$$\text{Velocity of an object} = \frac{\text{Displacement}}{\text{Time Interval}}$$

Velocity is a vector quantity whose direction is in the direction of displacement. The units of velocity and speed are same. Average velocity and average speed represent the different motions of an object in different time intervals. They do not represent instantaneous speed or instantaneous velocity.

Example 3 : A car travels from city A to city B at a speed of 40 km/h. The same car returns back at a speed of 60 km/h. Calculate the average speed and velocity of the car.

Solution : Let the distance between city A to B is x km.

$$\left(\because \text{Speed} = \frac{\text{Distance}}{\text{Time}} \quad \text{So time} = \frac{\text{Distance}}{\text{speed}}\right)$$

Time taken by car from city A to B is $t_1 = \frac{x}{40}$

Time taken by car from city B to A is $t_2 = \frac{x}{60}$

Total time t $= t_1 + t_2 = \frac{x}{40} + \frac{x}{60}$

$$= \frac{3x + 2x}{120} = \frac{5x}{120}$$

Total distance covered by the car is $= x + x = 2x$

But, the displacement by the car is $= x - x = 0$

average speed $= \frac{\text{Total distance covered}}{\text{Total time period}} = \frac{2x}{5x/120}$

$$= \frac{2x \times 120}{5x} = \frac{240}{5} = 48 \text{ km/h}$$

Velocity of the car in this particular journey $= \frac{\text{Displacement}}{\text{Time interval}} = \frac{x - x}{5x/120}$

$$= \frac{0}{5x/120} = \frac{0 \times 120}{5x} = 0$$

4.2 Graphs of Motion

Until now we have only talked about average speed and velocity. But can we find out the instantaneous speed or velocity of an object? come, lets understand this with the help of a graph-

The figures related to Apoorva's journey from home to school is given in table number-3.

Table3 : Distance travelled and time taken from Apoorva's home to school

Time (min.)	2	4	6	8	10	12
Distance (m)	12	24	36	48	60	72

In your graph paper, put time on the x axis and distance on the y axis and decide their scales. Write the scale on the upper right corner of your graph paper. Now mark the points according to the given figures. Draw a straight line joining all these points using a scale.

This graph shows Apoorva's journey from home to school. Note that the graph drawn here and all other graphs in this chapter are the graphs of distance covered and time, and not the path of journey.

Now from this graph tell-

- How much distance did Apoorva cover in first 2 minutes?
- How much distance did she cover in next 2 minutes?
- How much distance did she cover between 10-12 minutes?
- Are all these distances same?

When an object covers uniform distance in uniform time interval, its motion is said to be a uniform motion. For such a motion the distance verses time graph is a straight line.

What was Apoorva's speed from home to school? How can we calculate this from a graph? Let's understand.

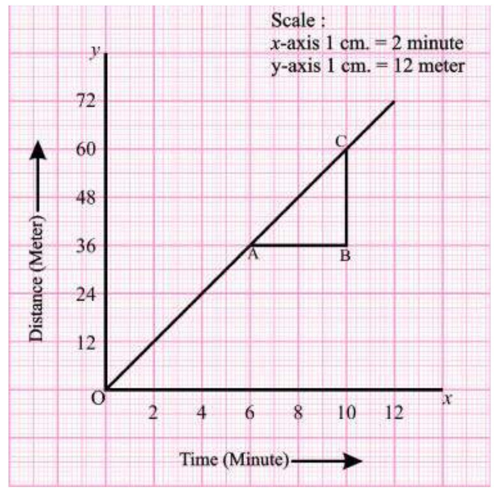


Fig. 4 : Graph for a uniform motion

To do this, choose a point A in the distance time graph (fig. 4). Draw a line AB parallel to x axis from A and from the point B draw a line parallel to y axis which meets point C and makes a triangle ABC.

Now the line AB in the graph, shows time interval (t_2-t_1) while BC, shows the distance (s_2-s_1). From the graph we can see that the object covers a distance of (s_2-s_1) from A to B in a time interval of (t_2-t_1). Thus, the speed of the object can be expressed as following:

$$v = \frac{s_2 - s_1}{t_2 - t_1}$$

If we want to know the speed of an object at an instant, then we can measure the scope of the graph at that particular point.

4.2.1 Uniform motions with different speeds

Drashti and Shrishti had a race from home to school. Both ran at a uniform motion but their speeds were different from each other. Fig. 5 shows their motions respectively.

- Do the graphs show uniform motion or non-uniform motion?
- By looking at the graph alone and without reading the numbers, can you tell whose speed was more.
- With the use of the graphs, calculate the speeds of Drashti and Shrishti.
- By comparing the speeds of Drashti and Shrishti, find out whether the answer given by you without looking at the numbers is right or wrong?

In the two uniform motion graphs, we can find out whose speed is more from the slope of the drawn lines. To find out the slope, we observe the angle made by the straight line on to the x axis at the point of origin.

If the angle is less, the slope of the straight line will be less and the speed of the person will be less. By looking at the graph (Fig. 5) say amongst Drashti and Shrishti whose slope of the motion graph is more?

Will her speed be more too?

Do remember that such a comparison of speed can be done only through graphs whose scales are same. We cannot compare graphs having different scales by just looking at them.

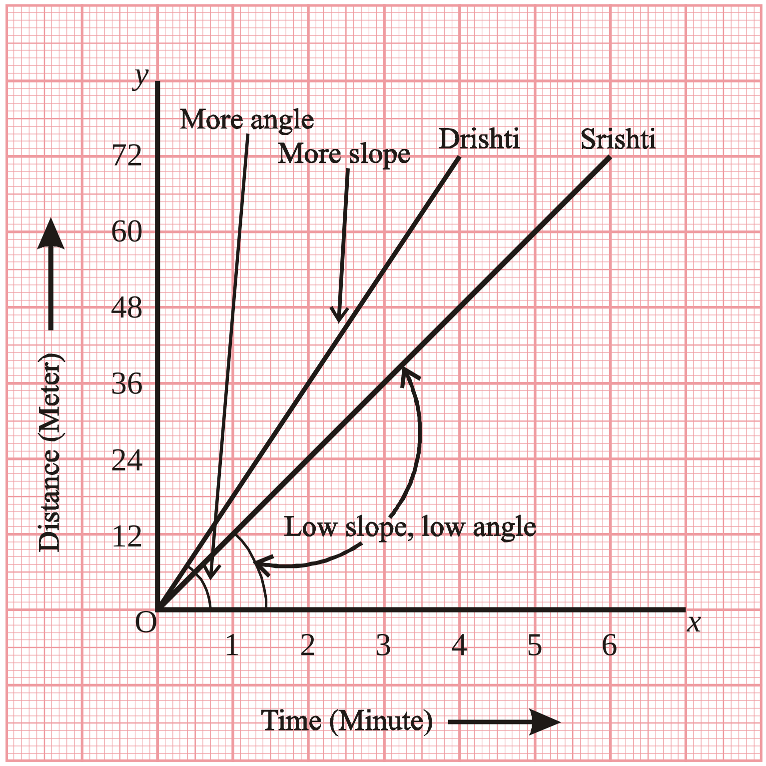


Fig. 5 : Motion of Drishti and Shrishti

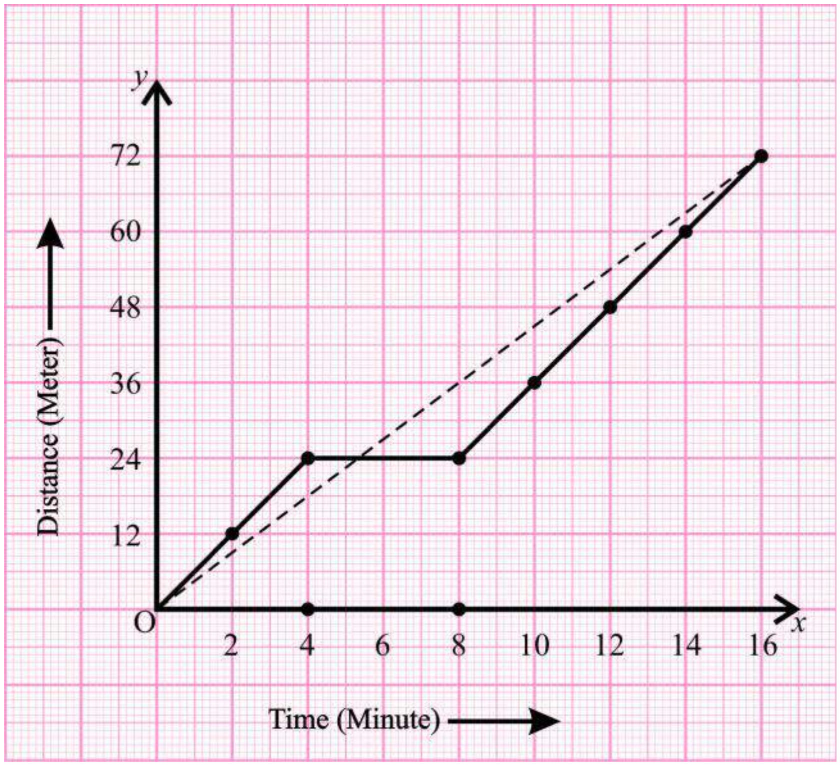
4.2.2 Graph of Halts

Suppose, on the way to school Apoorva stops for 4 minutes after walking for 4 minutes. After this she walks with a uniform motion and reaches her school. The graph showing her motion to reach school is given (Fig. 6).

When Apoorva stopped after 4 minutes, she had already covered a distance of 24 meter. Now she remained stationary for next 4 min. During this, the time increased to 8 minutes but the distance covered remained 24 m. Therefore, the next point on the graph was marked at 8 min. and 24 m.

Whenever an object stops/halts after reaching a certain position, the time passes but the distance remains the same. Therefore, as we just saw in the graph, for a stationary object, the distance time plot is parallel to the time axis.

Now, by looking at the graph in fig. 6 find out what was the average speed of Apoorva in such type of motion? What was her average speed when she reached school without a halt? (see graph in fig. 4 and table 3).



Graph fig. 6 : Graph of Apoorva's halt

- What is the difference between both these average speed.
- Give reason for this difference.

Question

The data related to Anamika's journey is given in table 4.

Table 4 : Data of Anamika's journey

Time (in min.)	2	4	6	8	10	12	14	16
Distance (m)	6	12	24	36	36	36	45	54

Based on this data draw a graph for her motion and find out her average speed.

- In which part of journey her speed will be maximum.
- Did she stop on her way? If yes then for how long?

4.2.3 Graph for non-uniform motion

Until now we have only studied about uniform motion. Now we will learn about such motions which are not uniform. You must have seen a bus starting from a station or stopping at a station. When a bus leaves from a station, is its motion uniform?

Such a motion where the speed is either increasing or decreasing is called as non-uniform motion.

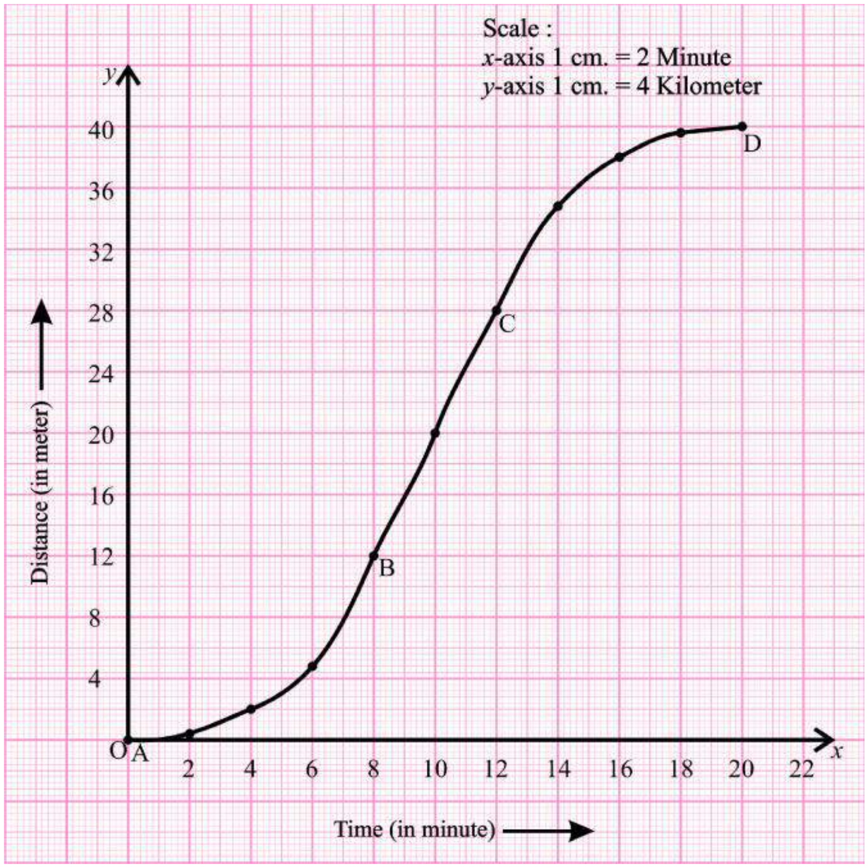


Fig. 7 : Graph of the motion of a vehicle having non-uniform speed

Table 5 : Distance travelled by Bus

Time (in min.)	Distance travelled (km.)
0 to 4	2 km
4 to 8	10 km
8 to 12	
12 to 16	
16 to 20	

See the graph given in fig.7 and fill the above table. Also, answer the following questions-

- Now tell if both the buses covered same distance in same time interval?
- Which section of the graph shows the change in motion of the bus and which part shows it's uniform motion? In which section was the bus stationary?

Look closely at the sections of uniform and non-uniform motion in the graph. Can you see any specific difference between the two?

The curve in the graph shows that the motion is continuously changing in that part. Look at the AB section of the graph. In this section, the speed of the bus is increasing after leaving from the station.

Questions

1. Write down the differences between speed and velocity.
2. In what situation will be the average velocity of an object be equal to its average speed?
3. Draw a velocity time graph for a uniform motion.

4.2.4 Acceleration

In general, what difference can you see in the cars that run on roads and a racing car that runs on a track?

One main difference is that a racing car has a very high speed.

Second difference is that a racing car has a very good pick-up. Pick-up shows how fast the speed of a car increases. For this, a technical word 'acceleration' is used.

With the help of table 1, calculate the velocity of bus A and B and complete the table 6.

(In table 1, by converting the distance in meter and time in seconds, calculate the velocity).

Table 6 : Calculation of velocities for bus A and B

Time	Velocity of bus A (m/s)	Velocity of bus B (m/s)
9.00		
9.15	$\frac{(20-10)\times1000}{(15)\times60}=\frac{10\times1000}{900}=11.11$	$\frac{(18-10)\times1000}{15\times60}=\frac{8000}{900}=8.89$
9.30	-------------- = 11.11	--------------
9.45	-------------- = 11.11	--------------
10.00	-------------- = 11.11	
10.15		$\frac{(52-40)\times1000}{15\times60}=\frac{12000}{900}=13.33$

In table 6 we see that during the motion of bus A, the change in velocity is zero and in same time intervals the velocity is constant. But in the motion of bus B, the change in velocity is different at different times. Therefore, to express the change in velocity of a bus we need to know about a new quantity. The rate of change of velocity of the bus is called acceleration.

$$\text{Acceleration} = \frac{\text{Change in velocity}}{\text{Time interval}}$$

If an object is moving with a velocity u, and in time t its velocity changes to v, then its acceleration

$$a = \frac{v - u}{t}$$

Acceleration is denoted by 'a'. The SI unit of acceleration is meter/second^2 (m/s^2). If acceleration is in the direction of velocity, then it is taken as positive. If it is in the opposite direction of velocity, then it is considered as negative and is called as deceleration.

When the change of velocity with respect to time is constant, then it is called as uniform accelerated motion and its acceleration is constant.

Activity-2

The distance covered by an object in a time interval of 2 seconds (s) is as follows. Calculate its velocity and acceleration and fill the table 7.

Table 7 : Velocity and acceleration of an object

Time (in sec.)	Distance (in m.)	Velocity (m/s)	acceleration (m/s^2)
0	0		
2	1	$\frac{1-0}{2-0} = \frac{1}{2} = 0.5$	$\frac{1.5-0.5}{4-2} = \frac{1}{2} = 0.5$
4	4	$\frac{4-1}{4-2} = \frac{3}{2} = 1.5$	
6	9	....	....
8	16	....	....
10	25	....	....

In table 7, you see that at every moment acceleration is same (ie. in same time interval, the change in velocity is same). Therefore, the motion of the object will be a uniformly accelerated motion.

After completing the above table draw the distance time graph, velocity time graph and acceleration time graph for a uniform accelerated motion.

In a uniform accelerated motion, acceleration is constant with time. Therefore, acceleration time graph is a straight line parallel to time axis.

Area covered by the acceleration time graph on time axis between 4-8 sec. is.

= Area for ABML

= AL × LM

= $4\ m/s^2 \times (8-4)s$

= $4\ m/s^2 \times 4\ s$

= 16 m/s

In this way, we can calculate velocity through the area covered under acceleration time graph on time axis.

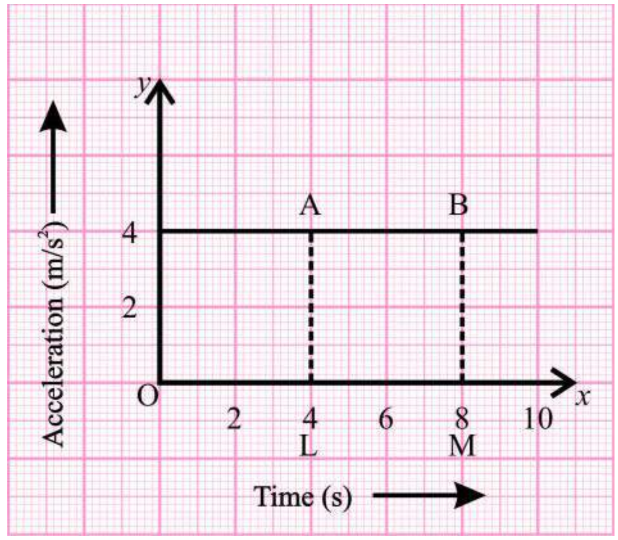


Fig. 8 : Acceleration - Time graph of uniform accelerated motion

Come, let's see a velocity time graph for a uniform accelerated motion.

From the graph, In $t_1 = 2s$, v = 0.5 m/s

In $t_2 = 6s$, v = 1.5 m/s

$$\text{acceleration} = \frac{v-u}{t_2-t_1} = \frac{1.5-0.5}{6-2} = \frac{1}{4} = 0.25 m/s^2$$

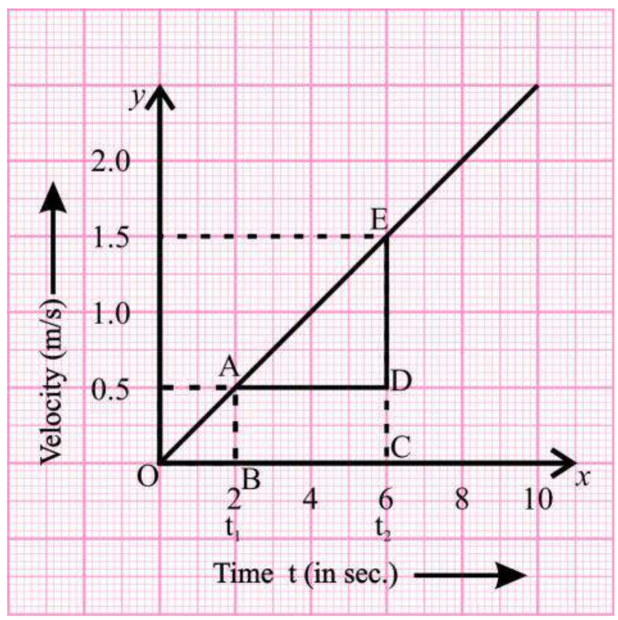


Fig. 9 : Velocity - Time graph of uniform accelerated motion

We know that for an object moving with uniform velocity, the product of its velocity and time gives displacement. In the fig. 9 the area of the field ABCDE in the given time interval shows the displacement.

that means, s = ABCDE

= area of rectangle ABCD

+ area of triangle ADE

$$= (AB \times BC) + \frac{1}{2} \times (AD \times DE)$$

$$s = (0.5 \times 4) + \frac{1}{2} \times (4 \times 1)$$

$$= 2 + \frac{1}{2} \times 4$$

$$= 2 + 2$$

$$= 4\ m.$$

The area covered by velocity-time graph on the time axis shows the measurement of displacement.

4.3 Equation of Motion

When an object moves with uniform acceleration, then it is possible to establish a relation between its velocity (v), acceleration (a) and travelled distance (s) in a given time interval. These are known as the equations of motion.

In this equation-

t is time interval,

u is initial velocity of the object,

v is final velocity of the object,

a is uniform acceleration of the object in time t, and

s is the distance covered by the object in time t.

Velocity-time relation in a uniform accelerated motion

We saw a velocity-time graph for a uniform accelerated motion in fig. 9. A similar graph is shown in fig. 10.

From the graph we can see that the initial velocity of the object is u which in time t, increases to v. At the point A, the initial velocity of the object is u and at the point B its final velocity is v. (from the graph in fig. 10).

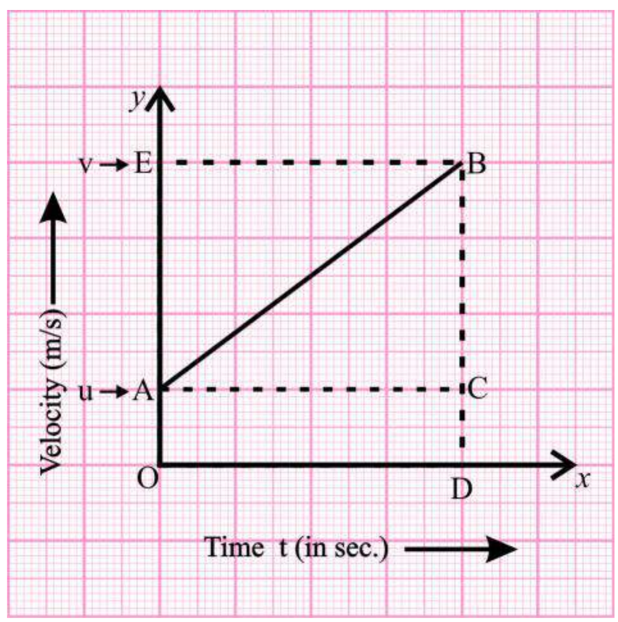


Fig. 10

BC = v – u ....(i)

We know that the acceleration, $a = \frac{BC}{AC} = \frac{BC}{OD}$

$a = \frac{v-u}{t}$

a t = v – u ....(ii)

v = u + at (this is the first equation of motion)

Position time relation in a uniform accelerated motion

(a) For a uniform accelerated motion let us find the area covered by velocity time graph on the time axis which is equal to the measurement of displacement (s).

From the graph, s = area of figure OABD

s = area of rectangle OACD + area of triangle ABC

$$= (OA \times OD) + \frac{1}{2} (AC \times BC)$$

$$= ut + \frac{1}{2} (OD \times BC) \quad \text{from equation (i) and fig. 11}$$

$$= ut + \frac{1}{2} t (v - u)$$

$$= ut + \frac{1}{2} t (v - u) t$$

$$= ut + \frac{1}{2} at.t \quad \text{from equation (ii)}$$

$$s = ut + \frac{1}{2} at^2$$

We can also find out s by one another method.

(b) (Since OABD is a parallelogram)

Therefore,

$$s = \text{area of parallelogram OABD}$$

$$s = \frac{1}{2} \times \text{(Addition of parallel sides of the parallelogram)} \times \text{height}$$

$$s = \frac{1}{2} (OA + BD) \times OD \quad \text{(From fig. 10)}$$

$$s = \frac{1}{2} ?(u + v) \times t \quad \text{Putting the value of t from equation (ii)}$$

$$s = \frac{1}{2} ?(v + u) \times \left(\frac{v - u}{a}\right)$$

$$s = \frac{v^2 - u^2}{2a}$$

$$v^2 - u^2 = 2as \quad \text{This is the third equation of motion}$$

Accordingly, following are the three equations of motion.

$$v = u + at$$

$$s = ut + \frac{1}{2} at^2$$

$$v^2 - u^2 = 2as$$

Example 4 : A body is in a state of motion with a velocity of 4 m/s. If its acceleration is 2 m/s^2 then what will be its velocity after 5 s? Also find the distance covered by the body.

Solution : Given that,

velocity of body $u = 4$ m/s

acceleration $a = 2\ m/s^2$

final velocity $v = ?$ and covered distance $s = ?$

time $t = 5$ s

By the first equation of motion,

$$v = u + at$$
$$= 4 + 2 \times 5$$
$$= 4 + 10$$
$$= 14\ m/s$$

$$s = ut + \frac{1}{2}at^2$$
$$= 4 \times 5 + \frac{1}{2} \times 2 \times (5)^2$$
$$= 20 + \frac{1}{2} \times 2 \times 25$$
$$= 20 + 25$$
$$= 45\ m$$

Therefore, its velocity after 5 s of time is 14 m/s and distance covered by it is 45 m.

Example 5 : A car travels at a uniform acceleration of 4 m/s^2. So, 10 s after starting the motion, how much distance would have been covered by it?

Solution : acceleration $a = 4\ m/s^2$

initial velocity $u = 0$

time $t = 10$ s

distance $s = ?$

We know that, $s = ut + 1/2\ at^2$

$$s = (0 \times 5) + \frac{1}{2} \times (4) \times (10)^2$$
$$s = 0 + \frac{1}{2} \times 4 \times 100$$
$$s = 200\ m$$

Therefore, the distance travelled by car is 200 m.

Example 6 : A vehicle is moving at a constant speed of 36 km/h. On applying the brakes, it causes a deceleration of 0.5 m/s^2. How much distance would have been covered by the vehicle before stopping?

Solution : given that,

initial velocity of the vehicle $u = 36$ km/h

$$u = \frac{36 \times 1000}{60 \times 60} \text{ m/s}$$

$u = 10$ m/s

deceleration $a = -0.5$ m/s^2 (here the -ve sign shows deceleration)

Final velocity $v = 0$

distance travelled $s = ?$

$$v^2 = u^2 + 2as$$

$$(0)^2 = (10)^2 + 2 \times (-0.5) \times s$$

$$0 = 100 - 1s$$

$$1s = 100$$

$$s = 100 \text{ m.}$$

Thus, the distance covered by the vehicle is 100 m.

Example 7 : The following speed-time graph shows the motion of a particle in a given direction.

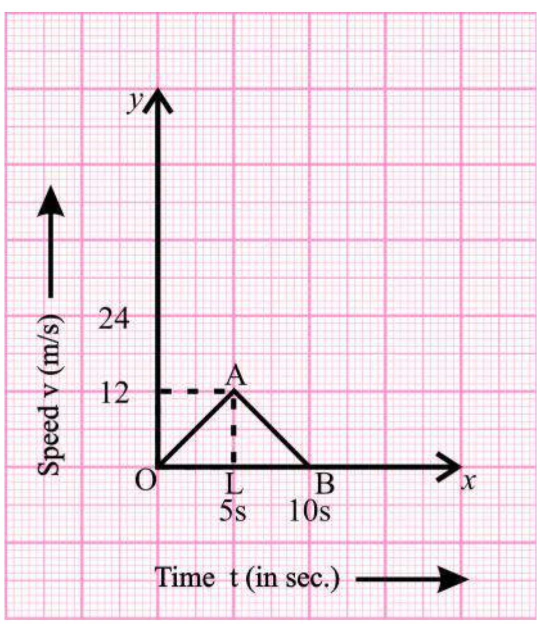


Fig. 11 : Speed-time graph

Find the distance covered between 0 to 10s and the average speed of the particle.

Solution (i) : s = distance covered between 0 to 10 s

= area covered by speed-time graph on the time axis

= area of ΔOAB

$= \frac{1}{2}$ base $\times$ height $= \frac{1}{2}$ OB $\times$ AL

$= \frac{1}{2} \times 10 \times 12$

= 60 m

(ii) Average speed of particle in 0 to 10 s.

$= \frac{\text{Distance travelled}}{\text{Total time taken}}$

$= \frac{60}{(10-0)} = \frac{60}{10} = 6$ m/s

Question

1. Draw a velocity-time graph for a uniform deceleration motion.
2. A car increases its velocity from 18 km/h to 36 km/h in 5 sec, at a constant acceleration. Find its acceleration and distance covered by it.
3. A car is moving at a constant velocity of 36 km/h. On applying brakes it stops at a distance of 10 m. Calculate deceleration and time taken by the car to stop.

4.4 Circular motion

We know that when the motion of an object is accelerated, its velocity changes. What are the ways by which a change in velocity can take place? There are three possible situations for change in velocity-

1. When there is change in the value of velocity but the direction of motion is constant.
2. When the value of velocity is constant but the direction of motion change.
3. When there is change in the value of velocity as well as the direction of motion of the object.

Now, can you think of circular motion, where in a uniform motion, the value of the velocity remains constant but there is a continuous change in the direction of motion.

Find out how the direction of the velocity and its value changes in the following examples.

(i) a runner, running on a circular track. (ii) motion of a fan.

(iii) motion of hands of a clock.

You experience circular motion also in circular................................ Find out such other examples of circular motion in your daily life.

What we have learnt

- The change in position of an object with time is called motion. It can be described by the distance covered or by displacement.
- The length of the path covered by the object is called distance. It is a scalar quantity. Its SI unit is meters (m).
- The difference in the position of the object is called displacement. It is a vector quantity. Its SI unit is meter (m).
- Displacement does not depend on the path travelled, whereas, distance depends on the path travelled.
- The distance covered in unit time is called speed. Its SI unit is meter/second (m/s).
- The rate of change of displacement is called velocity. It is known as the distance travelled in a given direction in a unit time. Its unit is meter/second (m/s).
- When an object covers uniform distance in a uniform time then its motion is called as uniform motion.
- In a uniform motion, the velocity-time graph is a straight line parallel to time axis.
- The rate of change of velocity of an object is called acceleration. It is a vector quantity. Its SI unit is meter/second^2 m/s^2.
- The acceleration time graph in a uniform accelerated motion is a straight line parallel to the time axis.
- When an object moves on a circular path, with a constant speed, then its motion is called as a uniform circular motion.

Keywords :- Distance, Displacement, Speed, Velocity, Acceleration, Retardation, Uniform circular motion.

Exercise

1. Choose the right option-

(i) If the distance covered by a body is $s = at + \frac{1}{2}bt^2$, then the acceleration of the body will be-

(a) a (b) b (c) 2 b (d) a + b

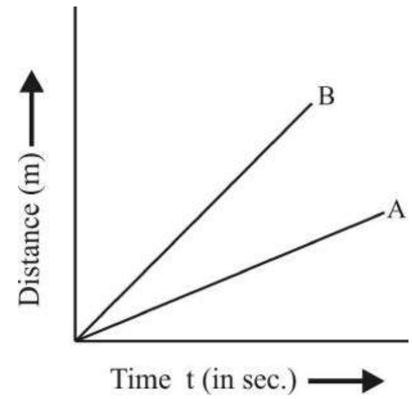
(ii) The area covered by velocity-time graph on the time axis is-

(a) m (b) m/s (c) m/s^2 (d) None of these

(iii) Below is the distance-time graph for the two bodies A and B. Say which body has more velocity.

(a) A (b) B

(c) A and B (d) None of these



(iv) Which one of the following is an example of uniform circular motion.

(a) Motion of earth around the sun.

(b) Motion of a toy train along a linear path.

(c) Motion of the second's hand of a clock.

(d) Motion of a racing car along circular track.

2. Fill in the following blanks-

(i) A body is moving at a constant velocity, its acceleration will be ....

(ii) The direction of velocity of a body depends on ....

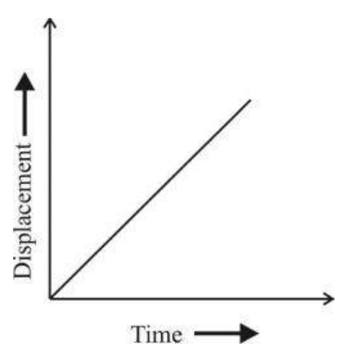
(iii) If the speed of an object is 72 km/h, its speed in m/s is ....

(iv) A person covers one round of a circular track of 2 m. radius in 2 s. What will be his displacement after 8 second.

3. What is the meaning of a uniform circular motion? Give its two examples.

4. A body moves around the sun at a constant velocity. Is its motion a uniform motion or a non-uniform motion?

5. The displacement-time graph for an object is given below. What result can you find out for its velocity?



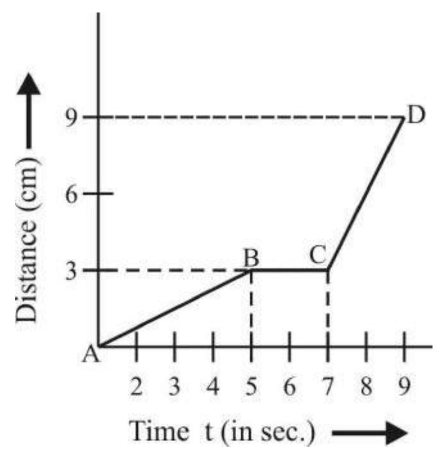
6. The position-time graph for a given object is a straight line parallel to its time axis. What can you say about its motion?

7. Define uniform motion and a non-uniform motion also state two example of each.
8. Write all the three equations of motion and explain the symbols used in them.
9. An athlete covers one round of a circular track of 7 m. radius is 44 sec. How much distance will it cover in 1 minute? (Answer 60 m.)
10. Using the graphical method derive the second equation of motion $s = ut + \frac{1}{2} at^2$.
11. Neeraj reaches school in a car at an average speed of 20 km/h. While returning; his speed becomes 30 km/h due to lesser crowd. What is the average speed of Neeraj's car for the whole journey? (24 km/h)
12. A ball is dropped from the top of a 20 m. high tower. If its velocity is increasing with an acceleration of 10 m/s^2 then at what speed will the ball hit the ground? How much time will it take to hit the ground? (20 m/s)
13. A car is moving on a straight road at a uniform acceleration. The velocity of the car at different times is given below. Draw its velocity-time graph and calculate its acceleration and also find out the distance covered by it in 30 seconds.

t Time (s)	0	10	20	30	40	50
v speed (m/s)	5	10	15	20	25	30

14. In the following figure, the position-time graph for an object at different times is shown. Calculate the speed of the object.

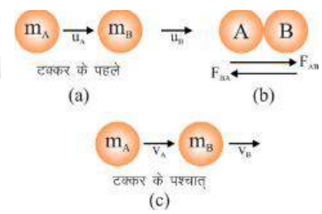
(i) A to B (ii) B to C (iii) C to B



15. A train starts moving from rest and acquires a velocity of 72 km/h in 5 minutes. If the train moves at a constant acceleration, calculate the following-
    (i) Acceleration (0.06 m/s^2)
    (ii) Distance travelled by the bus to acquire this velocity. (3000 m.)

Chapter 5

Force and Laws of Motion



In a daily life we see different objects around us. We find that some objects appear to be stationary while others seem to be in motion. How do we bring any stationary object into motion? To ride a bicycle we need to pedal it. When we stop pedaling the speed of the bicycle decreases. To keep the cycle in motion we need to pedal again. Similarly, to bring a ball in motion, we can push or throw it. On applying a push, does the ball get in motion forever? or does it come to a stop in a while? What is the reason behind the ball to stop?

To bring a ball in motion, we need to push it and then it slowly comes to a halt. How does a ball in motion comes to rest? Does it stop on its own or is there a factor that causes it to stop? We have read earlier that to bring an object into motion or to bring it to rest we need an external factor which is called as 'force'.

Activity-1

In this activity we need a smooth ball made up of a wooden piece, two wooden planks of length 1 m. and 30 cm. each, a plastic tray, sand and some oil.

- By placing the smaller plank at 45° angle from the ground make an inclined plane (fig.1).
- Place the longer plank below the inclined plane, touching it as shown in the figure.
- Place the wooden ball at the top of the inclined plank and leave it.
- Measure the distance covered by the ball on the longer plank.

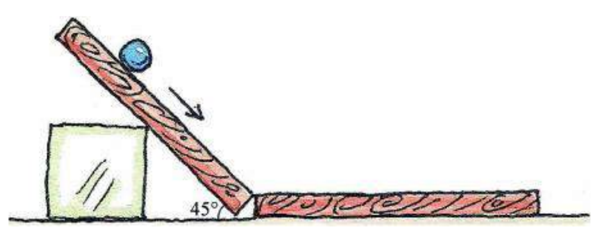


Fig. 1

- Now replace the longer plank with a tray filled with sand.
- Again, place the ball at the top of the inclined plane and leave it. now measure the distance covered by the ball on the tray of sand.
- Similarly, repeat the above steps using a smooth plastic tray and some such objects which get smoother after applying oil.
- Measure the distance covered by the wooden ball on all of these surfaces.

Now try answering the following questions depending upon the above activity.

1. Did the ball cover same distance on all the surfaces.
2. Arrange the distance covered by the ball on different surfaces in a particular order.
3. In which situation did the ball cover maximum distance and why?

In the earlier classes, we have read about the frictional forces which are responsible for bringing the motion of an object to rest. The value of frictional force changes according to the nature of surfaces in contact. The ball covers larger distance on the surface on which it experiences lower frictional force.

On this basis, state which of the surfaces in the given activity applies the smallest frictional force?

As we saw, an object remains in a state of motion for much longer on the surfaces which apply lower frictional force.

What would happen if the frictional force on a surface becomes zero? Will the object ever stop?

According to Galeleo, in the absence of an external force of resistivity, an object moving at a constant velocity remains in its state of motion and similarly an object at rest remains in the state of rest until an external force works on it. Therefore, we say that an object remains in its state of motion or rest unless an external force brings a change in its state. This is known as 'inertia'. We can witness several examples of inertia in our daily lives. For example, on suddenly applying brakes of a moving vehicle, the person sitting inside it involuntarily bends in the forward direction and the items in the vehicle also slide forward. You must have felt this too. Give some more examples of such situations. Can you tell why does this happen? Discuss amongst yourself.

A person sitting inside a moving vehicle is in motion alongwith the vehicle. When the vehicle comes to a halt, the lower body of the person which is in contact with the seat comes to rest immediately while the upper body remains in motion due to inertia.

Hence, the person sitting inside the vehicle bends forward. Similarly you can tell why a person bends backwards when the vehicle starts to move suddenly. Discuss among yourself and write the answer in your notebook.

5.1 Inertia and Mass

From all the examples that are given uptil now, we can see that every object resists any change in its state, whether it is at rest or in motion. It does not want to change its state and wants to remain in its initial state of motion. This characteristic of an object is called 'inertia'. Several other questions arise from this. For instance we can ask whether all the objects have inertia? If yes then on what factors its value depends upon and is the inertia for all objects same? Come lets understand this through an activity.

Activity-2

- Take two plastic bottles 'A' and 'B'.
- Fill water in bottle 'B'.
- Drop both the bottles by pushing them with your hand.
- Which bottle fell easily.

You will find that it was easier to push and drop the empty bottle as compared to the filled one.

Similarly it is easier to push an empty carton box as compared to a carton filled with books.

We can think of several such other examples.

For example when there is just one person riding a bicyle, it is easier to bring it to a halt by applying brakes. But when a friend of your's sits behind you, it is difficult to apply brakes and bring the bicycle to a halt.

Can you explain the reason behind this? Discuss amongst yourself.

To change the state of a filled bottle, we need to apply more force as compared to an empty bottle. In a similar way, when a single person rider a bicycle, it is easier to apply brakes while in case of two people sitting on the bicycle, more force has to be applied. This means that heavier objects have more 'inertia'. Inertia is that property due to which an object tries to remain in its state of motion or state of rest. Mass is the measurement of resistance of an object towards any change in its state. Which means that mass is the measure of the property of inertia of any object. If the mass of an object is more, its inertia will be greater. The S.I. unit of mass is kilogram (kg.)

5.2 Balanced and Unbalanced Force

Activity-3

Take a block of wood. On two opposite faces of this block, put a hook or a nail on each. tie a thread A and B of similar lengths on both the hooks, as shown in the fig.2. Now place this block on the table Now, if we pull only the thread A by applying a force P then the block shifts towards the right side. If only the thread B is pulled using a force Q, the block shifts towards left. But if we apply similar forces on both the threads and pull them, then we see that the block does not move. These similar forces balance each other and so there is no change in the position of the block. The balanced force in this example is shown in the fig.3 (where P = Q).

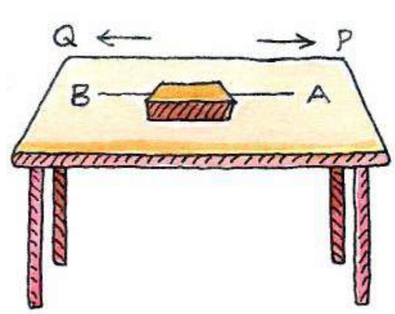


Fig. 2

If both the forces are not equal, then the net force on the block will be

= P – Q where P > Q

Fig. 3

Net force is the calculated force applied on the block. To understand net force, we will need to know all the forces that are applied on the object along with their directions. To get the net force we sum up all the forces that are applied in one direction and subtract all those forces that are applied in opposite direction. The net force applied on the block is a vector sum of P and Q. Therefore the net force applied on the block in a state of balanced force is-

Net force $= (\because P = Q)$

$= 0$

If the force applied on the thread B is more than the force applied on A, then the block will shift towards the left side. Both the forces are not balanced and so the motion of the object will be towards the force with greater magnitude ie., towards B. (from figure number-3)

Force applied on the block = Q – P

5.3 First law of motion

Newton presented the laws of motion by understanding the relation between force and motion. According to Newton, "every object remains in its state of rest or a state of uniform motion until some unbalanced external force acts upon it."

So we have read, inertia is that property of an object due to which the object resists any change in its state. Therefore, the first law of motion is also known as the 'law of inertia'.

Can you explain the following examples according to the first law of motion?

- On beating a blanket with a rod, all dust particles get removed.
- On shaking the trunk of a tree, the fruits hanging on its branches drop down.

Explain the reason behind these after discussing with your friends. Can you think of some other such examples?

> When we jump on the same position in a moving train, we fall back on the same position again. Why does it happen so?

5.4 Linear Momentum

The first law of motion tells us that when an unbalanced external force acts on an object, then there is a change in the velocity of the object. This change in velocity depends upon the force applied on the object. But how can we get to know the change in velocity? Lets discuss on this further.

If a tenis ball and a cricket ball thrown at a high speed hits you, you will get more hurt by which of the two balls? If a cycle and a truck moving at the same velocity hit a wall, the wall will get destroyed more due to which of the two? Think of more such examples and discuss on it. To think more on this, do the following activity-4.

Activity-4

- Take a big tray.
- Fill it with sand or wet soil.
- Drop a cricket ball and a plastic ball simultaneously from a same height on the tray. What happens? Is the effect of both the balls similar on the sand.
- If the cricket ball is dropped on the tray from different heights, what will be its effect? When will the ball sink more into the soil?

This activity shows that the impact of an object depends upon its mass. The impact of a cricket ball having greater mass is more. We also see that the ball when dropped from a greater height, falls on the sand with higher speed and sinks into the sand more. Mainly, the impact depends upon the velocity of the object and its mass. If any of these two quantities is increased in similar canditions, then the impact also increases.

The product of the mass of an object and its velocity is called 'momentum'. The momentum 'P' of an object is defined by the product of its mass 'm' and velocity 'v'. That means, P = mv.

Momentum is a vector quantity which has both magnitude and direction. The direction of momentum will be similar to the direction of velocity. The S.I. unit of momemtum is kilogram metre/second (kg. m/s).

Force and the change in momentum

Think of such a situation where a car with a week battery is pushed on a road so as to move it in a straight line. The car does not start initially but on applying force constantly for some time, the speed of the car increases. Now the car's engine can be ignited. We can say that by constantly applying force, the momentum of the car also increases gradually. It is clear through this that the change in momentum of the car does not only depend upon the measure of the force but also depends upon the time for which the force is applied. The change in momentum of an object depends mainly upon the amount of force applied and the total time of application of force.

5.5 Second law of motion

According to the second law of motion, "The rate of change of momentum of an object is directly proportional to the unbalanced force applied on that object".

If F is the net unbalanced force applied on the object, P is the momentum, then according to the second law of motion,

$$F \alpha \frac{p_2 - p_1}{t_2 - t_1}$$

where P_1 is the initial momemtum at time t_1 and

p_2 is the final momemtum at time t_2.

$F \alpha \frac{\Delta p}{\Delta t}$ where $\Delta p = p_2 - p_1$ (change in momentum)

$\Delta t = t_2 - t_1$ (change in time)

To remove the sign of proportionality, we put here a constant of proportionality K.

$$F = K \frac{\Delta p}{\Delta t}$$

On taking K = 1, $F = \frac{\Delta p}{\Delta t}$

$$F = \frac{\Delta p}{\Delta t}$$

$$F = \frac{m\Delta v}{\Delta t} \quad [p = mv]$$

$$F = m\frac{\Delta v}{\Delta t} \quad \left[\because a = \frac{\Delta v}{\Delta t}\right]$$

$$F = ma$$

This is the mathematical representation for the second law of motion.

If m = 1 kilogram (1 kg.)

a = 1 meter/second^2 (1 m/s^2)

then, F = 1 kilogram × 1 meter/sec^2 (kg.m/s^2)

f = 1 Newton (N)

1 Newton force is that force which when applied on an object of 1 kg. produces an acceleration of 1 m/sec^2 to the motion. Newton is the S.I. unit of force, it is represented using N.

Example-1. The force applied on an object of 3 kg. changes its velocity from 2 m/sec. to 3.5 m/sec. in a time period of 25 sec. Find the measure of the force applied.

Solution :

Mass of object	m	=	3 kg.
initial velocity of object	u	=	2 m/s
final velocity of object	v	=	3.5 m/s
time of application of force	t	=	25 sec.
to find,	F	=	?

we know that $F = \frac{p_2 - p_1}{t} = \frac{mv - mu}{t}$

$$F = \frac{m(v-u)}{t}$$

$$F = 3\frac{(3.5-2)}{25}$$

$$F = \frac{3\times1.5}{25} = \frac{3\times15}{250} = \frac{45}{250}$$

$$F = 0.18\text{N}$$

Therefore, the measure of applied force will be 0.18 Newton.

Example-2. On applying some force on a trolley of 5 kg. an acceleration of 10 m/s^2 is produced. Find the applied force.

Solution :

Mass of the trolley m = 5 kg

acceleration produced on the trolley a = 10 ms^{-2}

Force applied on the trolley F = ?

F = ma

F = 5 × 10

F = 50 N

Force applied on the trolley is 50 N.

Example-3. The figure shows the velocity-time graph of a 30 gm ball moving in a straight line on a table. How much frictional force needs to be applied to bring the ball to a state of rest.

Solution :

initial velocity of the ball u = 15 cm/s = 0.15 ms^{-1}

final velocity of the ball v = 0

time t = 5 s

mass of the ball m = 30 gm = 0.03 kg

Frictional force applied on the ball F = ?

$$F = m\frac{(v-u)}{t}$$

$$F = \frac{0.03\times(-0.15)}{5} = -0.0009\text{ N}$$

$$F = -9\times10^{-4}\text{ N}$$

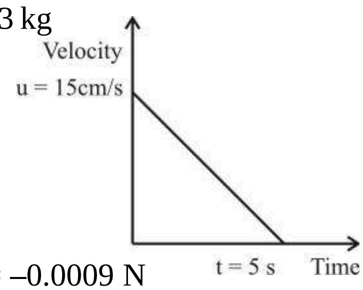


Fig. 4

Here, the negative sign shows that the frictional force is applied in an opposite direction to the direction of the initial velocity.

Example-4. A force of 10 Newton is applied for 5 sec. on an object of 5 kg. How much acceleration is produced due to this force? Also calculate the change in velocity of the object.

Solution : We know that the mass of the object	m	=	5 kg.
Force applied on the object	F	=	10 N
Time	t	=	5 s
We want to know the acceleration a and and the change in velocity	v – u	=	?
as,	F	=	ma
that means,	10	=	5 × a
a		=	$2 m/s^2$
$\because$ a		=	$\frac{v-u}{t}$
2		=	$\frac{v-u}{5}$
v – u		=	2 × 5 m/s
v – u		=	10 m/s
Change in velocity ,	v – u	=	10 m/s

Discuss

1. Why does a cricketer pull his hands backwards while catching a ball coming at a high speed?
2. When we jump from a height on a cemented floor we get hurt more as compared to when we jump from the same height on a bundle of hay.
3. A body moving at a constant speed is made to stop in 0.25 sec. by applying a force of 200 N. Calculate the initial momentum of the body.
4. A force of 5 N leads to an acceleration of 8 m/s^2 on a body of mass m_1. Same force causes an acceleration of 24 m/s^2 on another body of mass m_2. If both the bodies are tied together, how much acceleration will be produced by the same force?
5. If the net unbalanced force becomes zero, will the momentum also become zero? Explain.

5.6 Third law of motion

To understand the third law of motion, let us understand the following activity.

Activity-5

- Take a spring balance A and hang its fixed end on a wall with the help of a nail.
- Pull the free end of the spring balance and note the force applied.

- Now connect another spring balance B with A, as shown in fig.5.
- Pull both the springs A and B together and note down the applied force.
- You find that both the spring balances show the same value of force. Why is it so?

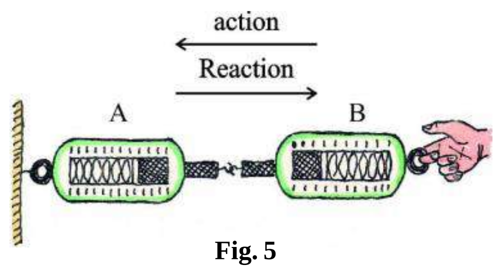


Fig. 5

In the above example, the spring balance B exerts a force on spring balance A. And a similar force is applied by A on B but in the opposite direction. Thus, both the similar forces act upon two different objects. When one body applies a force on the second body, the second body also applies the same amount of force on the first body but in the opposite direction. These pairs of forces acting on bodies are called as action-reaction forces.

According to the third law of motion "every action has an equal and opposite reaction". Action and reaction forces always act on two different bodies. Therefore even when these forces are equal and opposite, the net force is not equal to zero.

What happens when you walk? To start walking you need some force which causes acceleration. To produce acceleration we apply force on the ground through our foot, in a direction opposite to the direction of our movement. The ground also applies the same amount of force on our foot in an opposite direction which makes us move forward.

Notice that even if both the action and reaction forces have same magnitude, they do not cause same acceleration as the masses of both the bodies on which action-reaction forces act are different. The earth does not start moving backwards on getting pushed by our feet though it produces acceleration required by us to move forward.

If a body A applies a force of F_1 on body B and body B applies a force F_2 on body A, then according to the third law of motion $F_1 = - F_2$.

The negative sign here shows that the direction of force F_2 is opposite to the direction of F_1.

The first and second laws of motion are applied on the same object while the third law of motion is applied on two objects working together. Action and reaction represent those forces which act on two different objects at the same time.

Think about some other example of third law of motion.

5.7 The law of conservation of momentum

Suppose you have two balls A and B which have masses M_A and M_B respectvely. These two move in a straight line at a velocity of u_A and u_B respectively. There is no unbalanced force acting on them. Both these balls hit each other after a time t, the force applied by A on B is F_{AB} and the force applied by B on A is F_{BA}. Thus, the velocity of A and B now becomes V_A and V_B respectively.

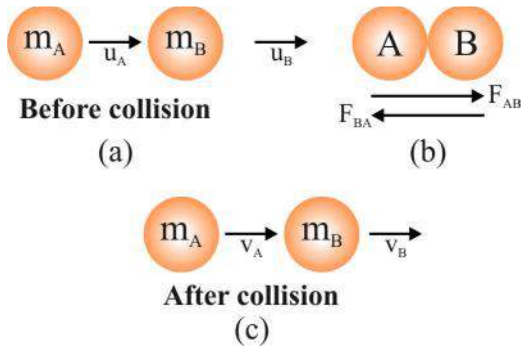


Fig. 6

The force applied by each ball on each other is equal and opposite, according to third law of motion.

Hence $F_{AB} = -F_{BA}$

There is a change in velocities of the balls due to these applied forces and hence change in momentum takes place.

So, according to second law of motion

Force = rate of change in momentum.

$$F_{AB} = \frac{m_B(v_B - u_B)}{t}$$

$$F_{BA} = \frac{m_A(v_A - u_A)}{t}$$

From third law of motion,

$F_{AB} = -F_{BA}$

$$\frac{m_B(v_B - u_B)}{t} = \frac{-m_A(v_A - u_A)}{t}$$

$m_B(v_B - u_B) = -m_A(v_A - u_A)$

$m_Bv_B - m_Bu_B = -m_Av_A + m_Au_A$

$m_Av_A + m_Bv_B = m_Au_A + m_Bu_B$

Momentum after collision = momemtum before collision

Through this equation we find that when there is an external force applied on the balls then there total momentum before and after collision remains same. The total momentum of both the balls does not change though their individual momentum does change. This is known as the law of conservation of momentum.

According to this law "The total momentum of two objects remains conserved in the absence of an external unbalanced force".

Let us perform an activity for this.

Activity-6

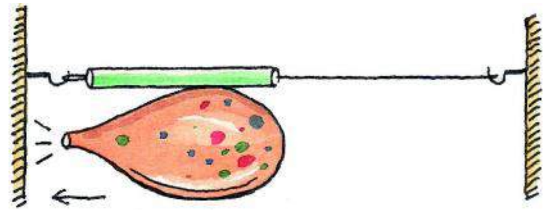


Fig. 7

- Take a huge balloon and after filling air in it tie its mouth using a thread.
- Attach a straw on the surface of the balloon using a cellotape.
- Pull out a thin and long thread accross the straw.
- Now tie both the ends of this thread across the walls. (as in fig.7)
- Now untie the thread put on the mouth of the balloon.
- As soon as you untie the thread, the air filled inside the balloon gushes out.
- Observe the motion of the balloon and the straw.

You can see that the third law of motion is applied in this situation. But can you say which are those objects on which this law is being applied?

Find out more examples which work on this similar concept.

Example-5. Two bodies of 40 kg. and 20 kg. masses are moving at a velocity of 10 m/sec and 50 m/sec. Their direction are towards each other. After a certain time period, they collide and stick to each other. What will be the velocity of this combined object.?

Solution : Given that,

Mass of first spherical object is $m_1 = 40$ kg

Mass of second spherical object is $m_2 = 20$ kg

Velocity of first spherical object $u_1 = 10$ m/s

Velocity of second spherical object $u_2 = 50$ m/s

Velocity of combined object after collision $v = ?$

According to law of conservation of momentum $(m_1 + m_2) = m_1u_1 + m_2u_2$

$$(40 + 20)\,v = 40 \times 10 + 20 \times (-50)$$

$$60v = 400 - 1000$$

[$\because$ As objects are moving towards each other $u_2 = -50$ m/s]

$$v = -\frac{600}{60}$$

$$v = -10 \text{ m/s}$$

Velocity of the combined object after collision is 10m/s and it will move towards the direction of 20 kg. object.

Example-6. A bullet of 20 gm is shot from a gun of 2 kg. at a velocity of 100 m/s. Find out the recoil velocity of the gun.

Solution :

mass of the gun $m_1 = 2$ kg

initial velocity of the gun $u_1 = 0$

mass of the bullet $m_2 = 20$ gm = 0.02 kg

initial velocity of the bullet $u_2 = 0$

final velocity of gun $v_1 = ?$

final velocity of bullet $v_2 = 100 \text{ m/s}^{-1}$

According to law of conservation of momentum

$$m_1v_1 + m_2v_2 = m_1u_1 + m_2u_2$$

$$2 \times v_1 + 0.02 \times 100 = 20 \times 0 + 0.020 \times 0$$

$$2v_1 + 2 = 0 \quad \text{or} \quad 2v_1 = -2$$

$$v_1 = -1 \text{ m/s}$$

Therefore, the gun will recoil with a velocity of 1 m/s backwards.

Discuss

1. If the action and reaction are always equal then explain how a bull is able to pull a cart forward?
2. The motion of a rocket is based on which concept?
3. A fire extinguisher is hurt by a rubber pipe that throws water at a very high speed. Explain this.

Questions

1. Two bodies of masses 1 kg. and 2 kg. are moving parallel to a line in the same direction, at a velocity of 2 m/s and 1 m/s respectively. Both the bodies collide with each other. After collision, the velocity of the first body becomes 1.5 m/s. Find the velocity of the second body after collision.

What we have learnt

- Force is that external factor which causes a change in the state of motion or the state of rest of an object or tries to cause a change.
- According to the first law of motion "A body remains in its state of rest or state of motion unless an external unbalanced force acts upon it".

- That property of an object due to which it resists any change in its state of rest or state of motion is called as inertia. The measure of inertia of an object depends upon its mass.
- The product of the mass and velocity of an object is called momentum. The direction of momentum is same as that of the direction of velocity of that object. The unit of momentum is kg ms^{-1}.
- If the time required for the change in momentum is less, then the applied force will be greater. In such a situation bringing a moving object to rest can hurt someone.
- According to the second law of motion, the rate of change of momentum of an object is proportional to the unbalanced force applied on it and is in the same direction.
- S.I. unit of force is $kgms^{-2}$ or Newton.
- According to the third law of motion, every action has an equal and opposite reaction. Both the action and reaction act on two different bodies.
- If there is no external force acting on an object then the momentum of the object remains conserved.

Keywords :- Balanced force, Unbalanced force, Inertia, Linear momentum, Laws of conservation of linear motion.

Exercise

1. Choose the correct option-

   (i) The reason for inertia of a body is-

   (a) only mass (b) only velocity

   (c) mass and velocity both (d) None

   (ii) A boy is sitting on the uppermust berth of a train. Just when the train is coming to a halt, he drops a mango in the open hands of his brother who is sitting on the seat right below him. Where will the mango fall?

   (a) right in his brother's hand

   (b) Some distance away from his hand in a direction opposite to the direction of train.

   (c) Some distance away from his hands in the direction of the train.

   (d) None of these.

   (iii) The concept of rocket launching is based on-

   (a) First law of motion (b) Second law of motion

   (c) Law of conservation of mass (d) Law of conservation of momentum

(iv) A ball stops in 0.06 sec. when a force of 500 N is applied to it. The momentum of the ball is-

(a) 500 N (b) 500 kgm/s (c) 30 kgm/s (d) 30 N

2. Fill in the blanks-

(i) The law of conservation of momentum is applied in the absence of ....

(ii) Both the ends of a balance are pulled with a weight of 20-20 kg. on each side. The reading on the balance is ....

(iii) The first law of motion is also known as the law of ....

(iv) If the acceleration of a body is doubled while keeping its mass constant, the force becomes ....

(v) Force is a .... quantity.

Discuss and Write

1. Three solids which are made up of aluminum, steel and wood respectively have same shape and volume. Say which of these solids will have more inertia and why?
2. Utensils made of glass break on falling on the ground but not when they fall on sand. Why is it so?
3. Write down the mathematical representation of the second law of motion and write the meaning of all the symbols used in it.
4. Why does a person get a backward push on using a gun.
5. Why is the luggage kept on the roof of a bus tied up with a rope?
6. Prove that if the momentum of two bodies is same then the velocity of lighter body will be more than the velocity of heavier body.
7. According to the third law of motion, when we apply a force on a body, the body applies equal and opposite force on us. If that body is a car standing aside a road, probably it will not get in motion on the application of a force by us. A student argues that both the forces here are equal and opposite and hence they cancel each other. Express your thoughts regarding this argument and tell why the car does not move in the opposite direction.
8. The velocity of a body of mass 50 kg. moving at a uniform accelerration becomes 7 m/s from 4 m/s in 6 sec. Calculate the initial and final momentum of the body and the force applied on it.
9. A football and a tenis ball are in a similar motion with same velocity. Both of them collide head on with each other and after some time they come to a stop. If the time interval of collision is 1 sec, then

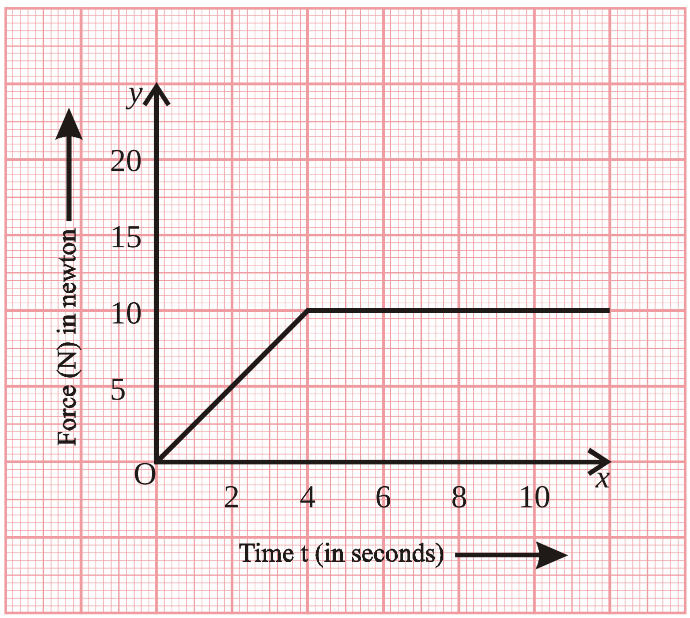
(i) Which of the two balls will be more affected by the force?

(ii) The momentum of which ball will change more?

(iii) The acceleration of which ball will be greatest?

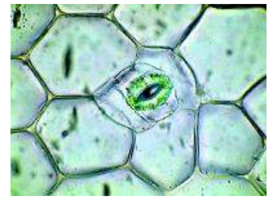
10. Prove that the total momentum of two objects remains constant before and after their collision.

11. The force-time graph of a body of mass 3 kg. is drawn in the following figure. Find the momentum of the body during the time interval of 0 to 10 sec.



Chapter 6

Fundamental Unit of Life : Cell



We have studied about the diversity in shape and size of cells of both unicellular and multicellular forms of organisms. We also studied that, in the year 1665, Robert Hook gave the name 'cell' to those compartments that he observed in a thin section of cork. Let us study the arrangement and functions of cells with the help of some activities.

6.1 Observing Different Types of Cells

We would require the following things to carry out our observations.

Blade, slide, coverslip, matchsticks, Rheo leaf, ice-cream spoon, red ink, microscope

Activity-1

Observing cells in a section of matchstick.

Take a matchstick and soak it in water for about an hour. Now use a sharp blade to cut a thin transverse section of it. Keep this section on a drop of water, put a coverslip on it and observe it under the microscope. Make a sketch of what you observe. Compare your observation / sketch with figure 1. This figure shows us the sketch that Robert Hooke made in the year 1665, after observing a section of cork under the microscope.

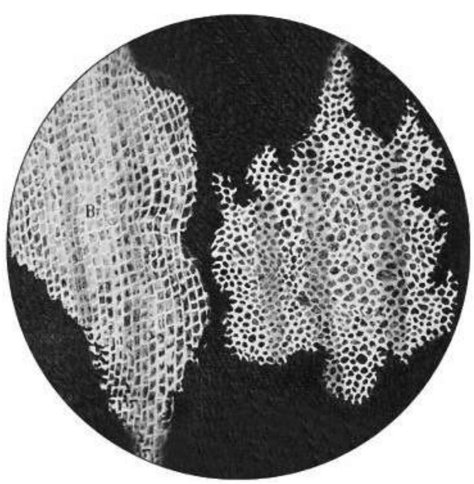


Fig. 1: Section of cork

Activity-2

Observing the outer layer of cells of a leaf

(Activity-2 and 4 may be done together)

Peel off a thin layer from the lower side of the leaf of Rheo. Keep this on a slide, put a few drops of water on it and spread it out evenly. Observe it under the microscope and try to make a sketch of your observation.

Compare it with figure-2 and try to answer the following questions.

- Do all the cells appear same?
- What parts are visible in the cell under the microscope?

You could do this experiment using the leaves of amorphophallous (zimikand) or china rose (Jasone) in case you don't have Rheo (The shape of stomatal guard cells would not match figure 2 if you use Amorphophallous). It will be helpful if the leaf is thick so that a peel can be taken off easily. You could stain the peel using a few drops of diluted red ink or safranin or alta.

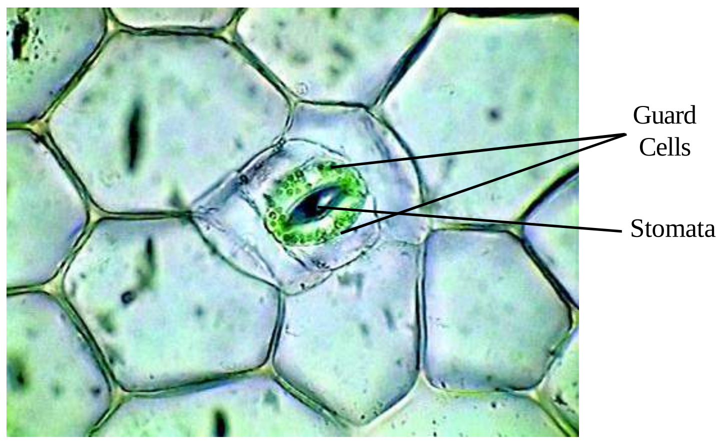


Fig. 2: Cells in the peel of Rheo leaf

Activity-3

Observing cheek cells

Use an ice-cream spoon to gently scrape off a layer(inside your mouth) from the inner walls of your cheek. Do not scrape too hard. Spread the scrapings in a drop of water on a slide. Use a few drops of dilute red or blue ink, safranin or alta to stain the scrapings. Observe the slide under a microscope.

- What are the similarities of cheek cells and cells in the leaf peel?
- Write a difference that you observe between them.

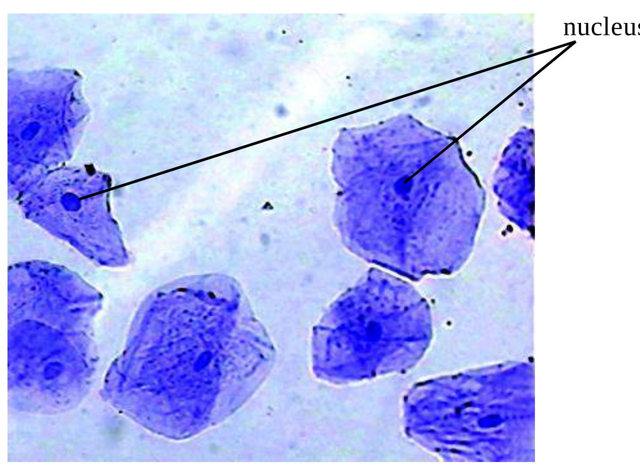


Fig. 3: Cheek cells

We often take the help of a microscope to observe cells as most of them are very small. But there are some large ones like the unfertilized eggs of hen and fish, a juicy hair inside a lobe of citrus fruit like orange etc.Following figure shows us some types of cells of the human body.

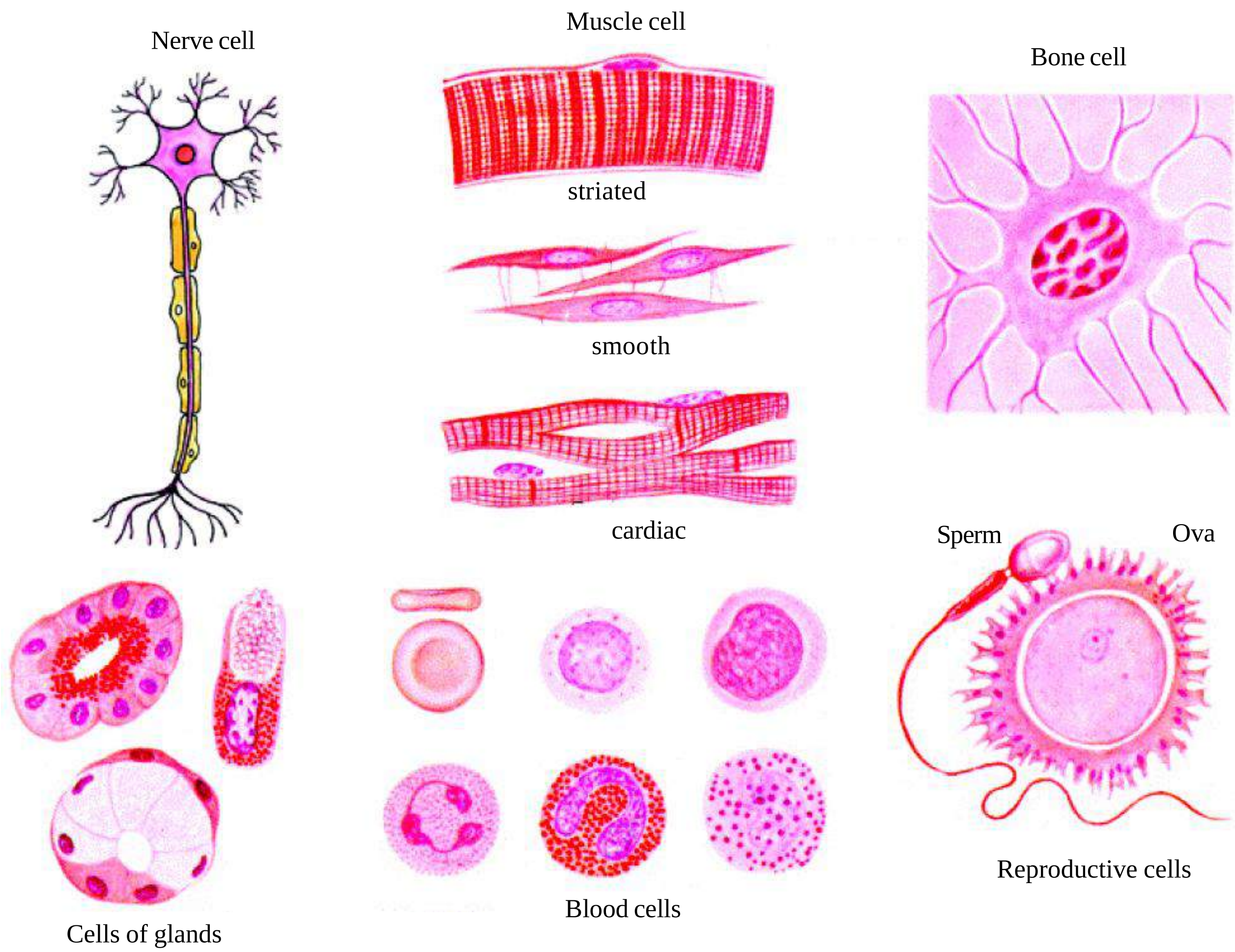


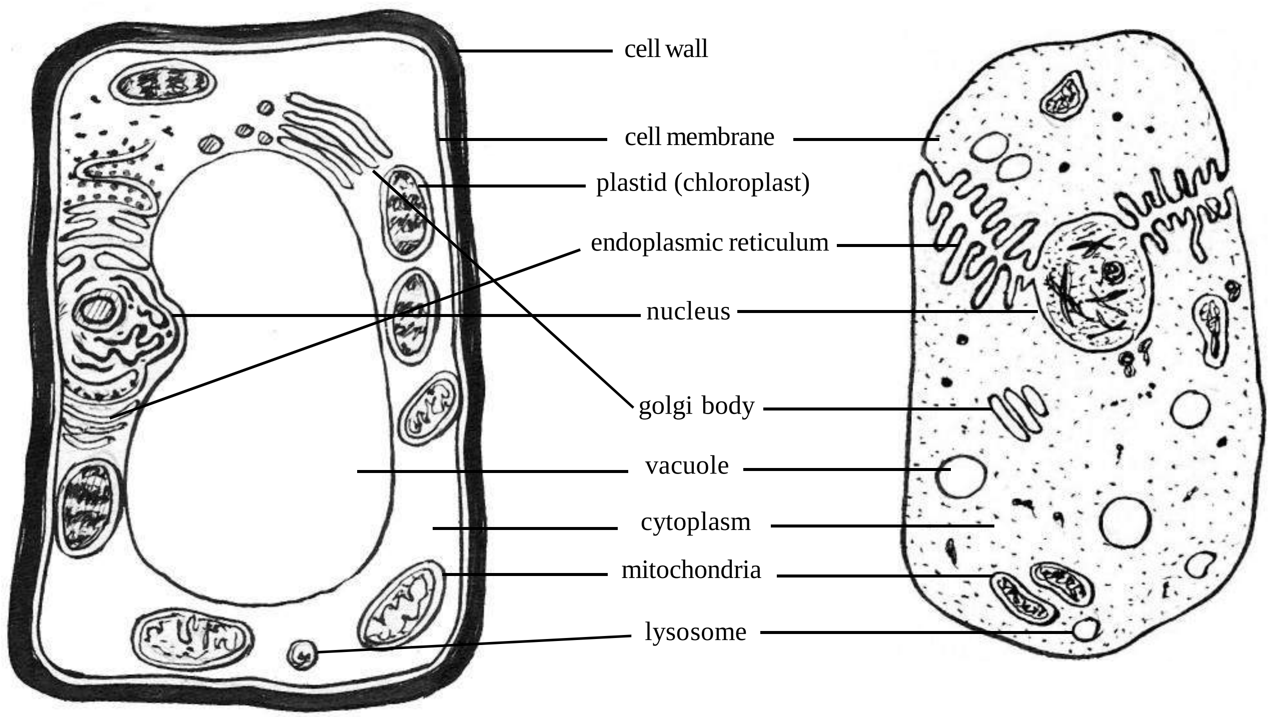
Fig. 4 : Different types of cells

- What differences could you find between these cells?

No matter how different cells appear, be they unicellular organisms or multicellular forms, all life processes (nutrition, respiration, excretion, transport and reproduction) occur in a cell.

6.2 Studying Cells: The Typical Cell

Keeping in view certain similarities of cells, scientists have tried to make models and diagrams to represent their structure. These are called as typical cells. The diagrams of typical animal and plant cells have been given here.



(a) Typical plant cell **(b) Typical animal cell**

Fig. 5

- What are the similarities that you see among the cells?
- Find out a structure present in plant cells but absent in animal cells.

The diagram of a typical cell is drawn on the basis of information gathered from various sources. Usuatly the structure of it is drawn as per the existing knowledge of cells in such a manner that we may get an idea of its appearance. There are several scientists today who treat unicellular organisms as models or typical cells to study cell structure and function. This helps them to get a live and dynamic resemblance to the form of cells. Such a diagram or a model becomes necessary to study cells and their internal structure whether they be our own body cells or those of any other organism.

Do you know?

Within just a period of 200 years we have been able to make microscopes that can give us an enlarged view of cells ranging from 10 to 5 lakh times their actual size. The technology of staining has also improved to such an extent that we are getting deeper insights about the functioning of cells. The structure of cells and their functioning is very complex and our knowledge regarding it is still incomplete, thus research in this area is an ongoing process.

It is not essential that all the parts of cells shown in a typical animal or plant cell may be present at a time in all actual cells. We often see structural variations in cells depending on the function that they carry out. The numbers of cellular parts are also not shown in a typical cell as for example plant cells may have hundreds of chloroplasts, but in a typical plant cell we see only one or two of them. Moreover all plant cells do not have chloroplasts but we see that the diagram of a typical plant cell always contains atleast one. Some parts are of course present in all living cells, but not all parts as shown in a typical cell may be present in all cells. Apart from this, the diagram of a typical cell is not drawn to scale, that is the actual proportion of different parts of the cell are not represented. If we make an attempt to draw a scale diagram of a true cell, the proportion of the cell to its parts could be somewhat like this - if the diameter of the cell is 30 meters, that of its nucleus could be 6meters, a mitochondria would be a meter across and a ribosome merely a centimeter across. This proportion varies from cell to cell. Thus the diagram of a typical cell is only a representative one showing a virtual arrangement.

6.3 Organization of the Cell

The cell has an internal structure that keeps changing. Regarding its parts we have so far come to know that some of them are formed from its membrane itself. We shall study such parts under endomembrane system. There are some other parts that were formed due to the entry of an organism into a cell. The symbiotic coexistence of this part with the cell made it an important part of the cell. We shall study these under endosymbiosis.

- Think and write about the relations that parts of cells have among themselves.

6.4 Endomembrane System and Cell Parts

Endoplasmic reticulum, golgi body, lysosome, cell membrane, nucleus etc. fall under this category. These parts are membrane bound, enclose a space within them that is partioned off from the cytoplasm and usually contain a fluid that differs from it. These parts have contacts and relations among themselves in various ways. One such pathway showing an arrangement of flow of substances is given in figure 6. The direction of arrows represents the flow of substances which can be in both directions.

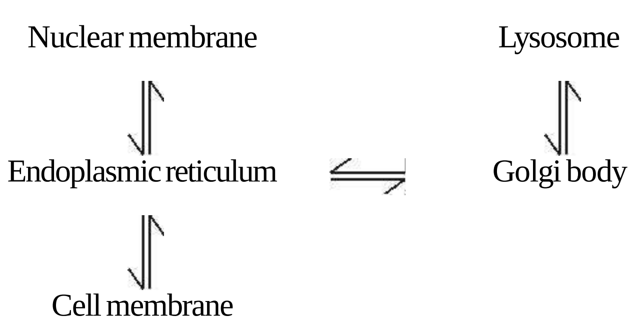


Fig. 6 : The interrelationship of some of the parts of endomembrane system

- Write any three routes though which substances pass to the cell membrane.

Let us now try to know about the structures of some parts of this system in detail.

6.4.1 Cell Membrane

Activity-4

Observation of the cell membrane

Make a concentrated sugar solution(say by dissolving two teaspoonful of sugar in half a cup of water). Put two drops of this on a freshly prepared slide of the peel of Rheo leaf(refer to activity 2). Leave the slide aside for some time (minimum 5 minutes). Now observe it under the microscope.

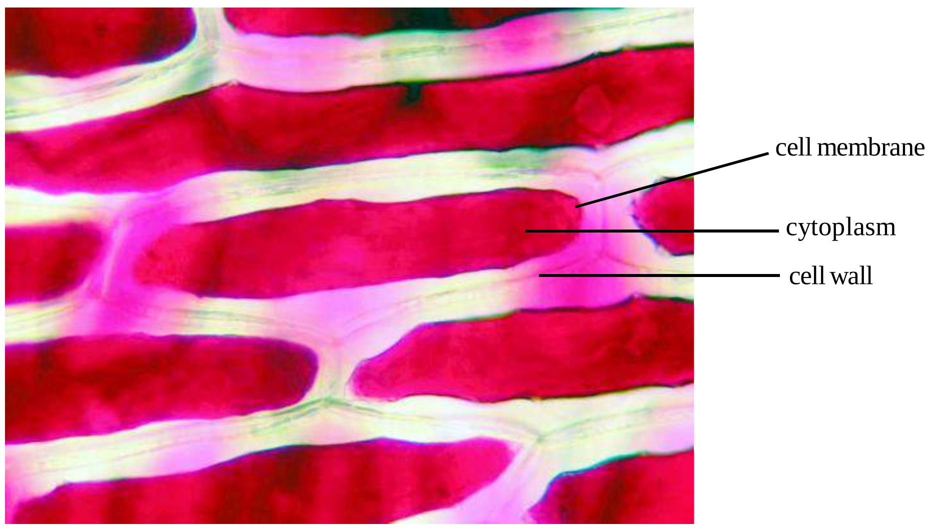


Fig. 7 : Shrinking of cytoplasm in the cell

Did the pink color shrink to a corner of the cell? The outer edge of this colored portion is the cell membrane (refer to diagram of typical cell). The cell membrane along with cytoplasm has moved away from the cell wall. This occurs when the contents shrink and the process is called as plasmolysis.

- How do you think the cytoplasm may have shrunk?

One reason for this is movement of water out of the cell. Does it have something to do with concentration of fluids within and outside the cell?

Suppose there was more water in the sugar solution than that inside the cytoplasm of the cell, water would have moved into the cell. The reverse would occur if concentrations were changed. Thus, the movement of fluids across a membrane due to a difference in concentration is called as osmosis.

Something like this occurs even across the cell membrane which plays a very important role in the passage of materials across it. The structure of the cell membrane is visible only under the electron microscope. It is elastic in nature and made up of mainly proteins and fatty, oily substances called as lipids. It is a bilayer membrane that forms a protective covering of the cytoplasm giving a shape to the cell. Substances are selectively passed across the cell membrane and thus it is called as selectively permeable membrane.

- What would be the effect on a cell if the membrane was not selectively permeable?

Do you know?

There are certain sites of identification on the cell membrane that help cells to recognize each other. This has a lot of importance in the life of organisms. During the early developmental stages, as cells of different layers are formed and displaced, cell to cell connection is established with the help of these sites. Cells recognize each other and connect to play an important role in the formation of tissues and organs. Apart from this, the cells of the body of an organism are able to identify any foreign cells with the help of these sites.

We had tried to observe the cell wall and cell membrane separately with the help of plasmolysis in plant cells in activity-4. We shall now use an unfertilized egg(the common poultry egg) to observe the cell membrane of an animal cell.

Activity- 5

Observing cell membrane in an egg

We would need, an egg, vinegar(circa), beaker, concentrated sugar solution and water for this activity.

Keep the eggs in vinegar for 4-5 days, turn it regularly. The calcium carbonate present in the hard shell would dissolve. A thin translucent covering would be visible and you could touch to feel its texture. This smooth elastic covering is the cell membrane. Now put it in the beaker containing concentrated sugar solution and leave it for around 10 minutes.

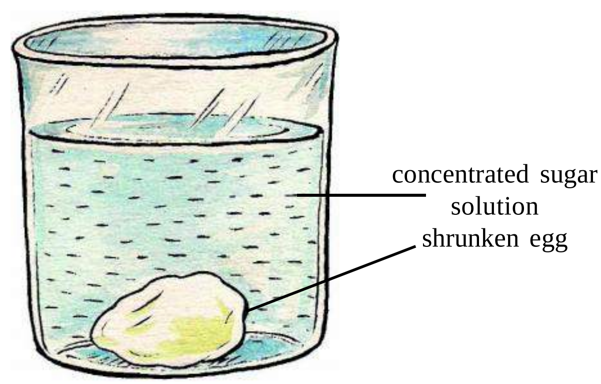


Fig. 8 : A deshelled egg kept in concentrated sugar solution

- What difference do you see in the egg now? What could be the reason for this?

6.4.2 Cell Wall

Cell wall is a special feature of plant cells. Animal cells usually lack a covering outside the cell membrane. Nearly all plant cells have a very prominent mainly cellulosic cell wall that forms a strong covering over the cell membrane. This is a prominent distinguishing feature of plant cells.

It is a hard or elastic and porous covering that renders a particular shape, support and protection to the plant cell. This layer is formed from the live cell. The cells that Robert Hook saw in a section of cork or those of the matchstick are dead cells in which we can see the cell wall.

- What is the difference between cell wall and cell membrane?
- What do you think is the role of cell wall in a plant cell?

6.4.3 Cytoplasm

Cell membrane delimits the extent of the cytoplasm, forming a boundary of it. All other parts of the cell like mitochondria, plastid, endoplasmic reticulum, nucleus etc. are found in the cytoplasm. Thus the cytoplasm is a basic fluid in which, stored, secretory, excretory substances are present. The water content of cytoplasm is usually large.

6.4.4 Nucleus

Robert Brown saw a structure in the center of the cell which he named nucleus in the year 1831. This is a very important part of the cell.

- Observe figures 5 a and b and state whether the nucleus is always located in the center of the cell.
- Which type of cell do you think Robert Brown may have studied, plant or animal?

Do you know?

Some cells do not have a nucleus like the red blood cells in mammals or a type of cell of xylem or phloem tissue(you will read about them in the next chapter) in plants. Actually these cells do contain a nucleus in the initial stages, that degenerates and there is more space available for the transport of substances.

There are thread like structures inside the nucleus which are called as chromatin. They are mainly composed of genetic material. These appear as rods during cell division and are called as chromosomes. Characters from parents are carried to young ones by these structures.

Nucleus controls and coordinates all functions of the cell. It also determines the characteristic features of living organisms. We find a bilayered nuclear membrane around the nucleus that is similar to the cell membrane, in most cells.

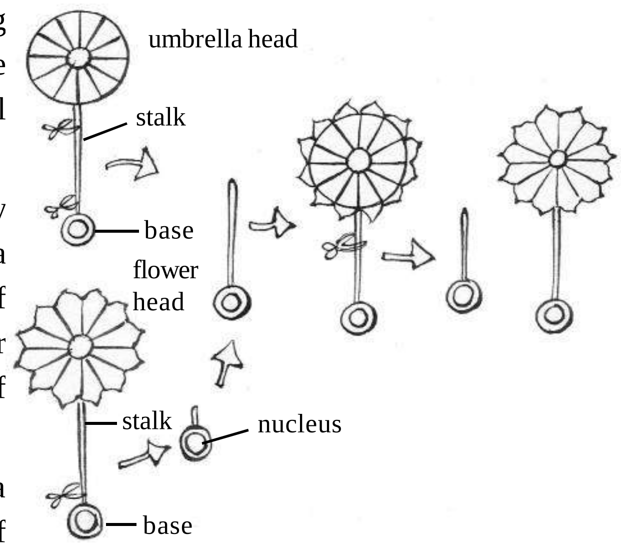
Nucleus forms a major basis of classification. Organisms having a membrane bound nucleus are called eukaryotes while those without the membrane are prokaryotes.

Do you know?

Experiment on Acetabularia

A German scientist named Joachim Hamerling experimented on Acetabularia and showed for the first time in 1934 that the nucleus determined all the characters of an organism.

This marine alga is unicellular and has a body with three clearly distinguishable parts, an umbrella like head, a stalk and a base. Different species of the alga have different types of head, like flower shaped, in the form of a reverse umbrella etc. If the head is cut out, it grows again on the stalk.



Hamerling took the base of the alga with a flower shaped head and transplanted the stalk of the algae with an umbrella shaped head. The head of this alga had combined features of both the flower headed and umbrella headed algae. Thus some substances from the base and the stalk determined the form of head. He cut the head of this newly formed alga. The head that formed now was in the shape of a flower. This showed that certainly some substances passed on from the nucleus that determined the shape of the head.

Hamerling had already observed that the base of alga had the nucleus. His experiments along with others on nucleus and cell formation confirmed that the nucleus had the information to form a cell of the body of an organism.

- Can the nucleus be called a control center of the cell? Why?

6.4.5 Endoplasmic reticulum

You will find an extensive network of tubes and vesicles(small rounded bag like structures) in figure 5 a and b. When observed under the electron microscope it appears rough at some places and smooth at others. The figure also shows rough and smooth endoplasmic reticulum. Rough endoplasmic reticulum has ribosomes on its surface and helps in the synthesis of proteins. Smooth endoplasmic reticulum helps in the synthesis of fats. Substances formed with the help of endoplasmic reticulum are constantly involved in the process of membrane repair and synthesis.

- Through which cellular part, can materials be transported from the nuclear membrane to the cell membrane?(take the help of figure 6)

6.4.6 Golgi body

These were first described in the year 1898 by Camillo Golgi and are the only parts in a cell named after a scientist. These are membranous bag like structures There are some fluid filled vesicles along its edges and around it. The proteins synthesized by ribosomes are sent to the golgi body for packaging in vesicles before transport to other sites inside the cell, or outside it.The number of golgi bodies vary from cell to cell. Secretary cells often have large numbers of them.

6.4.7 Lysosomes

There are some lethal substances present in the cells that have the ability to digest the entire cell. How is it that a cell is not affected by them normally? This could be answered with the discovery of lysosomes which were found to be membrane bound bodies that contained the lethal substances. Thus in a normal condition these substances were not in contact with other substances of the cell. The lysosomes destroy certain substances that are produced in the cell or may gain entry into them that are harmful (they are also capable of breaking down larger molecules to smaller ones whether they are harmful or not). Lysosomes themselves may be destroyed in this process. They are also capable of digesting the whole cell, thus they are called as suicidel bags of the cell.

- What do you think will be the role of a lysosome in a completely infected cell?

6.4.8 Vacuoles

- Which is the largest part in the plant cell as seen in Figure 5a?

Fluid filled bodies of various shapes that usually contain storage products are called as vacuoles (term vesicles used earlier represent very small vacuoles). Usually animal cells have smaller vacuoles as compared to plant cells.

6.5 Function of the endomembrane system

Let us take an example to understand the function of this system. This will give us a further idea of how parts within a cell work together to carry out a certain function.

Ribosomes attach to the walls of the endoplasmic reticulum during the process of protein synthesis. The synthesized protein molecule enters the cavity of the endoplasmic reticulum. Small vesicles form from the endoplasmic reticulum that carries these protein molecules to the golgi body. Here packaging of these molecules are done in such a manner that more proteins may be transported together and they may not be damaged during transport. These are then transported to other parts of the cell like nuclear membrane, cell membrane etc. These are used for different purposes like repair or construction of different parts or may be secreted out of the cell for other purposes.

6.6 Parts formed by endosymbiosis

Scientists have found that some parts of the cell were formed due to the entry of a unicellular organism into another. The cell that entered was bilayered membrane bound and had genetic material in it. As time passed these became symbiotic inhabitants in the host cell. They got shelter in the host cell, while the host cell got some important substances like nutrients and energy from the guest cell. These guest cells formed mitochondria or the chloroplast, The former mainly helped in providing energy to the host cell, while the later mainly provided some essential nutrients to it.

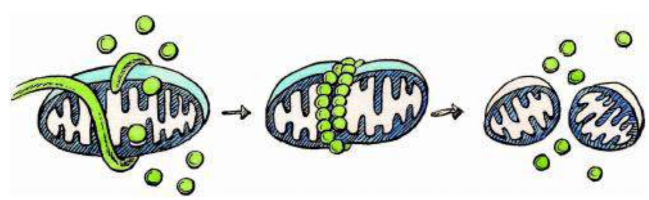
6.6.1 Mitochondria

Different cells have different shapes of mitochondria in them like spherical, rod shaped or branched. These are nearly 6 to 10 times shorter than the nucleus. There can be around 100 to 1000 mitochondria in a cell. 15-20% of a mammalian liver cell consists of mitochondria.

Mitochondria play an important role in the respiration of the cell. It functions as an energy source for running life processes within the cell. Mitochondrial genetic material passes from one generation to the other as mitochondria divide within the cell, during cell division or otherwise.

Do you know?

There is a dynamic relationship of endoplasmic reticulum and the mitochondria. It has been observed that tubules of the endoplasmic reticulum form a noose around the mitochondria stimulating its division. The noose tightens as the mitochondria divide into two parts each of which start functioning as an individual mitochondrion.



- Why is it necessary for mitochondria to be present in large numbers inside a cell?

6.6.2 Plastid

These are mainly found in plant cells. We do not find them in animal cells (follow Whittaker's classification for definition of animals)

Plastids may be of two types on the basis of presence or absence of pigments.

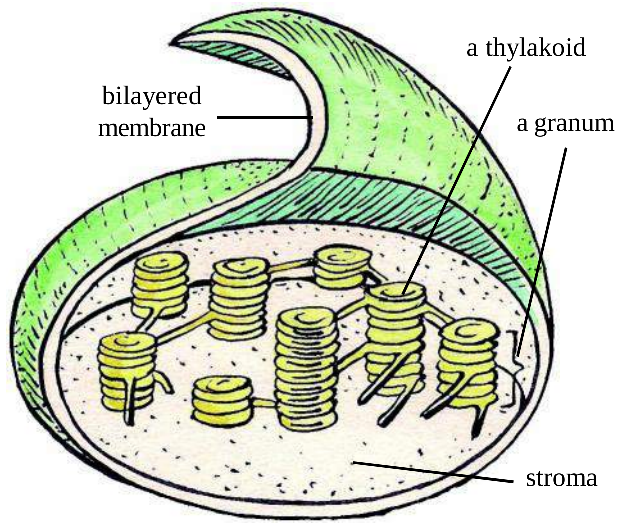
They are-

1. **Colorless plastids-** these lack pigments and are often found as starch filled bodies in maize, potato and radish cells.

2. **Colored plastids-** These contain various pigments and are found in some cells seeds, flowers, leaves, fruits etc. of the plant. The green colored plastid is called as chloroplast. It may be of various shapes like disc, egg, ladder like, ribbon like, star shaped, ring shaped, reticulate etc.

The diameter of a chloroplast is nearly twice that of a mitochondrion. It is bounded by a bilayered membrane. Apart from this there is another membrane that forms coin shaped sac like structures called as thylakoids and their interconnections. Thylakoids arranged in a stack like manner are called as grana.

Stroma is the substance filled between the membranes.



Apparent 3D view of a chloroplast

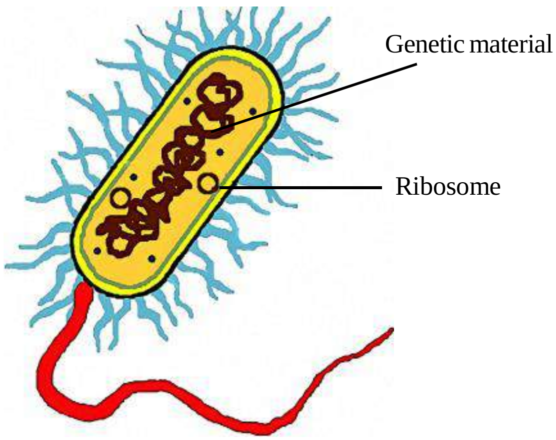
Photosynthesis occurs in plants cells due to the presence of chloroplasts.

- Think why? The chloroplast is often called as the kitchen of the plant cell.
- How would the working of a cell be affected if mitochondria were absent?
- What were the special features of organisms that entered and started living symbiotically in a host cell?

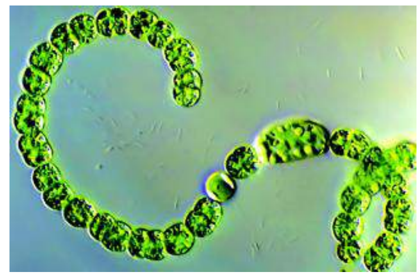
So far we had been studying eukaryotic cells, that is, those containing a membrane bound nucleus. Now let us study prokaryotic cells and their characteristic features.

6.7 Characteristics of Prokaryotic Cells

These cells are bound by a cell wall and a cell membrane. They lack some parts observed in the eukaryotic cell like mitochondrion, endoplasmic reticulum, golgi body etc. The functions of these parts are carried out in the cytoplasm itself. Some of the life processes of these organisms are carried out on the inner side of the cell membrane. These have ribosomes of a smaller size as compared to eukaryotic cells. Most bacteria and cyanobacteria are prokaryotic organisms.



(a) Bacteria



(b) Cyanobacteria

Fig. 9: Prokaryotic organisms

- With the help of chapter 1 write other characteristic features of prokaryotic organisms.
- Write at least two differences between eukaryotic and prokaryotic cells.

All life processes like respiration, nutrition, excretion of waste products etc. go on in the cells. All the parts of the cell function in coordination with each other to carry out these processes properly. It is just as all parts of our body function in coordination to carry out these processes in our body. Thus cells have been called the functional unit of living forms.

6.8 Cell Theory

People believed for a long time that life originated spontaneously from air, water and soil. It is only a couple of centuries back, after long periods of research, that we came to know that this was not so. Only living organisms gave rise to other living organisms. But what was that unit from which life forms and the structure of all organisms are made of? Nearly 200 years back research in search of this unit started. Some scientists who largely contributed towards this were Mathais Jacob Schleiden, Theodore Schwann and Rudolf Virchow.

Theodore Schwann was a zoologist while Schleiden was a botanist. Both had extensively studied cells and found that cells were those units that formed the bodies of living organisms. Nearly two decades after this, in the year 1855, Rudolf Virchow found that cells divided giving rise to new cells.

These scientists together proposed the cell theory that became a fundamental theory of life science. The cell theory states that-

1. All living organisms are made up of cells, their communities and intercellular substances.
2. Cells are the structural and functional unit of living organisms.
3. Cells arise from pre-existing cells.

It is important to note that it took nearly 200 years from naming the cell to proposing the cell theory.

- How does cell theory establish our understanding of cells?
- Can we attribute any theory of science to an individual scientist only? Why, why not?

6.9 Why are cells usually small?

Cells are usually so small that it is not possible to see them without a magnifier.

- Have you ever thought why cells may be so small?
- What would happen if cells were big?
- What are the advantages for a cell to have a small size?

We have studied that there is a continuous exchange of materials like nutrients, gases and excretory products between the cell and its surrounding. This happens through the surface of the cells. If the exchange occurs across smaller distances it would require less energy. It could only be possible if the size of the cells were small.

Let us try to understand this with the help of some mathematical calculations -

If we consider a cell to be spherical then, as its radius doubles, the increase in surface area would be in squares and that of volume in cubes.

Let us see the values given in the table. Surface area and volume have been calculated in each case and presented in the table.

Table 1 : The ratio of the surface area to volume of a spherical cell

Radius(mm)	0.5	1.0	1.5	3.0	3.5
Surface Area(SA)	3.4	12.6	28.6	113.4	153.6
Volume(V)	0.6	4.7	14.4	112.5	179.5
Ratio of SA to V	6:1	3:1	2:1	1:1	0.8:1

We may find such relations in different shapes of cells as well.

Observe the table and answer the following questions.

- As the radius of the cell increases what difference do you observe in the surface area and volume of it?
- How does the radius affect the ratio of surface area and volume of cell?

Larger surface area would increase the area of contact with resources outside a cell and thereby also the chance of entry of more of the resources into the cell.

An increase in volume of the cell would increase demand of more resources. We have seen that the increase in surface area is less as compared to the volume. Thus as cell size would increase the demand for intake of resources from the surface would increase.A lesser surface area would fail to meet up to the demands. Thus the pace of life processes would decrease.

You have observed some large cells like that of the eggs of hen (the area with the yolk). These have attained their maturity and their life processes have become very slow. You may have now understood how in spite of their large size they remain alive.

6.10 Are Cells Flat?

Cells appear flat or two dimensional when we observe them under the microscope. No matter how small they might be, cells are actually three dimensional and have length, breadth and height. We may observe the egg cell of birds, or a juicy hair cell of an orange to get an idea of this.

Key words

prokaryote, eukaryote, cell theory, nucleus, mitochondria, chloroplast, lysosome

What we have learnt

- Cells are the structural and functional unit of living organisms.
- Cells were discovered by Robert Hooke.
- Cells are bounded by an elastic, selectively permeable membrane.
- Plant cells have a cell wall, around the cell membrane, made of cellulose.
- Eukaryotic cells have membrane bound nucleus.
- Lysosomes are membrane bound organelles that contain digestive enzymes capable of digesting several types of substances.
- Packaging of substances are done in the golgi bodies
- Mitochondria are the power house of the cell.
- Plastids are found only in plant cells. They are of mainly two groups- colored and colorless.
- Chloroplasts are chlorophyll containing green colored plastids.
- Prokaryotes do not contain membrane bound organelles.
- Cells are not flat they are three dimensional.
- Genetic material is found in the nucleus, mitochondria and plastids of cells.

Exercise

1. Choose the correct option

   i) Name 'cell' was given by one of the following-

   (a) Robert Hooke (b) Robert Brown

   (c) Leeuwenhoek (d) Flemming

   ii) Cell theory was proposed by-

   (a) Shleiden, Schwann and Virchow

   (b) Watson and Crick

   (c) Darwin and Wallace

   (d) Mendel and Morgan

   iii) Single layered membrane is found in-

   (a) Mitochondria (b) Chloroplast

   (c) Lysosome (d) None of the above

   iv) Cellulosic cell wall is not present in one of the following-

   (a) Bacteria (b) Cells of Hydrilla

   (c) Cells of Mango plant (d) Cells of Cactus

   v) Prokaryotic cell has one of these-

   (a) Mitochondria (b) Ribosome

   (c) Plastid (d) Lysosome

2. Draw a typical plant cell and label the following parts-

   (a) Cell wall (b) Nucleus (c) Chloroplast (d) Vacuole

3. Write a difference between cell wall and cell membrane.
4. Draw a labeled diagram of a typical animal cell.
5. How are prokaryotic cells different from eukaryotic cells?
6. Explain how the cell theory clarifies our understanding of the cell?
7. Write two similarities and differences between mitochondria and chloroplast.
8. Write the names of those plant parts that contain colorless plastids, chloroplasts, other colored plastids (those other than chloroplast).
9. Explain the function of endomembrane system.
10. Why are cells usually small?

11. We add salt while cooking vegetables. As soon as we add salt we find water coming out. Explain why this happens.

12. What will happen if -

    (i) There is no nucleus in a cell

    (ii) Plasma membrane of the cell bursts

    (iii) Boil a Rheo leaf in water and put it in concentrated sugar solution

    (iv) Golgi body is removed from the cell

Chapter 7

Multicelluar Structure : Tissue

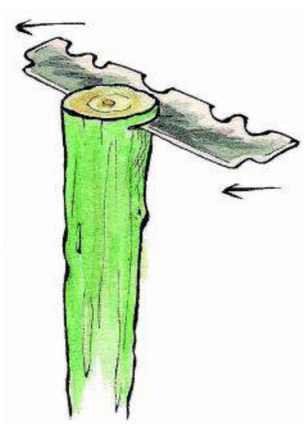
We studied about cells, their structure and function in detail in the previous chapter. We know that all living organisms are composed of cells. The thin layer of cork that Robert Hooke observed under the microscope consisted of a group of several cells. Hooke had named a member of the group, as a cell. We see groups of cells when we try to observe different parts of animals and plants under the microscope, like the leaf peel, internal layer of cheek, muscle of fish/chick etc.

Let us perform some activities to find out some functions that groups of cells are capable of doing.

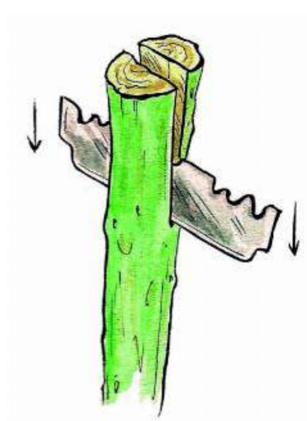
Activity-1

We would need a glass tumbler, red ink, cutter or blade, hand lens and a plant with soft stems or firm leaf stalks (like amorphophallous or jimikand/periwinkle/canna/moneyplant) to perform this activity.

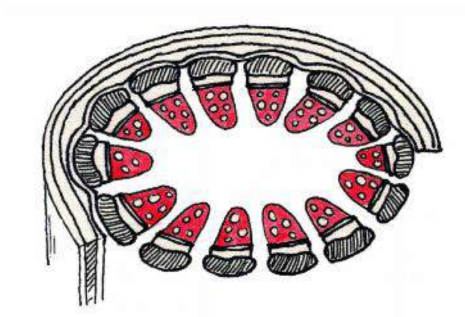
We would need two stalks of the plant. Take one stalk and cut the base uniformly to make it flat. Now observe it with hand lens (for periwinkle and money plant it would be better to cut a transverse section of it and observe it under the microscope). Cut a longitudinal section of the stalk as well. You may take the help of the figure 1 for this. Make a sketch of your observations. Add water to the cut sections so that they don't dry up.



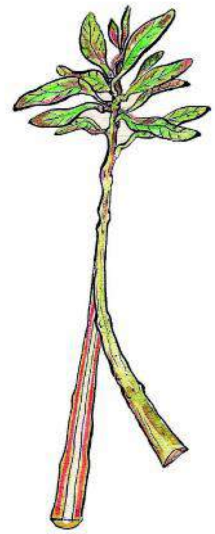
Transverse section



Longitudinal section



(a) Transverse section-
stem of dicotyledonous plant



(b) Longitudinal section-
stem of dicotyledonous plant

Fig. 1

Take an empty glass tumbler and fill 3/4th of it with water. Add enough red ink to get a dark red solution. Place the other stalk of the plant in the tumbler and see to it that the plant stands upright. Leave the set up in sunlight for two hours. Now cut transverse and longitudinal sections of this stalk and observe it carefully. You may take the help of figure 1(a) and (b) for this.

Fig. 2 : stalk of periwinkle immersed in red ink solution

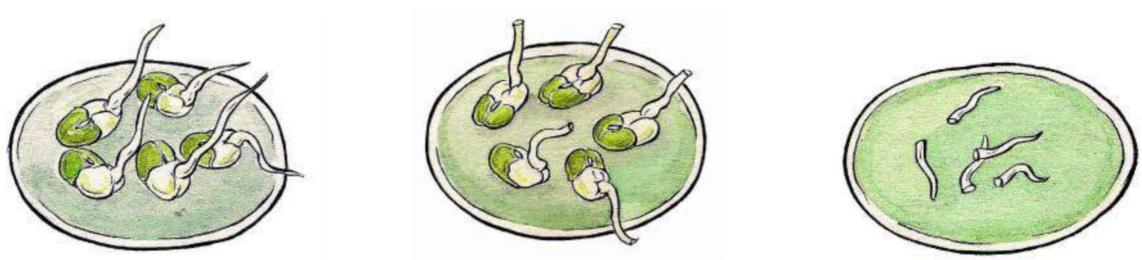
- What major difference do you find while comparing your observation of both the stalks?
- Why do you think only some areas are reddish in the second stalk?
- Can we say that these areas are involved in conduction of water in the stem?

We can clearly see that cells in the colored area are arranged in a manner different from those around them. These areas are involved usually in upward conduction of water in a plant.

Activity-2

For this we would require a clean cotton cloth, gram/moong seeds, blade, 4 bowls, slide, coverslip, red ink, microscope, candle, match box

Soak around 30 seeds either of gram or moong in a bowl for at least 6-7 hours. You may then remove the seeds from the bowl and loosely tie them up in a cotton cloth. Wet the cloth from time to time so that the seeds don't dry up. The seeds would germinate and in 2-3 days they would have quite a long radicle. Choose 10 seeds that have a long clear radicle. Keep 5 of these in bowl A. Put the other 5 in bowl B. Now measure the length of all the radicles of bowl A and B. You may use a thread for the same. This is length for first day. Cut around a millimeter of the tips of the radicle of bowl B and put the cut ends in bowl C. Keep them moistened so that they do not dry. Let them grow for another 3-4 days. On the fifth day measure the radicles once again.



(a) Bowl (a) 5 germinated sead of moong

(b) Bowl (b) 5 germinated seeds with root tip cut

(c) Bowl (c) with 5 root tips

Fig. 3

Table 1

Length of Radicle	Bowl A					Bowl B				
First Day										
Fifth Day										

- Which bowl had longer radicles after the 5th day?
- Did the radicles grow after their tips were cut?

Activity-3

We will use the freshly cut tips of bowl 3. You may do this activity as soon as you cut the tips of the radicles in activity 2. Take a cut tip and place it on a few drops of water on a slide. Heat the slide on a candle flame for some time. Do not let the water dry up completely. Now add a drop of diluted red ink or safranin and cover it with a coverslip. See to it that no bubbles remain under the cover slip. Now gently tap the coverslip with the back of your pen to flatten the tip. Observe the slide under the microscope. Take the help of Figure 4 for your observation. Make a sketch of what you observe.

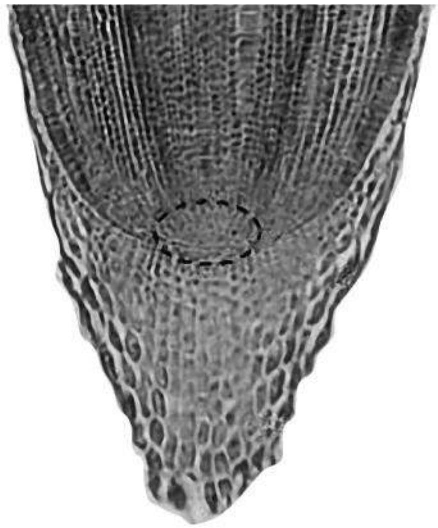


Fig. 4 : Arrangement of cells in the tip of the radicle (circled area shows the fast growing cells)

- In which of the bowls the growth of radicle continued?
- What do you think is the function of the tip of radicles?

You have thus observed that the tip of the radicle had the cells that were responsible for growth. Once these were removed, the tips did not grow in bowl B, while in A growth continued as the cells were present.

We observed so far in activity 1, 2 and 3 that there are some groups of cells that conduct water in plants while there are some others that carry out growth in plants. We also observed that their arrangement differed from those around them. We may thus say that cells are arranged in living organisms in particular patterns to carry out one or more functions. Such arrangements of groups of cells are called as tissue.

7.1 How did we come to know about tissues?

The name 'tissue' was given to interwoven structures by Marie François Xavier Bichat while he was studying diseased parts in the human body. The mention of tissue is found in a book he wrote in the year 1799 giving a detailed description of the composition of tissues of the human body. You may be surprised to learn that, though the microscope was in use in Bichat's time he never used it in his observations. His study was based on his observation of animal tissues which he classified mainly into three categories as-

1. Fibrous or those that were fiber like
2. Serous or those that were watery fluid like
3. Mucous or those that were slimy

He further subdivided these categories into 21 other types which he identified mainly on the basis of their function. Almost all names in classification of animal tissues and most of their description come from Bichat's classification (including nervous, connective, muscle etc.).

Bichat was not the only scientist studying tissues. About a century before Bichat coined the name, scientists had been studying, describing and naming them on the basis of the nature of their surface, composition and function. Nehemiah Grew(1641- 1712) was one of them who, while studying plant matter, inferred that they were composed of 'pithy' or soft and spongy, and 'woody' or hard parts. Nehemiah Grew used the term 'Parenchyma' for the first time for pithy cells having thin walls that appeared to have material poured into their spaces. Schleiden and Schwann also studied such groups of cells and they found that the transverse section of shaft of bird feather and the lining of a lamb's stomach had cells that were similar to parenchyma.

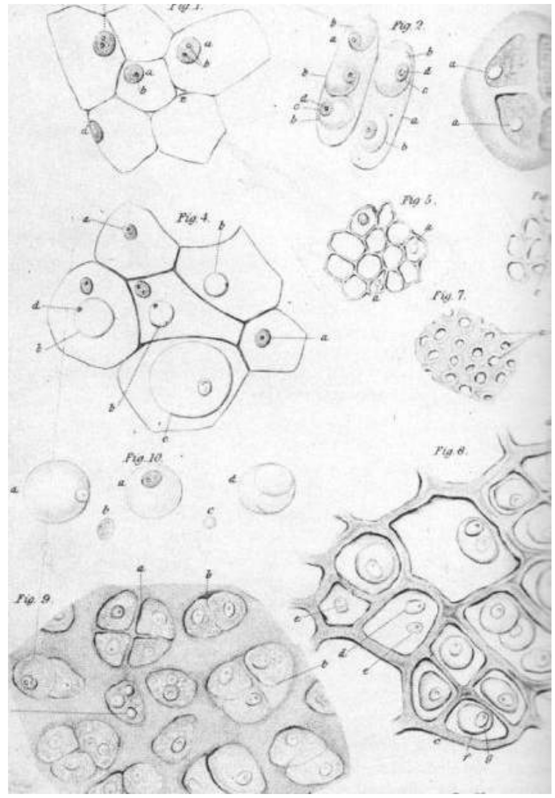


Fig. 5 : Sketches of different types of tissues as observed by Schwann

Another scientist studying tissues was Karl Von Nageli. He was a botanist who introduced the concept of formative and stable tissues. He named formative tissues as "Meristem" or fast growing tissue. He made meticulous observations and found that certain regions like tips of roots and stems in plants, skin and blood in animals were composed mainly of such tissues. He also named the tube like tissues that conducted water, minerals and food material in plants as xylem (meaning wood) and phloem(meaning bark) on the basis of the direction in which they carried water or food materials.

Schleiden and Schwann also observed the fast growing tissues and found that their cells were small with a prominent large nucleus, less cytoplasm and thin cell membrane or cell wall. As the cells matured, their size increased, the size of nucleus decreased, the amount of cytoplasm increased and the walls and membranes became thicker.

Thus we have studied how over time scientists had been studying the arrangement of cells in tissues minutely. The basis of all their detailed study had been the structure and function of the tissues. They studied tissues in both plants and animals to observe the similarities and differences between them. There are some tissues in our body that are very similar to those of plants and it may be very difficult for an experienced scientist as well to make out the differences. Usually mature animal tissues are softer than mature plant tissues. The cell theory was proposed on the basis of the similarities between plant and animal tissues.

- What are the main statements of the cell theory?

While comparing plant and animal tissues we would find that most of the plant tissues involved in conduction of materials across large distances are composed of dead cells while those of animal cells have more of living cells. It is also possible to identify areas of fast growing cells in plants more easily than in animals.

7.2 Grouping of Tissues

Scientists had been studying tissues and trying to name them on the basis of their characters like function, location, organization, arrangement, ability to divide etc. The process of grouping on the basis of these characters helped in the detailed study of tissues. We are now going to group animal and plant tissues separately to facilitate a better study of them. The major characters of each group and subgroups are also included in the flow charts presented here.

7.2.1 Grouping Plant Tissues

An example of grouping of plant tissues can be done in the following manner -

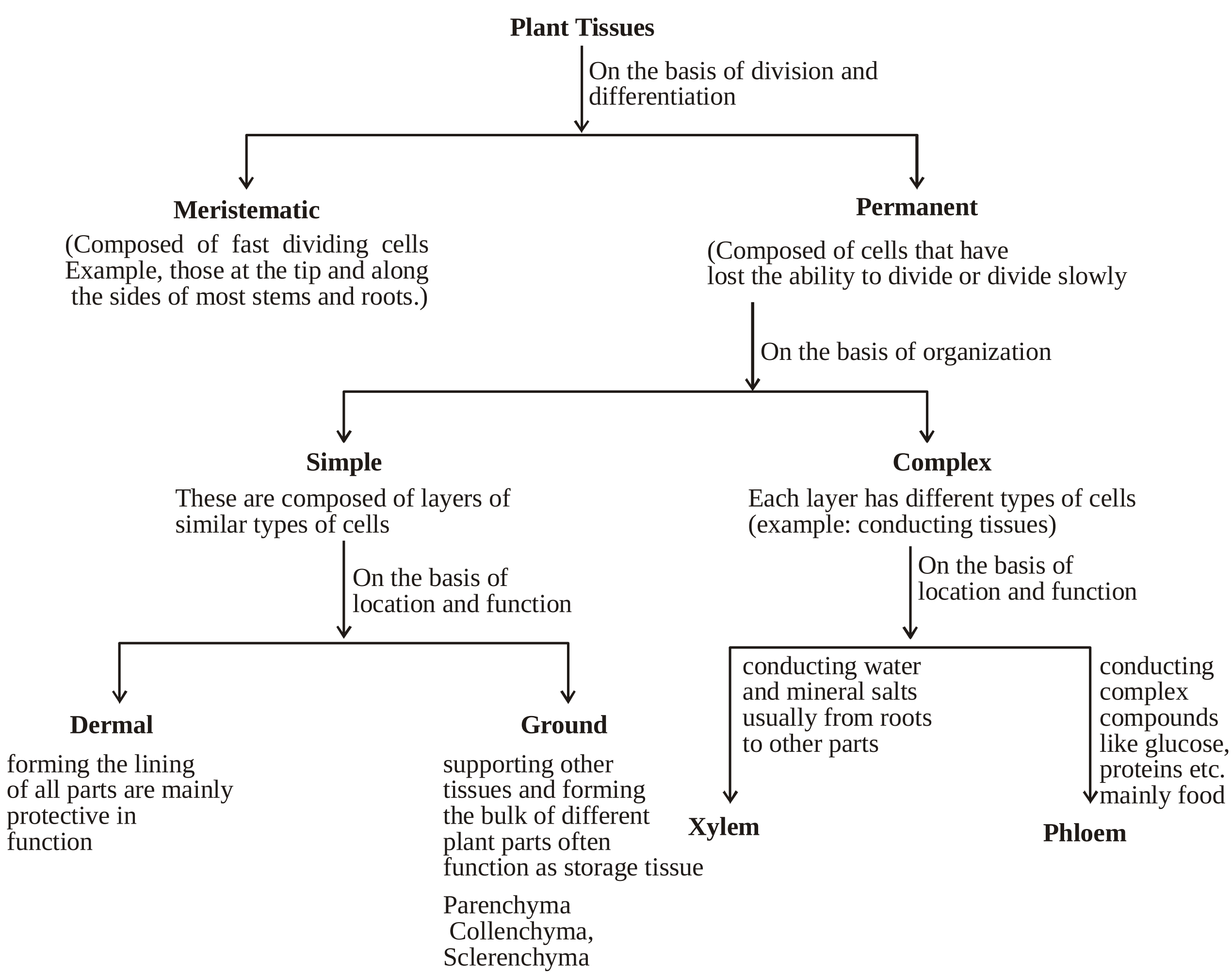


Fig. 6: Grouping of Plant Tissues

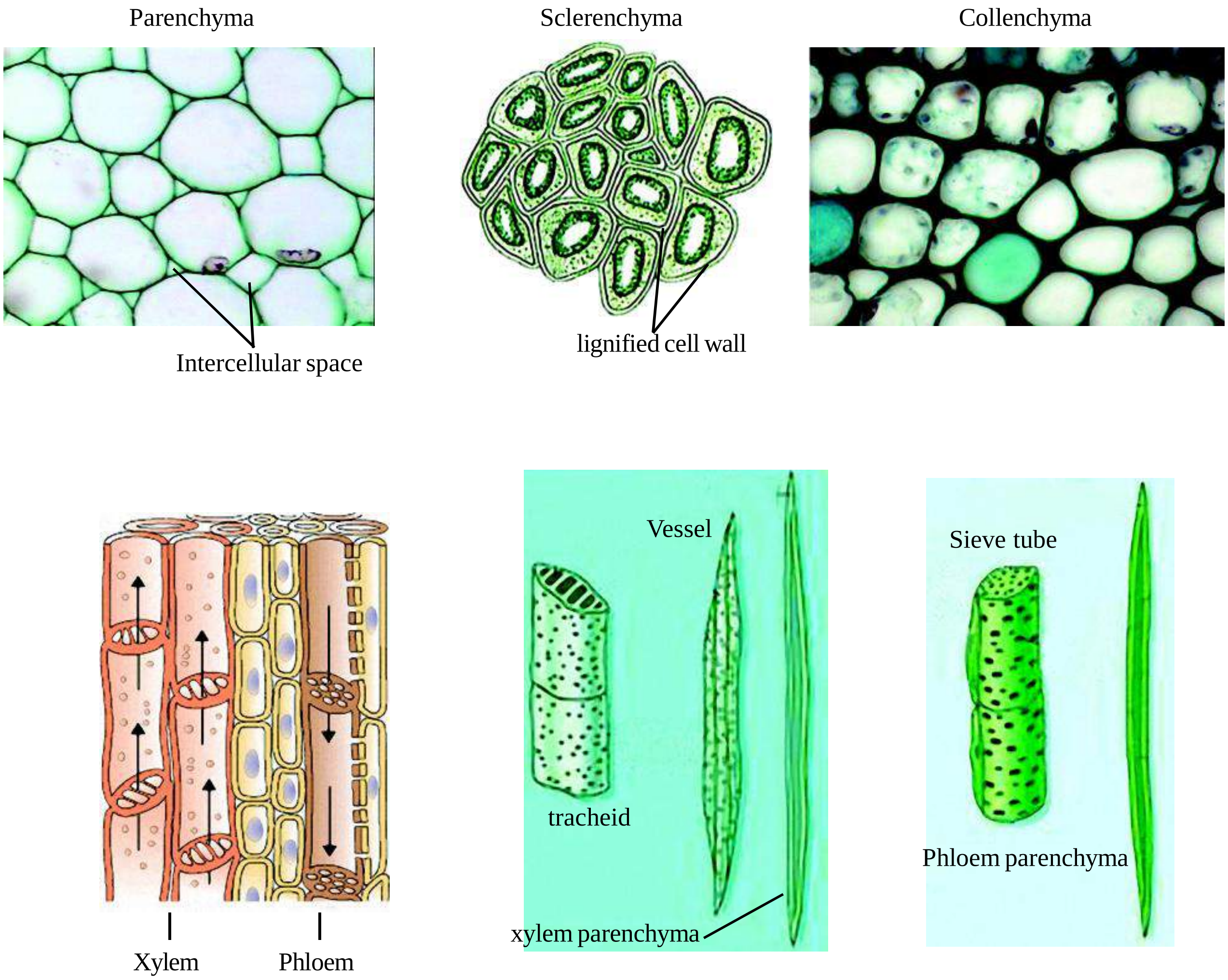


Fig. 7: Different Plant Tissues

There is a limitation of the classification schema of plant tissues as presented in figure 6. Permanent tissues are not just those that have completely lost the ability to divide. Parenchyma and collenchyma included in this category are capable of dividing. Thus we may see that the names of the categories represent stages in the development of tissues. There are intermediary stages as well like permanent tissues that still have the ability to divide.

7.2.2 Grouping of Animal Tissues

Let us now try to study a type of classification of Animal tissues (mainly those in humans).

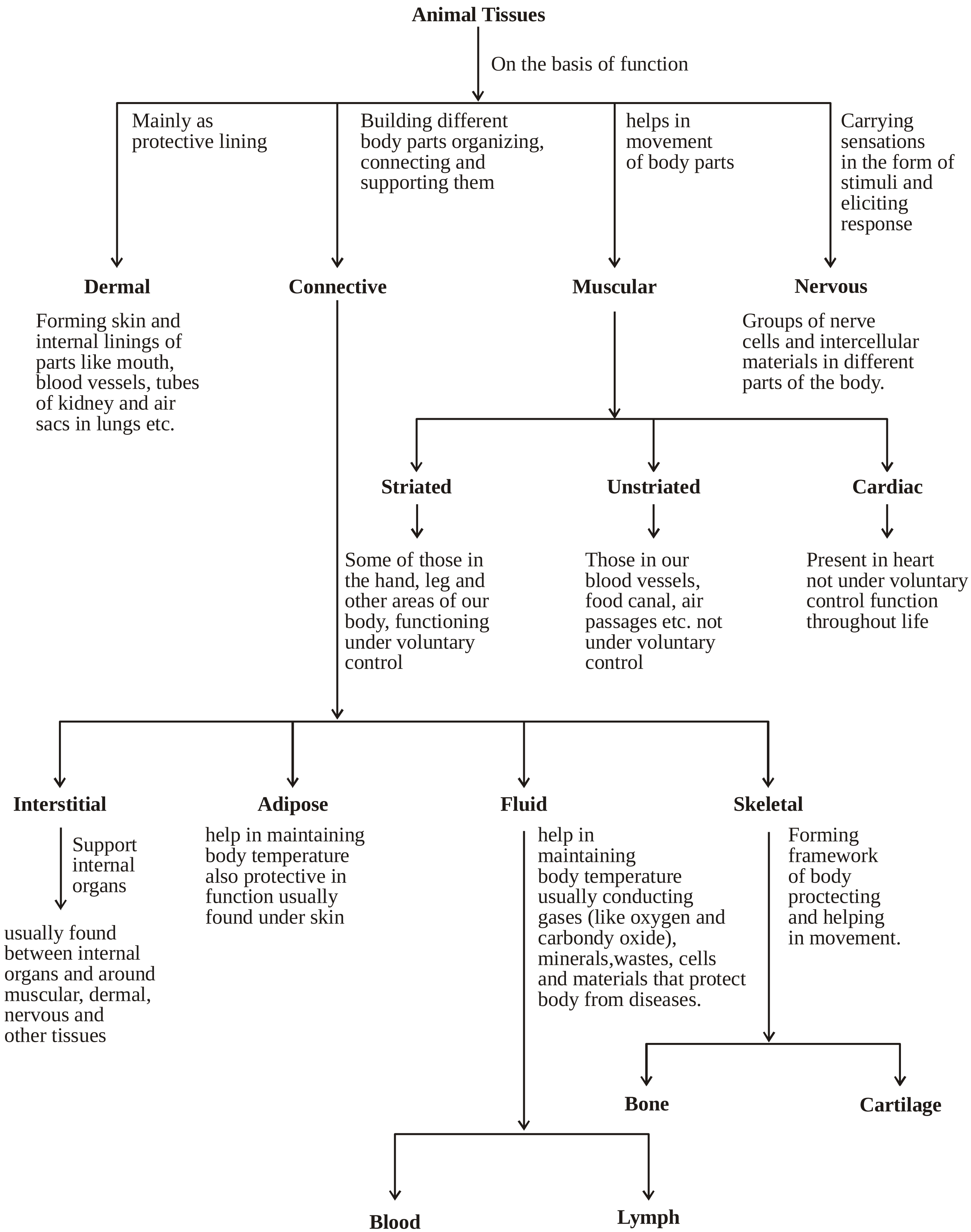


Fig. 8: Grouping some animal tissues

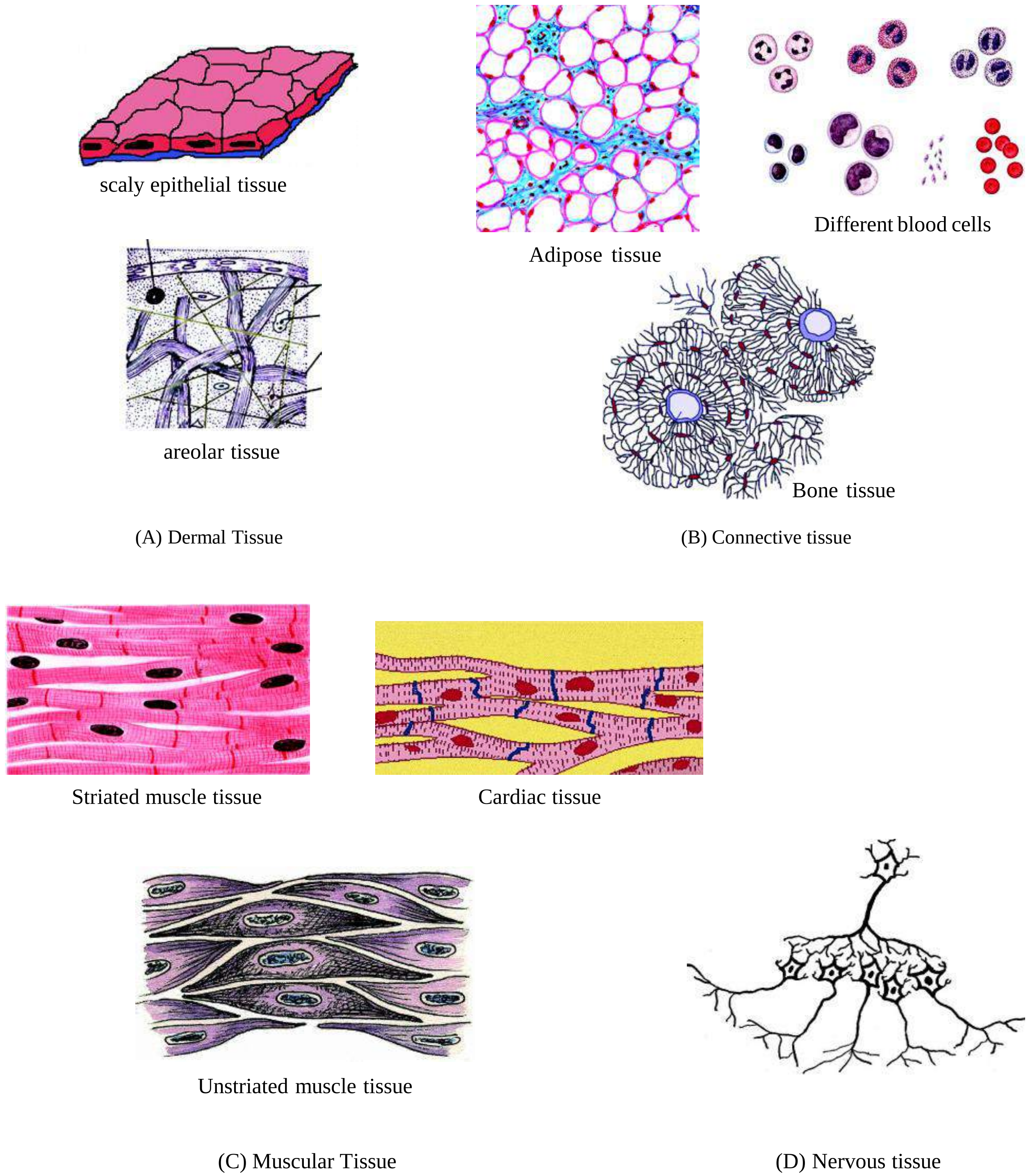


Fig. 9: Different types of animal tissues

So far we studied about how we came to know about the tissues and some schemas of grouping them. Let us now observe some of them.

7.3 Observing some plant tissues

Take the help of figure 7 to do these activities

7.3.1 Dermal tissue of the leaf

Activity-4

You would need leaves of Rheo or similar plants that have epidermis that strips off easily, microscope, slides and cover slips, blade/sharp scissor

- Tear a piece of leaf lengthwise and check for a thin peel near the edges. This is dermal tissue.
- Take a piece of this and put it on a few drops of water on a slide. Cover with a cover slip.
- Observe this under the microscope and make a sketch of what you see. You may take the help of figure 10 for your observation.
- Write a detailed account on arrangement and structure of cells that you observed.

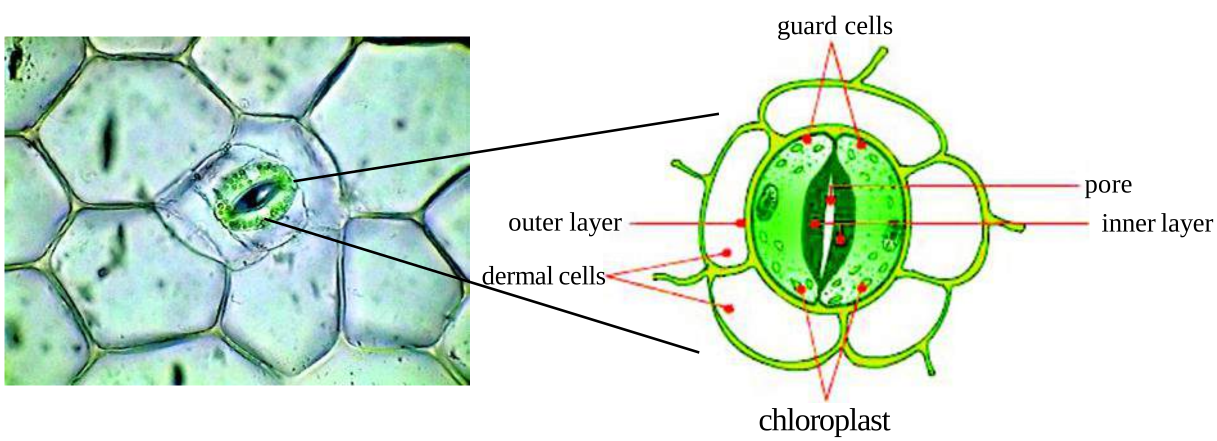


Fig. 10 : Cells in the peel of lower side of leaf and stomatal guard cells

- Could you observe chloroplast containing cells? Take the help of the figure to find out what they are called?

The cells that you observed under the microscope were of the outermost layer of leaf tissue called as dermal or rather epidermal tissue. Just like those of animal dermal tissue its major function is to form a protective layer. The intercellular space is nearly absent between the cells of this tissue. In dry areas, loss of water is prevented due to the presence of a thickened epidermis. The presence of an oily layer over the epidermis protects water plants. Cells that appear kidney shaped in the epidermal layer in most dicotyledonous plants are the guard cells. The pore between them is the stomata. These mainly help in exchange of air. Usually large amount of water passes out through them in several plants. This aids the conduction of water in the plant body.

Instruction : You may use other leaves preferably fleshy, to take a leaf peel. You may stain the peel for clearer observation.

7.3.2 Observing Parenchyma

Activity-5

For this we would need banana, petri dishes or watch glasses, dissection needles, iodine solution, microscope, slides and cover slips.

Instructions

1. Take a small piece of the soft banana tissue. You may use the dissecting needle to.
2. Put the sample onto a petri dish or watch glass and mash it slightly using the dissecting needle.
3. Take a small sample of the tissue onto a slide, spread it out with a needle and add a few drops of iodine solution. Place a cover slip on this.
4. Observe the cells under low power and find a section where the cells are lying separate, not over each other.
5. Iodine turns the starch blue black and we see clusters of starch containing plastids in the cells.
6. Observe the arrangement of these cells under higher power of the microscope.
7. Draw a neat and labeled diagram of your observation.

The cell in this tissue have a prominent nucleus, usually have granular cytoplasm, large vacuoles, thin cell walls and membranes, and intercellular space between them.

Parenchyma having chloroplast containing cells are called chlorenchyma. Aquatic plants have large air spaces between the cells of parenchyma, such parenchyma is called as aerenchyma.

7.3.3 Observing Sclerenchyma

Activity-6

We would need soft, ripe guava, microscope, slides and cover slips, iodine solution, dissecting needles or forceps

- Use the forceps or needle to take a small piece of soft guava tissue onto your slide.
- Add two drops of iodine solution.
- Tease the tissue slightly to separate the cells.
- Cover with a cover slip and observe under low power.

- You would find groups of dark cells amongst the rounded parenchyma cells.
- These are parts of sclerenchyma tissue.

Due to sclerenchyma, plant tissues become hard and strong. The cells of this tissue are usually fibrons, thin and dead. A section of these would show thick lignified walls around the cells that lack a nucleus. Lignin is a chemical substance (like cement) that renders strength to the cells. No intercellular space is seen due to deposition of lignin. Coconut fibers, seed coat of mature orange seeds, fibers in a dry bottle gourd etc. are composed of sclerenchyma tissue.

7.4 Observing animal tissues

7.4.1

Activity-7

- You have already observed the cells in the inner lining of your mouth by making slide of them in the previous chapter.
- You may observe dandruff or the layer of cell that peels off from your heels. All these represent the outermost layer of dermal tissue of animals called as epithelium or epidermal layer.
- Write about your observation and also make a sketch of it, keeping in view the arrangement of cells of this tissue and their intercellular space(if any).

We have observed that epithelium forms the outer and inner linings of different parts of the body. They usually form a protective covering. The cells are flat, usually with a prominent nucleus, joined to other cells and usually do not have any intercellular space.

Other functions of this tissue are like conduction of sensation, secretion and repair.

7.4.2 Observing muscular tissue

We shall use permanent slide of cardiac muscle. Take out the slide of cardiac muscle provided in your kit in your lab and observe it under the microscope. Note your observation and make a sketch of it. You may take the help of figure 9 for this.

- What are the different functions that are carried out due to the presence of muscular tissue?

All movements in animal bodies occur with the help of muscular tissue. They may be external movements like movement of hand, leg and trunk or internal like movement in the intestine, lungs and the heart.

7.5 Function of Tissues

We have so far studied that tissue is a community of cells and intercellular substances that are interacting in one or more task.

Do you know?

Tissues and cells are surrounded by fluids that form their environment. A change in its compositions and volume affects the function of the tissue. The type and concentration of minerals and salts must be at levels compatible for their proper functioning. All plant and animal tissues require a suitable fluid environment so that they may function effectively.

Most multicellular plants and animals have cells→tissues→organs→organ systems that distribute the task of survival. One arrangement functions in reproduction while another in excretion. Thus we may say that the plant and animal body shows a division of labour. As for example wood and bone are tissues that function mainly in a structural support in plants and animals respectively. Xylem of wood also conducts minerals and water while bone protects internal organs. An organ has at least two tissues that are organized in certain propositions and patterns performing one or more common tasks. As for example the leaf of plants and the eye of animals are organs. A leaf carries out photosynthesis with the help of light sensitive pigment chlorophyll and gaseous exchange with the help of stomata while the eye helps in seeing with the help of some light sensitive pigment. Thus, leaf or any other photosynthetic part of plants and the eye of animals have certain ability that are light dependent.

Not all tasks are carried out by a particular group of tissues. Some tissues carry out the function of conduction of substances from one part of a multicellular body to another.Some tissues are capable of fast growth and division. These tissues may be present anywhere in the body of a multicellular organism, for example in the skin or in all such tissues that form a lining(be it the lining of digestive system or the skin of the body) or dermal tissue. Those that form the bulk of a body or the ground substance might contain conducting tissues or vascular tissues. These are usually fibre like tissues forming muscles of animals and fibers of the conducting tissues in plants both rendering support, flexibility and connection between certain parts. These would also have fast growing tissue so that the process of growth and repair goes on replacing older layer of tissue with newer ones.

- Write about similar functions of animal and plant tissues

Do you know?

After a certain period of time the growth of certain tissues stops as the cells lose the ability to divide and differentiate(ability to take other forms). But there are some cells called as stem cells that can divide and differentiate constantly. Whenever cells of an organ die and fall off like those of our skin, the stem cells divide forming a new layer. After each division a single stem cell forms two cells, one of these differentiate into a cell of the concerned parts while the other remains as a stem cell.

Scientists have been able to identify not only those stem cells that form a particular organ but even those that may differentiate to form different organs of the body. Such stem cells in humans have been found mainly in the bone marrow and placenta. Damaged organs are being reconstructed or replaced with the help of stem cells.

7.6 Relation of structure and function of tissues

The structural organization cells→tissues→ organs → organ systems happened over a long period of time. There were single cellular forms in the beginning. Multicellular communities formed from these single cellular forms nearly 580 million years ago. The structures and functions of the cells also changed in this process.

If we think how the change of environment from water to land posed challenges to the body structure of plants we would have some idea of how their structure relates to function. Plants that left aquatic habitats found an abundance of sunlight and carbon dioxide for photosynthesis and oxygen for respiration. As they dispersed faster away from their aquatic dwelling, however, they faced a new challenge- how to keep from drying out in air. When we observe the internal structure of root, stem and leaves of land and water plants we see that a network of long tubes from root to leaves are present in land plants, ending in the stomata that open and close in ways that help to conserve water.

Branching in roots helped to draw more and more water and dissolved minerals to send it to large distances. Tube like structures formed carrying substances over large distances. You have seen these in activity 1.

Similarly we may understand the impact of the change of environment from water to land in animal cells and their function. Gases can only move into and out of the animal body by diffusing across a moist surface. This occurs across their body surface in animals living in water. The surfaces started drying out as animals started inhabiting land. Thus these animals were found to have specialized groups of cells organized into tissues, organs and organ systems to carry out gaseons within their body with very little exposure to environment. You may have understood that we are talking about the lungs. The internal lining of lungs are multilayered and highly folded facilitating large amounts of gaseous exchange.

Keywords

Tissue, division of labour, dermal tissue, ground tissue, vascular tissue, xylem, phloem, nervous tissue, connective tissue, muscular tissue

What we have learnt

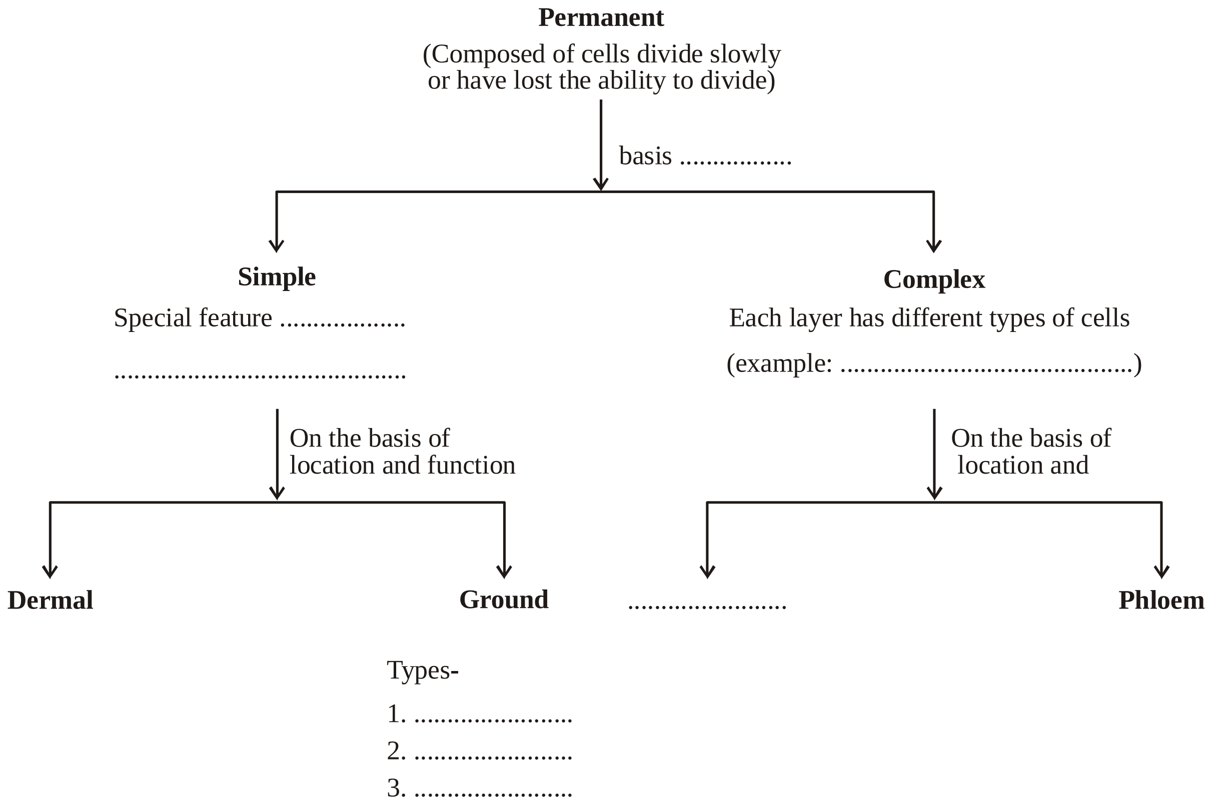
- Tissues are groups of cells along with their environment(fluid) that carry out one or more functions.
- Tissue can have one or more types of cells.
- Similar groups of cells develop into different types of tissues by division and differentiation.
- Distribution of work among different groups of tissues is their division of labour.

- Scientists have been studying the similarities and differences among different types of groups of cells over time and the cell theory had been proposed as the result of a study of similarities.
- Tissues have been grouped as meristematic and permanent on the basis of their ability to divide. Some permanent tissues like parenchyma and collenchyma have the ability to divide though they are grouped as permanent tissue.
- Animal tissues have been grouped into four categories on the basis of their structure and function as dermal, connective, muscular and nervous.
- Structure of tissues affect their function.
- Stem cells can be preserved and used later for replacement or reconstruction of damaged parts.

Exercise

1. Choose the right option
   (i) Grouping of plant tissues on the basis of function of conducting substances through them-
   (a) xylem and parenchyma (b) xylem and phloem
   (c) phloem and dermal tissue (d) parenchyma and aerenchyma
   (ii) Tissues are
   (a) groups of cells (b) cell and cytoplasm
   (c) groups of cells and their surrounding fluid (d) none of these
   (iii) Lignin deposits are seen in one of the following tissues
   (a) parenchyma (b) collenchyma
   (c) chlorenchyma (d) sclerenchyma
2. Fill in the blanks
   (i) .... tissue carries water and mineral salts in plants.
   (ii) .... tissue is found in the inner lining of our mouth.
   (iii) .... and .... tissues render support and movement to our body parts.
3. What are tissues?
4. Write about the function of any 3 types of tissues.
5. Write about the importance of division of labour among tissues of multicellular organisms.
6. Write some commonly observable examples of sclerenchyma tissue.
7. Why is blood called a connective tissue?
8. Write a note on the historic context of our knowledge of tissues.

9. Complete the flow chart given below-



10. 'There is a deep connection between the structure and function of tissues'. Justify this statement.

11. Group plant tissues on the basis of their characters and function.

12. What are the different groups into which animal tissues have been divided? What is the basis of such a grouping?

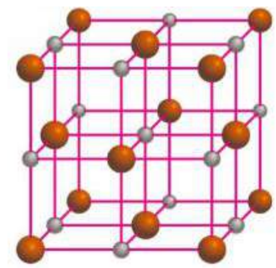
13. What are the other groups into which you may organize plant or animal tissues? What would be the basis of your grouping?

Thought provoking

Why do you think human placentas are stored away in laboratories these days?

Chapter 8

Chemical Bonding



In the chapter on atomic structure, we learnt that the number of electrons in an atom of any element is fixed. We also learnt that the number of electrons in a shell and the electronic configuration is also fixed. The number of electrons in an atom is equal to the number of protons in its nucleus. Since the charge on a proton is equal but opposite to that on an electron, therefore the atom is electrically neutral.

It is observed that some elements found in nature are reactive and others are non-reactive or inert. The difference in reactivity can be explained if we look at the electronic configurations of elements. It is interesting to note that the chemical properties of an element are dependent on the number of electrons present in its outermost shell (valence electrons). It is seen that elements that have eight electrons in their outermost shell (except helium, which has two electrons) generally do not form compounds. These elements are helium, neon, argon, krypton and xenon and they exist as monoatomic gases. Since these gases do not react they are known as inert (noble) gases. Except for helium all other inert gases have eight electrons (octet) in their outermost shell.

8.1 Ionic Bonds

Those elements (except hydrogen) that have less than eight electrons in the outermost shell of their atoms try to complete the octet, that is, they try to attain inert gas configuration by reacting with other atoms. The other atom can be of the same element or from a different element.

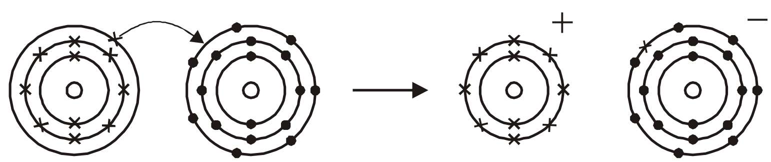
Let us try to understand the above statement by looking at sodium chloride, which you may know as common salt. Sodium chloride is formed by the elements, sodium and chlorine. We know that the atomic numbers of sodium and chlorine are 11 and 17 respectively. Let us write their electronic configurations:

$_{11}Na$ - 2, 8, 1

$_{17}Cl$ - 2, 8, 7

By looking at the electronic configurations of the two elements, tell –

- How many electrons are present in the outermost (valence) shell of each atom?
- In how many ways can the sodium atom complete its octet? In how many ways can the chlorine atom attain inert gas configuration?



Sodium atom (Na) (2,8,1) | Chlorine atom (Cl) (2,8,7) | Sodium ion (Na^+) (2,8) | Chloride ion (Cl^-) (2,8,8)

11	Proton	= 11+		17	Proton	= 17+
10	Electron	= 10–		18	Electron	= 18–
	Total charge	= +1			Total charge	= –1

Fig. 1 : (a) Formation of sodium chloride

We saw that the sodium atom has 2 electrons in its K shell, 8 in the L shell and 1 electron in the M shell. One possibility to attain the octet configuration is that the sodium electron loses the one electron present in its M shell and then it will be left with 2 electrons in the K shell and 8 in the L shell. In this case, it attains the configuration of the inert gas neon (2,8).

The second possibility is that the sodium atom accepts 7 electrons so that it has 2 electrons in its K shell, 8 in the L shell and 8 in the M shell. In this case also it attains inert gas configuration (argon 2,8,8).

The atomic number of sodium is 11 which means that its atom has 11 protons in the nucleus and 11 electrons in shells. Can you tell what will be the charge on the sodium atom if it loses an electron or gains 7 electrons?

An atom is electrically neutral because the number of positively charged particles (protons) in its nucleus is equal to the number of negatively charged particles (electrons) in its shells. If the atom gains an electron it becomes a negatively charged ion or anion. If the atom loses electrons it becomes positively charged ion or cation. The charge on an ion is equal to the number of electrons gained or lost.

Now, we will consider the chlorine atom. Chlorine can also achieve inert gas configuration in two ways, either by gaining one electron or by losing seven electrons. If chlorine accepts an electron then it will have 2 electrons in the K shell, 8 in the L shell and 8 in the M shell and it will form chloride ion (Cl^-). If it loses 7 electrons, then it will have 2 electrons in the K shell and 8 in the L shell and it forms Cl^{7+} ion.

The nucleus of the sodium atom is not capable of holding on to seven extra electrons. Similarly, it is difficult for the chlorine atom to lose seven electrons and form Cl^{7+} ion. This means that it is easier for the sodium atom to lose an electron and for the chlorine atom to gain one electron. Therefore, sodium forms Na^+ ion by losing an electron and chlorine forms Cl^- ion by accepting an electron.

Due to opposite charges, sodium and chloride ions are attracted to each other and are held together by strong electrostatic forces of attraction to form sodium chloride.

The type of bond formed in this way is called ionic bond or electrostatic bond. The compounds formed in this manner are called electrovalent or ionic compounds. It should be noted that sodium chloride does not exist as a single molecule but as an aggregate of oppositely charged ions.

Here, the bond is not formed between one sodium ion and one chloride ion. Instead, a three dimensional crystal is formed in which each positively charged sodium ion is surrounded by negatively charged chloride ions and similarly each chloride ion is surrounded by positively charged sodium ions. The number of sodium ions, in the crystal, is equal to the number of chloride ions.

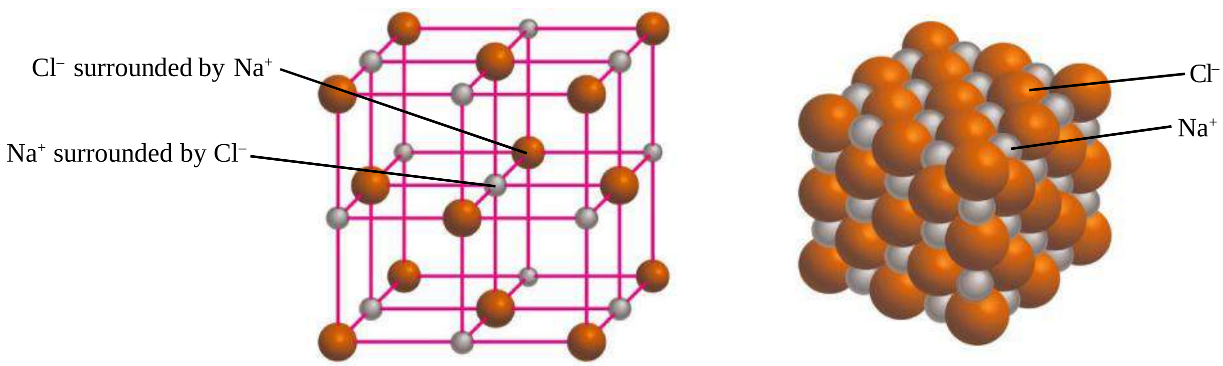


Fig. 1 (b) :Three dimensional structure of sodium chloride

> The American chemist Gilbert Newton Lewis used electron dot configurations, also called Lewis symbols, to show the number of bonding electrons in an atom. In this method, the electrons in the outermost shell of an atom are shown by putting an equal number of dots around the symbol of the element.
>
> 
>

Now, we will look at some more ionic compounds. Ionic bonds are also formed between magnesium and chloride ions. The atomic number of magnesium is 12. Write its electronic configuration and think of how it will attain inert gas configuration?

We know that for magnesium (2,8,2) to attain inert gas configuration (2,8), it will have to lose two electrons but the chlorine atom needs only one electron to complete its octet. Think, how will the two electrons lost by magnesium be accommodated? Here, two chlorine atoms will take part in bond formation with one magnesium atom. Therefore, each chlorine atom will accept one of the two electrons lost by the magnesium atom and attain inert gas (2,8,8) configuration. This is why the formula of the compound is $MgCl_2$.Can you tell the value of the charge on the magnesium ion?

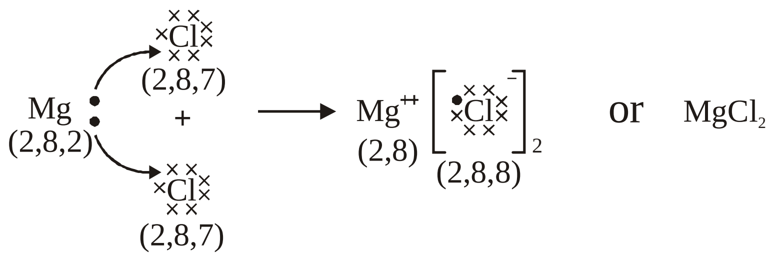


Fig. 2 : Formation of magnesium chloride

Now, let's look at another ionic compound which is formed by calcium and oxygen. The atomic numbers of calcium and oxygen are 20 and 8 respectively. Write down their electronic configurations and think of how they will attain inert gas configuration?

We can see that calcium has two electrons in its outermost shell and oxygen has 6 electrons in its outermost shell. Therefore, it is easy for calcium to lose two electrons and for oxygen to gain two electrons. In this way, oxygen accepts the two electrons lost by calcium and forms an ionic bond. What will be the charges on calcium ion and oxide ion, respectively, in calcium oxide?

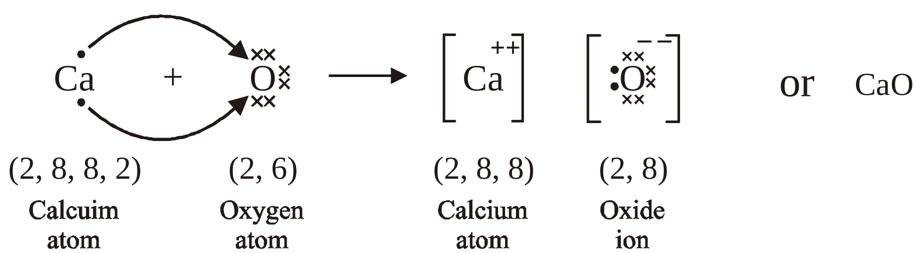


Fig. 3 : Formation of Calcium oxide

So far, we have seen that during bond formation between elements, one or two electrons are lost by one atom and accepted by the other atom or atoms. Now we will look at a compound formed by the element aluminium.

The atomic numbers of aluminium and chloride are 13 and 17 respectively. $AlCl_3$ is formed by the transfer of electrons between Al and Cl. Can you show the electronic structure of $AlCl_3$ to complete the equation given below?

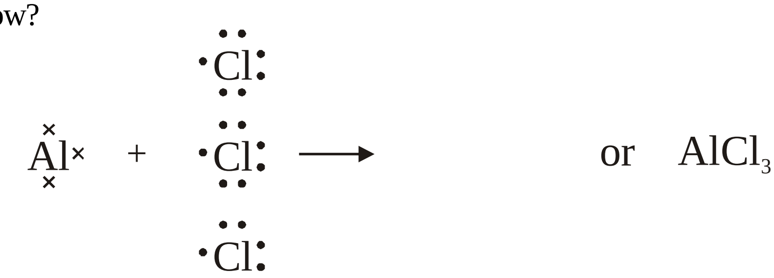


Fig. 4 : Formation of aluminium chloride

Through the examples seen so far, we now know that sodium needs to lose one electron to form bonds and oxygen gains or accepts two electrons. In this way the number of electrons in the outermost shells of both atoms becomes eight. Think, what will be the formula of the compound formed by bonding between sodium and oxygen? How will they form ionic bonds? Complete the figure below by showing electron transfer between sodium and oxygen.

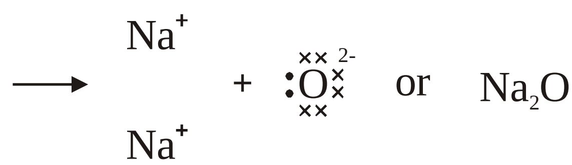


Fig. 5 : Formation of sodium oxide

8.2 Valency

We saw many different examples of how atoms of different elements lose or accept electrons to achieve inert gas configuration. Therefore, we can understand valency in the following ways:

- Sodium has one electron in its valence shell which it loses to achieve inert gas configuration, therefore, the valency of sodium is one.
- Calcium loses two electrons from its valence shell so its valency is two.
- Chlorine has 7 electrons in its valence shell and it gains an electron to complete its octet, therefore, the valency of chlorine is one.

Valency tells us how many electrons will be lost or accepted by the atom of any element to achieve inert gas configuration. In this way, we find that atoms of some elements lose atoms from their valence shell and atoms of some other elements gain electrons to complete their octet. So far, we have identified metals and non-metals based on their physical properties. Now, we can say that during ionic bond formation, the elements that lose electrons are called metals and the elements that gain electrons are called non-metals.

Questions

1. The atomic numbers of potassium and chlorine are 19 and 17 respectively:
   - (a) Write their electronic configuration.
   - (b) In how many ways can the two elements achieve inert gas configuration? Describe.
   - (c) Depict the ionic bond in potassium chloride using Lewis symbols.
   - (d) What will be the charges on potassium and chloride ions in potassium chloride?
2. The atomic numbers of lithium and fluorine are 3 and 9 respectively. Use electron dot structures to show the ionic bond formation between lithium and fluorine.

3. What is the valency of oxygen? What is the valency of potassium? Explain.

4. The number of electrons in the M shell of an element is 7 and its valency is 1. What will be the electronic configuration of the ion of this element?

You know that aluminium has three electrons in its valence shell which it loses to form Al^{3+}. Can you name the element that has four electrons in its outermost shell?

8.3 Covalent bonds

We will now consider the element carbon whose atomic number is 6 and electronic configuration is 2,4. If carbon loses 4 electrons to attain inert gas configuration similar to helium (2) then it will form C^{4+} ion. On the other hand, if it gains four electrons to attain inert gas configuration similar to neon (2,8) then it will form C^{4-}.

In both cases the ions formed are unstable so both are not possible. Then, how does carbon form bonds? Let us see.

One alternative is that carbon shares its electrons with other elements. What does sharing mean? Let us take the example of carbon tetrachloride to understand this better. Carbon tetrachloride is formed by one carbon and 4 chlorine atoms. We already know that a chlorine atom needs one electron to complete its octet. In this case, each chlorine contributes one of its electrons to one atom of carbon and similarly carbon also shares one of its four electrons with each of the chlorine atoms to form bonds. In this way, carbon and each of the chlorine atoms attain inert gas configuration (2,8 and 2,8,8). Both shared electrons are owned equally by both the atoms therefore, they are included in the octets of both atoms.

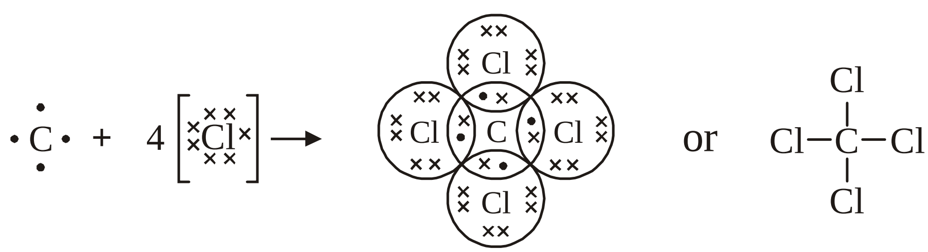


Fig. 6 : Covalent bond in carbon tetrachloride

Now we will look at the compound methane formed by carbon and hydrogen. We have seen that it is easier for the carbon atom to share its valence electrons rather than losing them or gaining additional electrons. What about the hydrogen atom? The atomic number of hydrogen is one which means that it has one proton in its nucleus and one electron in the K shell. The nearest rare gas is helium which has two electrons in its K shell. When a bond is formed between carbon and hydrogen, the carbon atom needs to share four electrons but the hydrogen atom needs to share only one. So, one atom of carbon and four atoms of hydrogen share electrons to form CH_4 molecule.

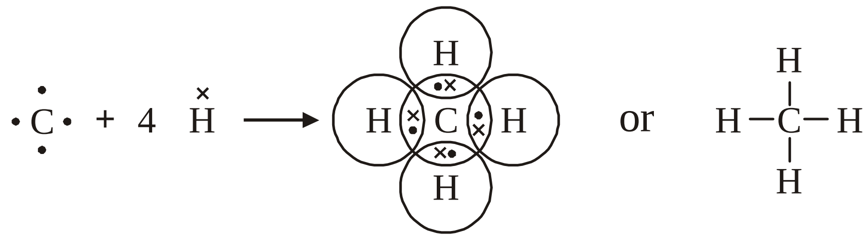


Fig. 7 : Covalent bonding in methane

Now, we will look at another carbon compound, carbon dioxide. It is clear from the name itself that the molecule has two oxygen atoms (di- is a suffix that stands for two so dioxide implies two atoms of oxygen). Previously, we have seen that usually oxygen accepts two electrons to form the divalent ion, O^{2-} but at the same time carbon prefers to share electrons to form bonds. Can you tell how carbon and oxygen will share electrons to form the stable compound carbon dioxide? It is possible only when each oxygen atom shares its two valence electrons with two-two electrons of carbon (fig.8).

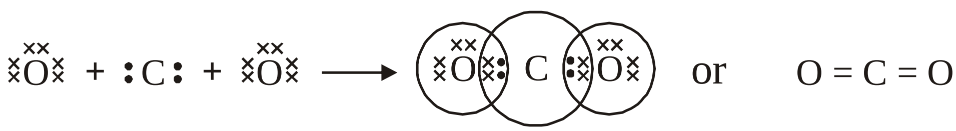


Fig. 8 : Covalent bonding in carbon dioxide

By looking at the given structure, can you tell how many bonds are formed between the carbon atom and the oxygen atom? In this compound, two pairs of (four) electrons of carbon combines with one pair of electrons of each oxygen atom to form a double bond. In the previous example, carbon formed CCl_4 with chlorine and CH_4 with hydrogen by sharing one-one electron to form single bonds. But in carbon dioxide molecule, a double bond is present between the oxygen and carbon atoms. Single and double bonds between two atoms are shown by a single dash (–) or a double dash (=) respectively.

Such compounds where electrons are shared between atoms to form bonds are called covalent compounds. It should be noted here that two or more atoms attain the nearest inert gas configuration by sharing of electrons. Such groups of atoms are known as molecules or we can say that the molecules of covalent compounds are made up of two or more atoms.

Water is a compound which is formed by combination of hydrogen and oxygen. We know that hydrogen needs to share one electron and oxygen needs to share two electrons to complete their octet. Try to make a structure of water that satisfies the valence of both hydrogen and oxygen (figure-9).

Fig. 9 : Covalent bonding in water

The molecular formula of the compound ammonia is NH_3. It is formed by nitrogen and hydrogen. Hydrogen needs to share one electron and nitrogen needs to share three electrons to attain inert gas configuration (fig.10).Can you draw the electron dot structure of ammonia?

Fig. 10 : Covalent bonding in ammonia

We will now consider bonding in hydrogen. You may know that hydrogen is the lightest gas. If we look at its electronic configuration we can see that its outermost shell (in this case, K) has only one electron and we also know that the hydrogen molecule exists. Two atoms of hydrogen shares an electron each with each other to form hydrogen molecule. We can show this by electron dot structures (figure-11).

Fig. 11 : Covalent bonding in hydrogen

So we see that molecules are formed not just by atoms of different elements but also by atoms of the same element.

The element hydrogen exists as a diatomic molecule having single bonds (we know that di- stands for two and therefore diatomic means two atoms).

Is there any element that exists as a molecule having double bonds? Let us consider the element oxygen. We already know that the atomic number of oxygen is 2, its electronic configuration is 2,6 and therefore it needs two electrons to attain the nearest inert gas configuration. So, two atoms of oxygen each contribute two electrons to form a doubly bonded oxygen molecule (fig.12).

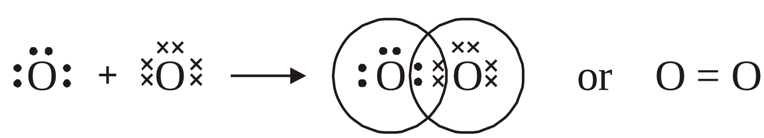


Fig. 12 : Covalent bonding in oxygen

You will be astonished to learn that carbon atoms can be linked to each other not just by single bonds but even by double and triple bonds.

Let us take C_2H_4 (or $H_2C{=}CH_2$) as an example.Here, one atom of carbon shares two electrons with another carbon atom to satisfy two valencies and the remaining two are satisfied by other atoms (fig.13).

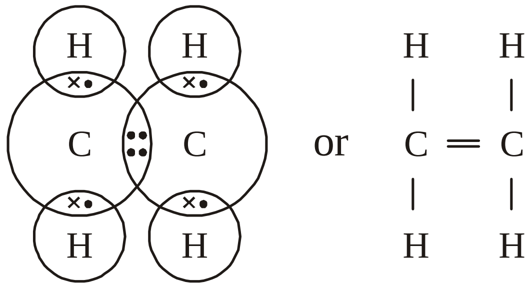


Fig. 13 : Covalent bonding in ethene

Similarly, we can also understand triple bond formation through sharing of electrons between two atoms.

Now we will consider nitrogen in which each nitrogen atom shares three-three electrons because the atomic number of nitrogen is 7 and its electronic configuration is 2,5. Since two atoms of nitrogen combine to form a molecule therefore nitrogen exists as a diatomic gas (fig.14).

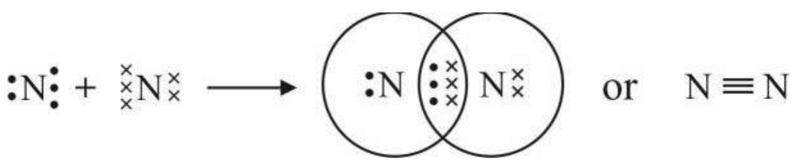


Fig. 14 : Covalent bonding in nitrogen

We have already seen how single and double bonds are formed between two carbon atoms. Similarly, triple bonds are also found between two carbon atoms. For example, a molecule of C_2H_2 (or CH≡CH) has the following structure (fig.15).

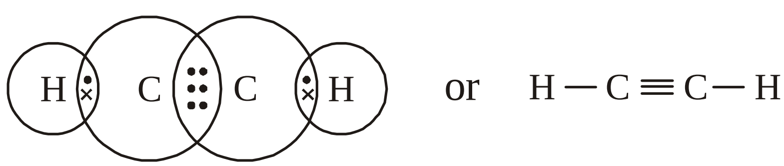


Fig. 15 : Covalent bonding in ethyne

In this chapter, we saw that the valency of an element depends on how many electrons it accepts or loses from its valence shell in order to attain the nearest inert gas configuration. We also saw that elements can also complete their octet by sharing of electrons between its own atoms or with atoms of another element. Therefore, we can understand valency as the number of electrons shared by the atoms of an element in order to complete their octet. If we take the example of carbon, since the carbon atom shares four electrons to complete its octet, its valency is four. The oxygen atom in calcium oxide accepts two electrons from the calcium atom but in carbon dioxide, an oxygen atom shares two electrons with the carbon atom. What is the valency of oxygen in the twocases? Thus, the valency of an element is the number of electrons it loses, accepts or shares in order to form bonds.

Questions

1. Draw the electron dot structure of ethane (C_2H_6).
2. Draw the electron dot structure of any molecule which has a double bond.
3. The atomic number of chlorine is 17.
   (a) Write its electronic configuration.
   (b) Explain the formation of chlorine molecule using electron dot structures.

8.4 Ionic and covalent bonds

We saw that covalent bonds are formed by sharing of electrons between atoms and ionic bonds are formed when the valence shells of atoms gain or lose electrons.The compounds having ionic bonds are known as ionic or electrovalent compounds and the compounds that have covalent bonds are known as covalent compounds. Now, let us look at the properties of the two types of compounds.

8.4.1 Properties of ionic compounds

1. Usually, ionic compounds are soluble in water.
2. Ionic compounds have high melting and boiling points because the oppositely charged ions in them are held together by strong electrostatic forces of attraction. More energy is required to break the bonds formed by the string electrostatic forces.
3. Ionic compounds ionize when dissolved in water or on melting and therefore, can conduct electricity.

8.4.2 Properties of covalent compounds

1. Usually, covalent compounds are not soluble in water.
2. Their melting and boiling points are low as compared to ionic compounds.
3. Covalent compounds do not conduct electricity because they do not form ions.

We will now examine whether different ionic and covalent compounds conduct electricity or not.

Activity-1

Take four beakers and label them ‘A’, ‘B’, ‘C’ and ‘D’. Take 100-150 ml water in each beaker and prepare separate solutions as described below:

1. Dissolve 2 spoonfuls common salt in beaker ‘A’.
2. Dissolve 2 spoonfuls calcium chloride in beaker ‘B’.

3. Dissolve 2 spoonfuls sugar in beaker 'C'.
4. Dissolve 2 spoonfuls glucose in beaker 'D'.

First, insert two graphite rods in beaker 'A' (fig.16). The graphite rods act as electrodes. Connect these rods to a bulb and a 9 V battery as shown in the figure to complete the circuit. Take care that the two rods do not touch each other or come in contact.

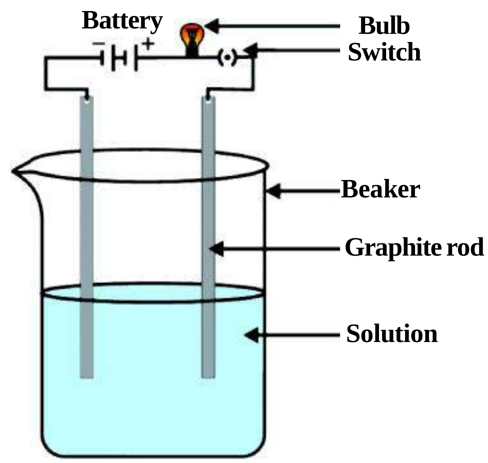


Fig. 16 : Testing if solutions of compounds conduct electricity

- Did the bulb light up?
- Repeat this experiment with the other three beakers and note your observations.

Now answer the following questions:

- Why did the bulb light up in case of beaker 'A' and beaker 'B'?
- Why did the bulb light up in case of beaker 'C' and beaker 'D'?
- You must have understood now that electricity is conducted by salt and calcium chloride because of electrovalent bonds but not in glucose and sugar because they have covalent bonds.

Questions

- Write down the differences between ionic and covalent compounds.
- Explain why ionic compounds have high melting and boiling points.

Keywords

Ion, cation, anion, ionic bond, covalent bond, sharing, valency, ionic compound, covalent compound, noble or inert gas, valence shell, octet, electrostatic attraction, electron dot or Lewis structures

What we have learnt

- During ionic bond formation, one atom loses electrons to form cations and another atom accepts electrons to form anions. The oppositely charged ions are bound together by strong electrostatic forces of attraction to form ionic bonds.
- Covalent bonds are formed by sharing of electrons between atoms.

- When one-one electron is shared between two atoms a single bond is formed. Double bond is formed by sharing of two-two electrons between two atoms and triple bonds are formed by sharing of three-three electrons between two atoms.
- The number of electrons in the outermost shell that are shared, accepted or lost in order to attain inert gas configuration is called the valency of the element.
- Ionic compounds are soluble in water, have high boiling and melting points and conduct electricity when ionized in solutions or melts.
- Covalent compounds do not dissolve in water, have lower melting and boiling points and do not conduct electricity.

Exercises

1. Choose the correct option

   (i) When sodium reacts with chlorine

   (a) Each sodium atom accepts an electron

   (b) Each chlorine atom accepts an electron

   (c) Each sodium atom loses seven electrons

   (d) Each chlorine atom loses seven electrons

   (ii) A sodium atom and a sodium ion:

   (a) Are chemically same

   (b) Have the same number of protons

   (c) Form covalent bonds

   (d) Have the same number of electrons

   (iii) An ionic bond is formed when

   (a) The combining atoms accept electrons

   (b) The combining atoms lose electrons

   (c) One atom loses and the second gains electrons

   (d) When two metals react

(iv) Which of the following elements loses two electrons in order to attain inert gas configuration similar to argon?

(a) magnesium (b) sodium

(c) calcium (d) sulphur

(v) double bonds are found in which of the following molecules:

(a) N_2 (b) C_2H_2

(c) Cl_2 (d) CCl_4

2. Fill in the blanks

(i) Sodium atom .... an electron to attain the electronic configuration of the element ....

(ii) Two atoms of nitrogen share .... pairs of electrons to form a nitrogen molecule.

(iii) The number of electrons in the outermost shells of inert gases is .... but in case of helium it is ....

(iv) Chlorine molecule has .... bond but magnesium chloride has .... bond.

(v) Ionic compounds are usually .... in water but covalent compounds are .... in water.

3. What type of bond is formed when electrons are transferred from one atom to another? Explain.

4. Draw the electron dot structure of a molecule that has a triple bond.

5. Argon atoms does not form Ar_2 molecule by covalent bonding. Why?

6. The electronic configuration of elements X and Y are:

X = 2,8,8,2 Y = 2,6

Explain the type of bonding seen when X and Y combine. Show through electron dot structures.

7. What is the role of valence electrons in the formation of chemical compunds? Explain.

8. (i) Give the number of covalent bonds in one molecule of ammonia.

(ii) 'Sodium chloride is a molecule'. Explain why this statement is not true.

9. Draw the electron dot structures of the given compounds and write the type of bonding seen in each.

(i) Water (ii) nitrogen

(iii) magnesium oxide (iv) calcium oxide

10. Write down the properties of ionic and covalent compounds.

11. Explain how the valency of an element is related to its electronic configuration.

12. The atomic numbers of three elements are 6,7 and 8 respectively.

    (i) Write the electronic configuration of each element and give their valency.

    (ii) What type of compounds (ionic/covalent) will be formed by each of the elements? Explain.

13. Separate ionic compounds and covalent compounds in the given group. Give reasons for your choice.

14. Which of the following are possible? Give reasons for your answer.

    (i) Mg_2 (ii) $MgCl_2$ (iii) Cl_2

Chapter 9

Chemical Formula and Mole Concept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(1776 - 1856)

We know that compounds are formed when two or more elements react together. Compounds are formed by the combination of a fixed number of atoms of different elements.We use sugar, salt, water, baking soda etc. in our daily lives and these are all compounds. We have already leant a little bit about how formulae of compounds are written. Now, we will understand chemical formulae of compounds in more detail.

9.1 Formulae of covalent compounds

In a previous chapter, we saw many compounds such as carbon dioxide, water, ammonia etc. that show covalent bonding. In carbon dioxide, two-two electrons each of a carbon atom are shared equally with two-two electrons of two oxygen atoms (fig.1a).

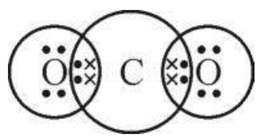


Fig. 1 (a)

Suppose we add another oxygen atom to a molecule of carbon dioxide, then the additional atom will share its electrons with which atom of the molecule?There are two possibilities.

First, it can share its electrons with the carbon atom and second it can share its electrons with one of the oxygen atoms. The additional oxygen atom cannot share its electrons with the carbon atom because all the electrons on the carbon atom are already being shared with two oxygen atoms and it has already attained inert gas configuration (fig.1 b). If we consider sharing of additional electrons with the oxygen atom of carbon dioxide (fig.1 c), then too it is not possible because then the number of electrons on the new oxygen atom will become eight but that on the first oxygen atom will become 10. That is, the number of electrons in the outermost shell of the oxygen atom will become more than 8.

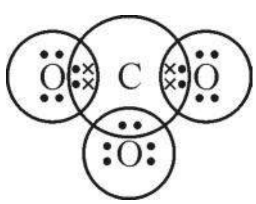


Fig. 1 (b)

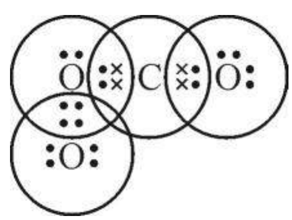


Fig. 1 (c)

Since, sharing of electron with an additional oxygen atom is not possible, therefore the compound CO_3 is not formed. A stable compound can be formed only between one carbon and two oxygen atoms and its formula is CO_2. Similarly, we can write the chemical formulae of other compounds if we know the symbols for different elements and their valencies.

9.2 Molecular weights of covalent compounds

We know that atoms of an element or of different elements combine together to form molecules. We can calculate the molecular weight of a molecule from the atomic weights of the elements present it. The molecular weight of a compound is the sum of the atomic weights of its constituent elements. For example, one atom of oxygen combines with two atoms of hydrogen to form a molecule of water. If we know the atomic weights of hydrogen and oxygen, we can calculate the molecular weight of water. Since the atomic weight of hydrogen is 1 u and that of oxygen is 16 u, therefore the molecular weight of water = $(2 \times 1) + 16 = 18$ u

Come, let us calculate the molecular weights of some more compounds –

The chemical formula of sulphur dioxide is SO_2. The atomic weight of sulphur is 32 u. Then,

The molecular weight of sulphur dioxide = $32 + (2 \times 16)$

= 64 u

Similarly, molecular weight of nitrogen = 2×14

= 28 u

Unit Formulae of ionic compounds and formula unit mass

Sodium chloride does not have a molecular formula because ionic solids do not have discrete molecules.The constituent particles of sodium chloride are sodium ions and chloride ions arranged in a three-dimensional structure. So the unit formula of sodium chloride is NaCl or Na^+Cl^-. Other ionic compounds also have similar unit formulae and these are used to calculate their weights. Since we are using unit formulae for weight calculation therefore it is called unit formula mass of ionic compounds. For example, the atomic weight of chlorine is 35.5 u and that of sodium is 23 u so the unit formula mass of sodium chloride is 35.5 + 23 = 58.5 u

Questions

1. If the atomic weight of carbon is 12 u then what will be the molecular weight of carbon dioxide?
2. If the atomic weight of nitrogen is 14 u then what is the molecular weight of ammonia?
3. Calculate the molecular weight of hydrogen.
4. Calculate the formula unit mass of the following ionic compounds:

   Na_2O, $MgCl_2$, $CaCl_2$, CaO

9.3 Polyatomic ions

We know that the solutions of ionic compounds in water conduct electricity. In activity-1 of chemical bonding chapter we saw that the solution of sodium chloride in water conducts electricity and that it ionizes to give sodium ions (Na^+) and chloride ions (Cl^-). If we repeat the same activity with a solution of sodium nitrate in water, it too conducts electricity. On this basis we can say that sodium nitrate is an ionic compound. It has Na^+ ions similar to NaCl. This implies that along with Na^+ions, the solution should also have negatively charged ions. This ion is NO_3^- where the nitrogen and three oxygen atoms have a sum negative charge. Such groups or clusters of atoms that carry a fixed charge are known as polyatomic ions.

$$NaNO_3 \longrightarrow Na^+ + NO_3^-$$

Other ionic compounds also dissolve in water to give positively and negatively charged ions. For example –

$$NH_4Cl \longrightarrow NH_4^+ + Cl^-$$

$$Na_2SO_4 \longrightarrow 2Na^+ + SO_4^{2-}$$

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

$$Na_2CO_3 \longrightarrow 2Na^+ + CO_3^{2-}$$

NH_4^+, SO_4^{2-}, $OH^+$and CO_3^{2-} formed in the reactions given above are all examples of polyatomic ions.

The charges found on ions is also their valency. Table – 1 gives the valency of some ions:

Table 1 : Valencies of ions

Monovalent	Divalent	Polyvalent
Na^+, Ag^+, NH_4^+	Cu^{2+}, Zn^{2+}, Fe^{2+}, Mg^{2+}	Al^{3+}
Br^- (bromide) I^- (iodide) HCO_3^- (hydrogencarbonate) OH^- (hydroxide)	S^{2-} (sulphide) CO_3^{2-} (carbonate)	PO_4^{3-} (phosphate)

Radicals

Charged atoms and clusters of charged atoms are also known as radicals. Radicals are of two types, positive radicals and negative radicals.

Usually, the cations obtained from bases are known as basic radicals. For example,

$NaOH \longrightarrow Na^+ + OH^-$

$NH_4OH \longrightarrow NH_4^+ + OH^-$

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

In the examples shown above, Na^+, NH_4^+(ammonium) and Ca^{2+} are basic radicals.

Usually, the anions obtained from acids are known as acidic radicals. For example –

$HCl \longrightarrow H^+ + Cl^-$

$HNO_3 \longrightarrow H^+ + NO_3^-$

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

In the examples given above, Cl^- (chloride), NO_3^- (nitrate), and SO_4^{2+} (sulfate) are acidic radicals.

9.3.1 Chemical formulae of compounds having polyatomic ions

Now we will use a special criss-cross method to write the chemical formulae using the charge present on ions (or the valence of ions). The given steps are followed while writing the chemical formulae:

Example – ammonium carbonate

1. First of all, we write down the names of the constituent ions keeping the symbol/formulae of the positive ion on the left side and the negatively charged ion on the right side.

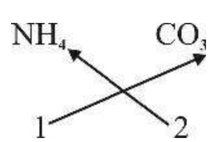
$NH_4 \qquad CO_3$

2. The valencies of the constituent ions are written below them.

Symbol/ Formulae	NH_4	CO_3
Valencies	1	2

3. The valencies of the ions are criss-crossed to determine their ratio in the compound.

Symbol/ Formulae



Valencies

This means that ammonium carbonate will have 2 ammonium ions and 1 carbonate ion.

4. The polyatomic ion is enclosed in a bracket and then the number that indicates the ratio is written as subscript. In case the number of polyatomic ion is one, the bracket is not required and 1 is also not written.

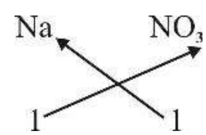
$(NH_4)_2CO_3$

Therefore, the formula of ammonium carbonate is $(NH_4)_2CO_3$.

Let us understand this through a few more examples:

- Sodium nitrate

  Symbol/ Formulae

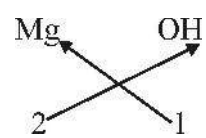


  Valencies

  So, formula is $NaNO_3$

- Magnesium hydroxide

  Symbol/ Formulae

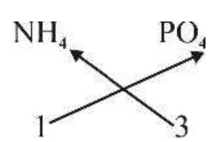


  Valencies

  So, formula is $Mg(OH)_2$

- Ammonium phosphate

  Symbol/ Formulae

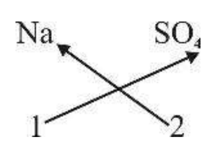


  Valencies

  So, formula is $(NH_4)_3PO_4$

- Sodium sulphate

  Symbol/ Formulae

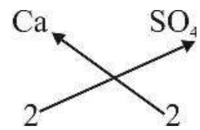


  Valencies

  So, formula is Na_2SO_4

- Calcium sulphate

  Symbol/ Formulae

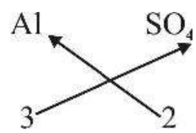
  Valencies

  So, formula is $CaSO_4$

When the charge on both ions in the compound is same, the formula is simplified. Therefore, here $Ca_2\,(SO_4)_2$ is simplified to $CaSO_4$

- Aluminum sulphate

  Symbol/ Formulae

  Valencies

  So, formula is $Al_2(SO_4)_3$

Questions

1. Complete the table–

Name of compound	radicals present		No. of charges		Formula of compound
	Positive	Nagative	Positive	Nagative	
Ammonium nitrate			1		
Sodium carbonate				2	Na_2CO_3
Ammonium hydroxide				1	
Magnesium carbonate			2		$MgCO_3$
Iron phosphate	Fe^{++}				

2. Use the criss-cross method to write down the formulae of the following ionic compounds – ammonium chloride, calcium hydroxide, magnesium sulphate, ammonium sulphate, calcium phosphate

9.4 Mole concept

What is mole? Mole is a number. Come, let us read about why it is useful and how it came about. The story of the mole starts with some chemical reactions. In 1799, it was discovered that elements react with each other only in fixed ratios. At first, this fixed ratio was recognized as ratio of weights. Then the scientist Gay-Lussac studied the chemical reactions of different gases. He saw that at a given temperature and pressure, the gases reacted with each other in simple ratios of their volumes from which he derived the law of combining volumes. Dalton in his atomic theory had already described that elements react with each other in definite ratios by weight. But Dalton could not explain the reason behind Gay-Lussac's law. Many other scientists worked on Gay-Lussac's law and finally Berzelius was able to give a simple explanation. According to Berzelius, equal volumes of gases under identical conditions of temperature and pressure have the same number of atoms. This means that the number of particles in 1 litre of hydrogen gas is the same as the number of particles in 1 litre of chlorine gas. When 1 L hydrogen gas reacts with 1 L of chlorine gasthen hydrogen chloride is formed. Berzelius said that 1 litre of both the gases reacted completely with each other because the number of particles in both were same. Around the same time, relative atomic weights of different elements were also being calculated and were being used to calculate molecular weights. This made it possible to calculate the density and weights of gases. When the weights of atoms or molecules of gases were taken at a fixed temperature and pressure, it was found they all had the same volume. For example –

(i) At 0^oC and 1 atmospheric pressure (1 atm), the volume of 2 g of hydrogen was 22.4 L.

(ii) At 0^oC and 1 atmospheric pressure, the volume of 36.5 g of hydrogen chloride was 22.4 L

(iii) At standard temperature and pressure, the volume of 18 g of steam was also 22.4 L.

(iv) Similarly, if the weights of several gases equal to their molecular weight in grams are taken, they are found to occupy 22.414 L at 0 °C and 1 atm.

After many calculations, it was found that 22.4 L of any gas at standard pressure and temperature contains the same number of particles which is equal to 6.022×10^{23}. This was as per Berzelius's statement. $6.022 \text{ X } 10^{23}$is also known as Avogadro's number and represented by N_0.

If we repeat these calculations for solids or liquids, we can say that the number of particles in gram atomic or molecular weight of any substance is also 6.022×10^{23}. (Here, the atomic and molecular weights of substances are taken in grams).

In 1896, Wilhelm Ostwald proposed the term mole for Avogadro's number. Mole is the Latin word for heap or pile. Finally, in 1967 a standard definition was proposed for mole and it was recognized as the simplest way of describing extremely large numbers of atoms and molecules.

1 mole = 6.022×10^{23}(Avogadro's number N_0)

Mole concept gives us the number of particles in a definite amount of any substance. For example, 23 g of sodium has 6.022×10^{23} particles and 1 mole sodium atoms. If we have 46 g of sodium then it means that we have 2 moles of sodium atoms and 12.044×10^{23} particles.

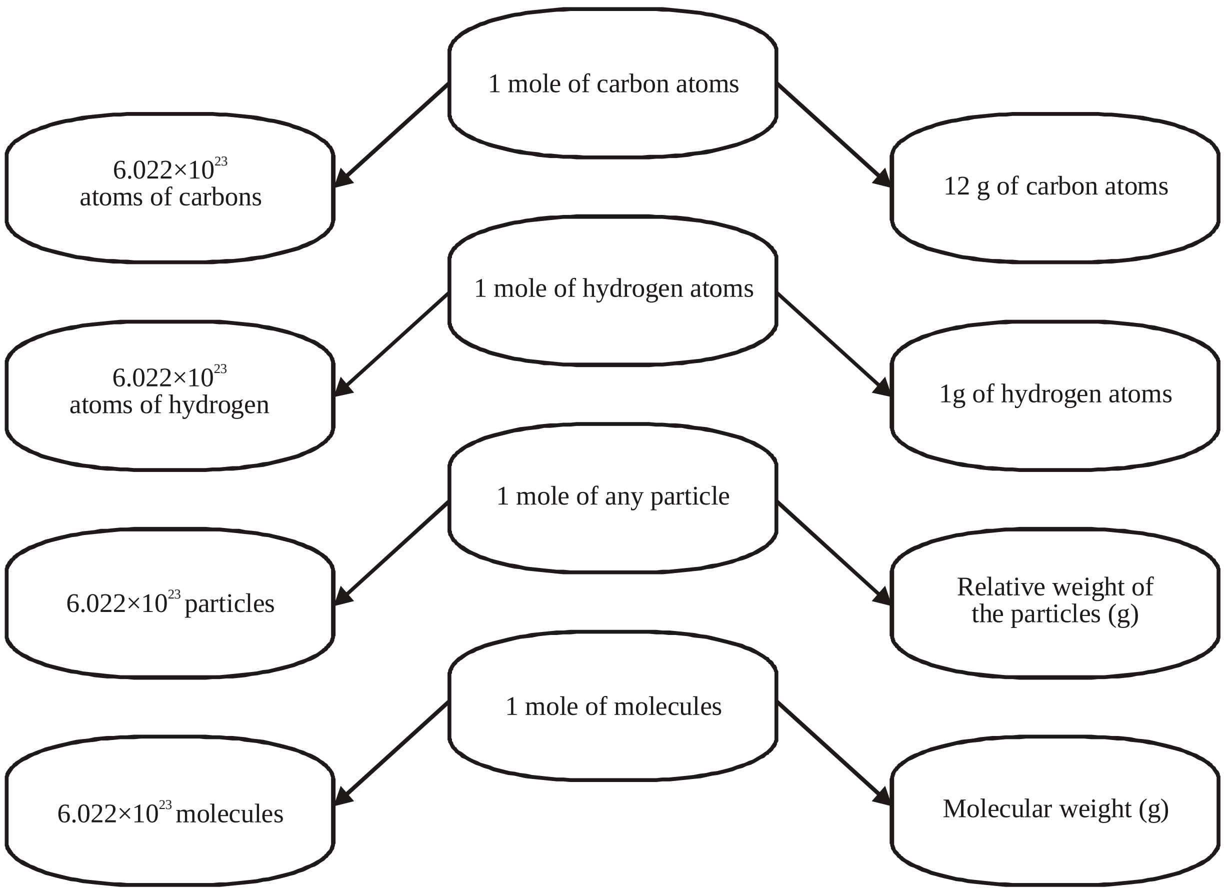


Fig. 3 : Relation between mole, Avogadro's number and weight

9.5 Representing weight of substances in Mole

We know that elements have atomic weight or gram atomic weight and molecules have molecular weight or gram molecular weight. On this basis, we can calculate the number of moles as follows:

For elements–

$$\text{Number of moles (n)} = \frac{\text{Mass given (m)}}{\text{Gram atomic weight (M)}}$$

For compounds or molecules–

$$\text{Number of moles (n)} = \frac{\text{Given mass (m)}}{\text{Gram molecular weight (M)}}$$

Showing number of particles in moles

The number of atoms/molecules/ions is related to moles as follows:

$$\text{Number of moles (n)} = \frac{\text{Number of particles (N)}}{\text{Avogadro's number } (N_0)}$$

Example-1

(a) 92 g sodium

Solution : Number of moles (n) = ?

Mass given (m) = 92 g

Gram atomic weight (M) = 23 g

Formula– $n = \frac{m}{M}$

$= \frac{92}{23}$

$=$ 4 moles

(b) 36 g water

Solution : Number of moles (n) = ?

Mass given (m) = 36 g

Gram molecular weight (M) = 18 g

Formula– $n = \frac{m}{M}$

$= \frac{36}{18}$

$=$ 2 moles

2. Find the number of moles:

(a) In 18.066×10^{23} Oxygen atoms

Solution : Number of moles (n) = ?

Number of particles (N) = 18.066×10^{23}

Avogadro's number (N_0) = 6.022×10^{23}

Formula– $n = \frac{N}{N_0}$

$n = \frac{18.066 \times 10^{23}}{6.022 \times 10^{23}}$

= 3 moles

(b) 6.022×10^{23} oxygen molecules

Solution : Number of moles (n) = ?

Number of particles (N) = 6.022×10^{23}

Avogadro's number (N_0) = 6.022×10^{23}

Formula– $n = \frac{N}{N_0}$

$n = \frac{6.022 \times 10^{23}}{6.022 \times 10^{23}}$

= 1 mole

3. Find the number of particles:

(a) In 10 g N_2 molecules

Solution : Number of particles (N) = ?

Mass given (m) = 10 gm.

Gram molecular weight (M) = 28 gm.

Formula– $N = n \times N_0$

$n = \frac{m}{M}$

$N = \frac{m \times N_0}{M}$

$N = \frac{10 \times 6.022 \times 10^{23}}{28}$

$= 2.15 \times 10^{23}$

(b) 2 moles of carbon atoms

Solution : Number of particles (N) = ?

	Number of moles (n)	=	2 moles
	Avogadro's number (N_0)	=	6.022×10^{23}
Formula–	N	=	$n \times N_0$
		=	$2 \times 6.022 \times 10^{23}$
		=	12.044×10^{23}

9.5.1 Let us understand mole concept

We know that the mass of 1 mole (6.022×10^{23}) particles of a substance is equal to its relative atomic or molecular or formula mass, given in grams. For gases, we can take volumes instead of weights. At 0^oC and 1 atmospheric pressure, one mole of any gas occupies 22.4 L of space.

This gives us another way of understanding and writing formulae and chemical equations. When we say that carbon dioxide is taking part in a reaction and depict it as CO_2 then are we saying that one molecule of CO_2 is involved?

We know that atoms and molecules are extremely minute particles and it is impossible to carry out a reaction where only atom or molecule of substances are taking part. This means that when we write CO_2 then it can also stand for 1 mole of CO_2 molecules. Let us see how this can prove useful.

The reaction of hydrogen and oxygen to form water can be written as:

$$2H_2 + O_2 \longrightarrow 2H_2O$$

In the given example, we can say that two molecules of hydrogen combine with one molecule of oxygen to form two molecules of water. But, can we have ½ molecule of oxygen as written below? What does it mean?

$$H_2 + \tfrac{1}{2} O_2 \longrightarrow H_2O$$

We can understand the above reaction using the mole concept. Here, one mole of hydrogen molecules combines with half mole of oxygen molecules to form one mole of water molecules. Therefore, when we write H_2 it can have two meanings:

- 1 molecule of hydrogen with relative molecular weight of 2 u.
- 1 mole of hydrogen molecules whose gram molecular weight is 2 grams.

Let us take another reaction –

$$H_2 + Cl_2 \longrightarrow 2HCl$$

We can describe the reaction in two ways-

- Two molecules of hydrogen chloride are formed when we react one molecule of hydrogen with one molecule of chlorine.

- When one mole of hydrogen molecules react with one mole of chlorine molecules, 2 moles of hydrogen chloride molecules are formed.

Questions

Explain the following reactions using the mole concept:

(a) $C + \frac{1}{2} O_2 \longrightarrow CO$

(b) $\frac{1}{2} Al_2O_3 + 3\ HCl \longrightarrow AlCl_3 + 1\frac{1}{2} H_2O$

Keywords

(molecular weight, empirical formula, unit formula mass, criss-cross method, mole, Avogadro number

What we have learnt

- The chemical formula of a compound is the symbolic representation of its composition.
- The molecular mass of a covalent compound can be calculated from the atomic mass of its constituent elements.
- Ions (cations and anions) are constituent particles of ionic compounds.
- The positive ions obtains from bases are called basic radicals and the negative ions obtained from acids are known as acidic radicals.
- Clusters of atoms carrying a fixed charge are known as polyatomic ions.
- In ionic compounds, the valency of each constituent ion is used to determine the chemical formula of the compound.
- The unit formula mass of ionic compounds is determined by using the weights of their constituent ions.
- The number of particles in one mole of any substance is called Avogadro's number. The value of Avogadro's number is 6.022×10^{23}.

International Mole Day

Every year, 23rd October is celebrated as international mole day. The day starts at 6:02 am and ends at 6:02 pm. The reason for choosing these timings is their similarity with Avogadro's number which is equal to 6.022×10^{23}.

Exercises

1. Choose the correct option–

   (i) The molecular weight of CH_3OH is–

   (a) 32 u (b) 29 u

   (c) 25 u (d) 20 u

   (ii) Basic radical is–

   (a) Positively charged ion (b) negatively charged ion

   (c) neutral atom (d) none of the above

   (iii) Ions that have a negative charge are–

   (a) Positively charged ion (b) Basic radicals

   (c) Acidic radicals (d) Neutral atoms

   (iv) The value of Avogadro's number is–

   (a) 6.022×10^{23} (b) 6.022×10^{22}

   (c) 6.022×10^{24} (d) 60.22×10^{23}

   (v) The volume of any gas at 0^oC and 1 atm pressure–

   (a) 11.2 litre (b) 22.4 litre

   (c) 100 litre (d) 33.8 litre

2. Fill in the blanks

   (i) Unit formula mass is used for .... compounds.

   (ii) The molecular weight of $C_{12}H_{22}O_{11}$ is ....

   (iii) The number of elements in PO_4^{3-} ....

   (iv) The number of atoms in one mole of carbon is ....

   (v) The mass of one mole of water is ....

3. How do we get acidic and basic radicals?

4. What are polyatomic ions? Give examples.

5. Connect the appropriate pairs:

	Column A		**Column B**
(i)	Number of atoms in one mole	(i)	14 gram
(ii)	Acidic radical	(ii)	Mg^{2+}
(iii)	Basic radical	(iii)	SO_4^{2-}
(iv)	The weight of one mole of nitrogen atoms	(iv)	2 mol
(v)	The number of moles in 88 g of CO_2	(v)	6.022×10^{23}

6. What is unit formula mass? Calculate the unit formula mass of $MgSO_4$.

7. If the formula of the carbonate of a metal is M_2CO_3 then what will be the formula of its nitrate.

8. If the formula of aluminium sulphate is $Al_2(SO_4)_3$ then what is the charge on Al ion and what is the formula of zinc sulphate?

9. The ion X has two positive charges on it. Write the formulae of the nitrate, sulphate and phosphate of X.

10. Calculate the molecular weights of the following:

    PCl_5, H_2O_2, S_8, HCl, NH_3

11. Calculate the masses of the following-

    5 moles of ammonia, 0.5 moles of water, 1.50 moles of Na^+ ions, 0.2 moles of oxygen atoms

12. Calculate the number of moles in the following:

    12 g of O_2, 22 g of CO_2

13. Determine the chemical formulae of the following using the crisscross method:

    Iron sulphate, Copper nitrate, Sodium sulphide, Magnesium hydrogencarbonate

Chapter 10

Chemical Reactions and Equations

Look at the following examples from daily life and think about the changes taking place:

- Formation of curd/ yogurt from milk
- Burning of coal
- Food is cooked
- Rusting of iron nail

In the examples given above, we find that the nature and identity of the initial materials have changed in some way. We have already studied physical and chemical changes in previous classes. Whenever a chemical change occurs, we can say that a chemical reaction has taken place.

Let us perform some activities to understand chemical reactions.

Activity-1

- Take a magnesium ribbon about 2 cm long. Clean it by rubbing with sandpaper.
- Hold it with a pair of tongs. Burn it using a spirit lamp or burner and collect the ash so formed in a watch-glass as shown in fig.1. Dissolve the ash in water and test it using litmus paper.
- Do this activity with the help of your teacher and keep the burning ribbon as far from your eyes as possible.

1. Did a new substance form during the activity?
2. Where there any changes in the state of magnesium?

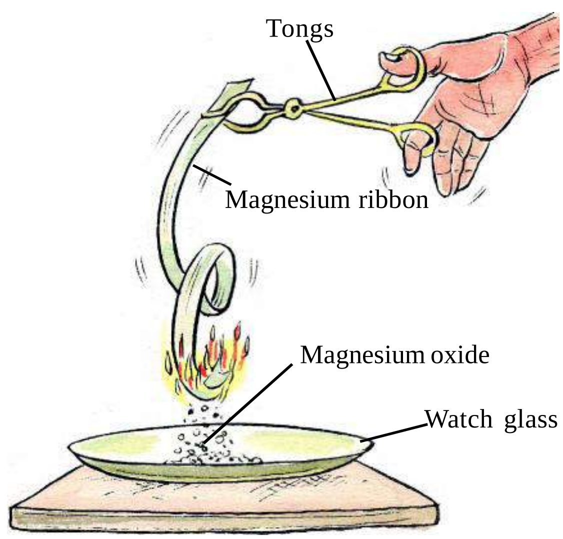


Fig.1 : Combustion of Magnesium ribbon

We saw that magnesium ribbon burns with a dazzling white flame and it changes into a white powder. This powder is magnesium oxide which is formed due to the reaction between magnesium and the oxygen present in the air. The solution of magnesium oxide in water is basic and turns red litmus blue.

Activity-2

- Take two test tubes. In the first, prepare a solution of sodium sulphate by dissolving it in water. Similarly, prepare a solution of barium chloride in the second test tube.
- In another test tube, take 10 mL of the sodium sulphate solution and slowly add the barium chloride solution to it.

1. Did you get any precipitate?
2. Note the colour of the precipitate?

Activity-3

- Take a few zinc granules in a boiling tube.
- Add some dilute hydrochloric acid to it.

1. Do you observe anything happening around the zinc granules (Fig.2)?
2. Touch the boiling tube. Is there any change in its temperature?
3. What happens when you put a lighted matchstick close to the mouth of the boiling tube?

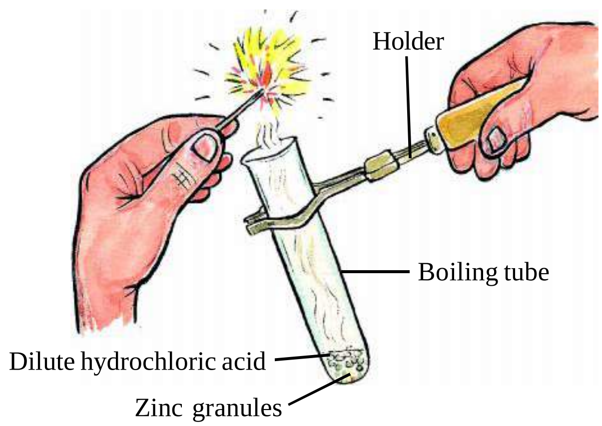


Fig. 2 : Formation of H_2 gas by the action of dilute hydrocholoric acid on zinc

In the three activities given above, new substances are being formed. Further, one or more of the following changes is taking place on the basis of which we can determine that a chemical reaction is taking place:

- Change in state
- Change in colour
- Evolution of gas during the reaction
- Change in temperature as a result of the reaction.

We see many chemical reactions around us in which we can observe these changes in state, colour etc. In this chapter, we will study some of these chemical reactions and their symbolic representation.

10.1 Chemical equations

In activity-1 when a magnesium ribbon is burnt in oxygen, it gets converted to magnesium oxide. This description of a chemical reaction in a sentence form is quite long. It is simpler to write it in the form of a word-equation.

The word-equation for the above reaction is-

magnesium + oxygen $\longrightarrow$ magnesium oxide ……..(1)

(Reactants) (Product)

Magnesium and oxygen are the substances that undergo chemical change in the reaction and are known as reactants. The new substance, magnesium oxide, formed during the reaction, is the product.

A word-equation shows change of reactants to products through an arrow ($\rightarrow$) placed between them. The arrowhead points towards the products, and shows the direction of the reaction.The reactants are written on the left-hand side (LHS) and products are written on the right-hand side (RHS). If the number of reactants or products is more than one then they are separated by placing a plus sign (+) between them.

10.2 Writing a chemical equation

Chemical equations can be made more concise and useful if we use chemical formulae instead of words. Word-equation (1) can be written as:

$$Mg + O_2 \longrightarrow MgO \quad \text{............... (2)}$$

Let us count and compare the number of atoms of each element on the LHS and RHS of the arrow. If the number of atoms of each element not same on both the sidesthen the equation is unbalanced.

From the law of conservation of mass, we know that matter (mass) is neither created nor destroyed during a chemical reaction, that is, atoms are neither created nor destroyed during a chemical reaction.

That is, the total mass of the elements present in the products of a chemical reaction has to be equal to the total mass of the elements present in the reactants.In other words, the number of atoms of each element remains the same, before and after a chemical reaction and therefore we need to balance chemical equations.

10.3 Balancing chemical equations

Let us learn howto step-wise balance a chemical equation.

Example- The chemical reaction showing the formation of water from oxygen and hydrogen can be written as follows:

$$H_2 + O_2 \longrightarrow H_2O \quad \text{.............. (3)}$$

Step-1. To balance a chemical equation, first draw boxes around each formula. Do not change anything inside the boxes while balancing the equation.

$$\boxed{H_2} + \boxed{O_2} \longrightarrow \boxed{H_2O} \quad \text{.............(4)}$$

Step-2. List the number of atoms of different elements present in the unbalanced equation (4)-

Element	Number of atoms in reactants (LHS)	Number of atoms in products (RHS)
H	2	2
O	2	1

Step-3. In equation (4), the number of oxygen atoms on the LHS is 2 while it is only one on the RHS. Therefore, to balance the oxygen atoms-

Atoms of oxygen	In reactants	In products
Initially	2 (in O_2)	1 (in H_2O)
To balance	2	1 × 2

You must remember that to equalise the number of atomswe cannot change the formulae of the compounds or elements involved in the reactions. For example, to balance oxygen atoms we can multiply by 2 and write $2H_2O$ but not H_2O_2.

Now the partly balanced equation becomes –

$$\boxed{H_2} + \boxed{O_2} \longrightarrow 2\ \boxed{H_2O} \quad .... (5)$$

Step-4. Since the hydrogen atoms are not balanced therefore we need to balance them in the partly balanced equation.

Atoms of hydrogen	In reactants	In products
In partly balanced equation	2 (in H_2)	4 (in $2H_2O$)
To balance	2×2	4

To balance the hydrogen atoms, multiply the LHS by 2. Now the equation becomes:

$$2\ \boxed{H_2} + \boxed{O_2} \longrightarrow 2\ \boxed{H_2O} \quad .... (6)$$

To check whether the equation is balanced, we compare the number of atoms of each element on both sides of the equation.

$$2H_2 + O_2 \longrightarrow 2H_2O \quad \text{balanced equation} \ .... (7)$$

Try to balance the equation given below using the same method-

$$Mg + O_2 \longrightarrow MgO \quad .... (8)$$

Let us take some examples of balancing equations-

$$N_2 + H_2 \longrightarrow NH_3 \quad .... (9)$$

Step-1. To balance a chemical equation, first draw boxes around each formula. Remember, do not change anything inside the boxes while balancing the equation.

$$\boxed{N_2} + \boxed{H_2} \longrightarrow \boxed{NH_3} \quad .... (10)$$

Step-2. List the number of atoms of different elements present in the unbalanced equation (4)-

Element	Number of atoms in reactants (LHS)	Number of atoms in products (RHS)
N	2	1
H	2	3

Step-3. In equation (10), the number of nitrogen atoms on the LHS is 2 while it is only one on the RHS. Therefore, to balance the nitrogen atoms-

Atoms of nitrogen	In reactants	In products
Initially	2 (in N_2)	1 (in NH_3)
To balance	2	1 × 2

Now the partly balanced equation becomes –

$$\boxed{N_2} + \boxed{H_2} \longrightarrow 2\,\boxed{NH_3} \quad \text{partly balanced equation .... (11)}$$

Step-4. The hydrogen atoms are still not balanced.We need to balance them in the partly balanced equation -

Atoms of hydrogen	In reactants	In products
In partly balanced equation	2 (in H_2)	6 (in $2NH_3$)
To balance	2×3	6

To balance the hydrogen atoms, multiply the LHS by 3. Now the equation becomes:

$$\boxed{N_2} + 3\,\boxed{H_2} \longrightarrow 2\,\boxed{NH_3} \quad ....(12)$$

To check whether the equation is balanced, we compare the number of atoms of each element on both sides of the equation.

$$N_2 + 3H_2 \longrightarrow 2\,NH_3 \quad \text{balanced equation.........13}$$

The number of atoms of elements on both sides of the equation is equal. Therefore, the equation is balanced. This method of balancing equations is known as hit-and-trail method. In this method, we balance the equation by using the smallest whole number coefficient at first and multiplying it successively as required.

Questions

1. Write the balanced chemical equations for the following reactions:

   (a) Hydrogen + Chlorine $\longrightarrow$ Hydrogen chloride

   (b) Sodium hydroxide + Sulphuric acid $\longrightarrow$ sodium sulphate water

2. Balance the given chemical equations:

   (i) $CH_4 + O_2 \longrightarrow H_2O + CO_2$

   (ii) $Fe + O_2 \longrightarrow Fe_3O_4$

   (iii) $KClO_3 \longrightarrow KCl + O_2$

10.4 Types of chemical reactions

Atoms are neither formed nor destroyed during a chemical reaction. Chemica changes take place during chemical reactions in which reactants form new products. The properties of products are different from their reactants. Actually, chemical reactions involve the breaking and making of bonds between atoms to produce new substances. Let us see different types of chemical reactions-

10.4.1 Combination reactions

Activity-4

- Take a small amount of calcium oxide or quick lime in a beaker.
- Slowly add water to it.
- Touch the beaker.
- Do you feel any change in temperature?

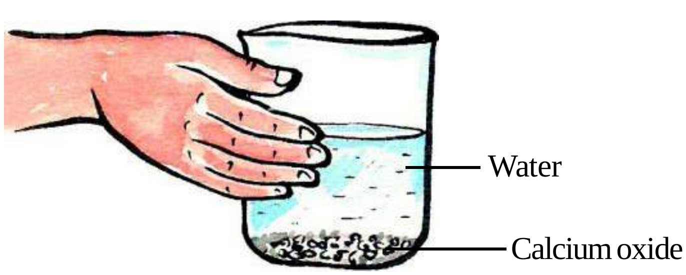


Fig. 3

Calcium oxide reacts rapidly with water to produce slaked lime (calcium hydroxide) releasing a large amount of heat (figure-3).

In this reaction, calcium oxide and water combine to form a single product, calcium hydroxide.

$$CaO + H_2O \longrightarrow Ca(OH)_2 \quad \text{............ (14)}$$

Such a reaction in which a single product is formed from two or more reactants is known as a combination reaction. Identify the type of reaction taking place in activity-1.

Let us discuss some more examples of combination reactions.

(i) Burning of coal

$$C(s) + O_2(g) \longrightarrow CO_2(g)$$

(ii) Formation of water from $H_2(g)$ and $O_2(g)$

$$2H_2(g) + O_2(g) \longrightarrow 2H_2O(l)$$

10.4.2 Decomposition reactions

Activity-5

- Take a small amount of baking soda (sodium hydrogencarbonate) in a boiling tube.
- Heat the boiling tube over a spirit lamp.
- Take a lighted matchstick close to the mouth of the boiling tube as shown in figure-4.
- What do you observe?

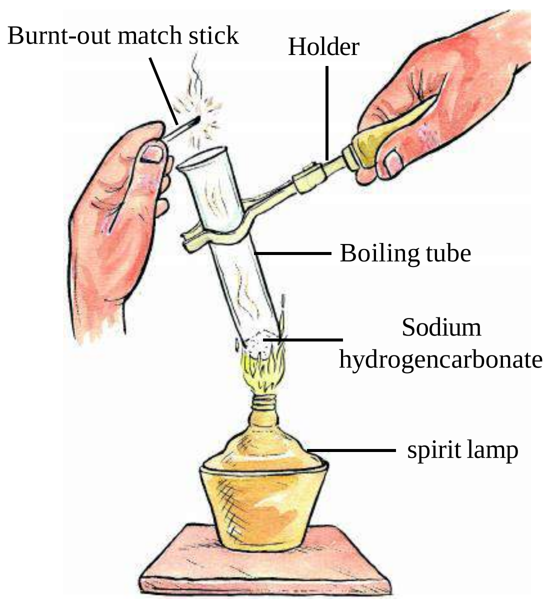


Fig. 4 : Decomposition of sodium hydrogencarbonate and evolution and testing of carbon dioxide gas

You will observe that the lighted matchstick goes out. When we heat sodium hydrogencarbonate, it breaks down into sodium carbonate, water and carbon dioxide.

$$2NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2 \quad ...... (17)$$

In this reaction you can observe that a single reactant breaks down to give two or more products. This is a decomposition reaction.When a decomposition reaction is carried out by heating, it is called thermal decomposition.

Let us discuss some more examples of decomposition reactions-

(i) Water decomposes into hydrogen and oxygen when electric current is passed through it.

$$2H_2O \longrightarrow 2H_2 + O_2 \quad .... (18)$$

This is an example of electrolytic decomposition.

(ii) Decomposition of calcium carbonate to calcium oxide and carbon dioxide on heating is an important decomposition reaction used in various industries including cement industry.

$$CaCO_3 \longrightarrow CaO + CO_2 \quad .... (19)$$

10.4.3 Displacement reactions

Activity -6

- Take three iron nails and clean them by rubbing with sand paper.
- Take two test tubes marked as (A) and (B). In each test tube, take about 10 mL copper sulphate solution.
- Tie two iron nails with a thread and immerse them carefully in the copper sulphate solution in test tube B for about 30 minutes and for comparison,keep one iron nail separately (Fig.5a and b).

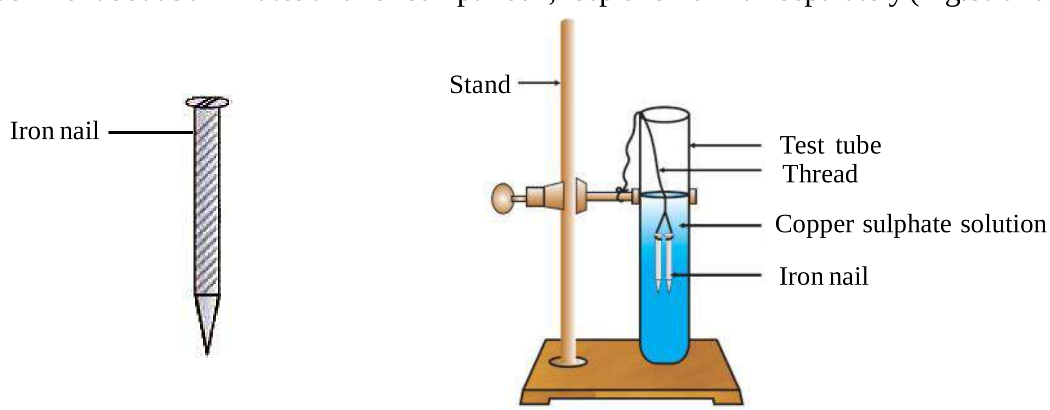


Fig. 5 (a) : Iron nail and iron nails dipped in copper sulphate solution

- After 30 minutes, take out both the iron nails from the copper sulphate solution.
- Compare the intensity of the blue colour of copper sulphate solutions in test tubes (A) and (B).
- Compare the colour of the iron nails dipped in the copper sulphate solution with the one kept separately.

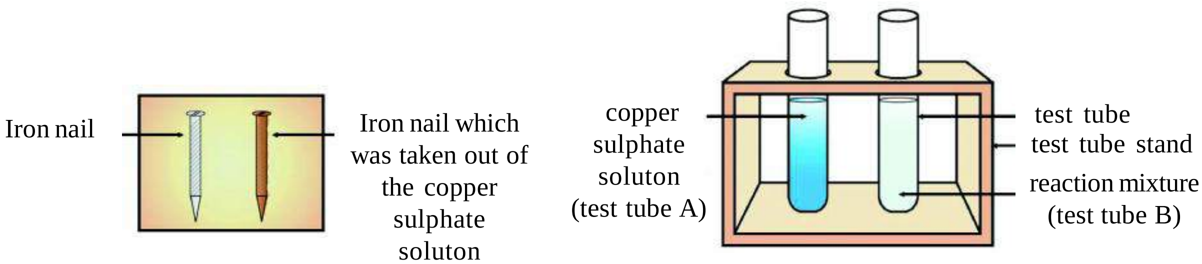


Fig. 5 (b) : Comparison between iron nail and copper sulphate soluton before and after the experiment

Think, why did the iron nail become brownish in colour and the blue colour of copper sulphate solution fade? The following chemical reaction takes place in this activity–

$$Fe + CuSO_4 \longrightarrow FeSO_4 + Cu \; \ldots\ldots\ldots\ldots\ldots \; (20)$$

In this reaction, iron has displaced or removed copper from copper sulphate solution and taken its place in the compound. This reaction is known as displacement reaction.

Let us see some other examples of displacement reactions:

$$Pb + CuCl_2 \longrightarrow PbCl_2 + Cu \quad \ldots\ldots\ldots\ldots\ldots\ldots \; (21)$$

$$Zn + 2AgNO_3 \longrightarrow Zn(NO_3)_2 + 2Ag \quad \ldots\ldots\ldots\ldots \; (22)$$

From the examples given above, we realize that iron and lead are more reactive as compared to copper. They are able to displace copper from its compounds. Similarly, zinc is more reactive than silver and it can displace silver from its silver compounds. Recall activity-3 where you had reacted zinc granules with dilute hydrochloric acid.

1. Write the balanced chemical equation for this reaction.
2. Do you think it is a displacement reaction? Give reasons.

10.4.4 Double displacement reactions

In activity 2 we saw that a white substance is formed which is insoluble in water. This insoluble substance is called precipitate. In this reaction, we get white precipitate of barium sulphate when we add sodium sulphate solution to barium chloride solution.

$$Na_2SO_4 + BaCl_2 \longrightarrow BaSO_4 + 2NaCl \; \ldots\ldots\ldots\ldots \; (23)$$

What does this happen? The white precipitate of $BaSO_4$ is formed by the reaction of SO_4^{--} and Ba^{2+}. The other product formed is sodium chloride which is formed by combination of Na^+ and Cl^- ions and which remains in the solution. Such reactions in which there is an exchange of ions between the reactants are called double displacement reactions.

Some other examples of double displacement reactions are:

(i) When we mixsolutions of lead nitrate and potassium iodide, then a yellow precipitate of lead iodide is obtained along with potassium nitrate solution. Such reactions are known as precipitation reactions.

$$Pb(NO_3)_2 + 2KI \longrightarrow PbI_2 + 2KNO_3 \text{ .... (24)}$$

(ii) In the reaction between sodium hydroxide (base) and hydrochloric acid, H+ and OH- ions combine to form water and Na+ and Cl- ions combine to give sodium chloride which remains dissolved in water. This reaction between acid and base is also known as neutralization reaction.

$$NaOH + HCl \longrightarrow NaCl + H_2O \text{ .... (25)}$$

Questions

(i) Write the balanced chemical equation for each of the following reactions and also identify the type of chemical reaction taking place:

(i) Zinc carbonate $\longrightarrow$ zinc oxide + carbon dioxide

(ii) Sodium hydroxide + sulphuric acid $\longrightarrow$ sodium sulphate + water

(iii) Potassium bromide + barium iodide $\longrightarrow$ potassium iodide + barium bromide

(ii) Why does the colour of copper sulphate solution change when an iron nail is dipped in it?

10.4.5 Oxidation and reduction reactions

Activity-7

- Take about 1 g copper powder in a china dish and heat it as shown in figure 6.
- What do you observe?
- The surface of copper powder becomes coated with a black layer. Why has this black substance formed?

This black layer is copper oxide which is formed by the reaction between copper and oxygen.

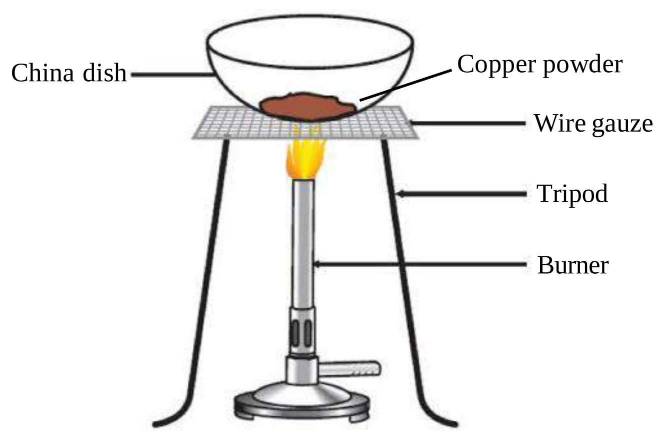


Fig. 6 : Oxidation of copper

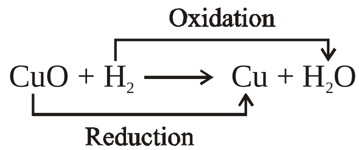
$$2Cu + O_2 \longrightarrow 2CuO \text{ .... (26)}$$

If hydrogen gas is passed over this heated material (CuO), the black coating on the surface turns brown as the copper oxide loses its oxygen and copper is obtained.

$$CuO + H_2 \longrightarrow Cu + H_2O \text{ .... (27)}$$

If a substance gains oxygen during a reaction, it is said to undergo oxidation. If a substance loses oxygen during a reaction, it is said to be reduced or undergoes reduction.

During this reaction (27), copper oxide is losing oxygen and is being reduced. The hydrogen is gaining oxygen and is being oxidised. In other words, one reactant gets oxidised while the other gets reduced during this reaction. Such reactions are called oxidation-reduction reactions or redox reactions.



Some other examples of redox reactions are

$$ZnO + C \longrightarrow Zn + CO \quad .... (28)$$

$$MnO_2 + 4HCl \longrightarrow MnCl_2 + 2H_2O + Cl_2 \quad .... (29)$$

In reaction (28) carbon is oxidised to CO and ZnO is reduced to Zn. In reaction (29), oxygen is being lost by manganese oxide, that is, it is getting reduced and the hydrogen of HCl is gaining oxygen and getting oxidised to water.

From the above examples we can say that if during a reaction, a substance gains oxygen or loses hydrogen it is oxidationand if a substance loses oxygen or gains hydrogen it is reduction.

Can we explain reduction-oxidation (redox) reactions on the basis of electron transfer?

In activity-1, the magnesium ribbon burnt in oxygen to form a white powder of magnesium oxide.

$$2Mg + O_2 \longrightarrow 2MgO \quad .... (30)$$

We can say that magnesium oxide is formed by the oxidation of magnesium. If we try to understand this reaction by looking at the electronic configurations of magnesium and oxygen then we find that a magnesium atom has two electrons in its outermost shell which it loses to form a positive magnesium ion.

$$Mg \longrightarrow Mg^{++} + 2e^- \quad .... (31)$$

This electrons are accepted by oxygen to form the oxide ion which is negatively charged.

$$O + 2e^- \longrightarrow O^{2-}$$

or $$O_2 + 4e^- \longrightarrow 2O^{2-} \quad .... (32)$$

In this way, loss of electrons by magnesium is called oxidation and accepting electrons by oxygen is called reduction. Since both oxidation and reduction are happening simultaneously in the above example, the reaction is called a redox reaction.

So far we have looked at different types of reactions on the basis of the reactants or products formed in them. Let us reconsider some of the activities done so far in the chapter.

In activity-4, we saw that the formation of calcium hydroxide is accompanied by the release of a large amount of heat. Such reactions are known as exothermic reactions.

Recall activity-1 where a magnesium ribbon was burnt using a spirit lamp.

(i) Was it a combination reaction?

(ii) Is oxidation or reduction taking place?

(iii) Is it exothermic?

Recall activity 3 where zin granules were reacted with dilute hydrochloric acid. Is this displacement reaction also an exothermic reaction?

Some more examples of exothermic reactions are given below-

1. Combustion of natural gas

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O + \text{heat} \; ....\; (33)$$

2. The formation of manures and respiration are also exothermic reactions.

Activity-8

- Take a small amount of lead nitrate powder in a boiling tube.
- Use a test tube holder to hold the boiling tube and heat it over a flame (figure 7).
- What do you observe? Note down the change, if any.

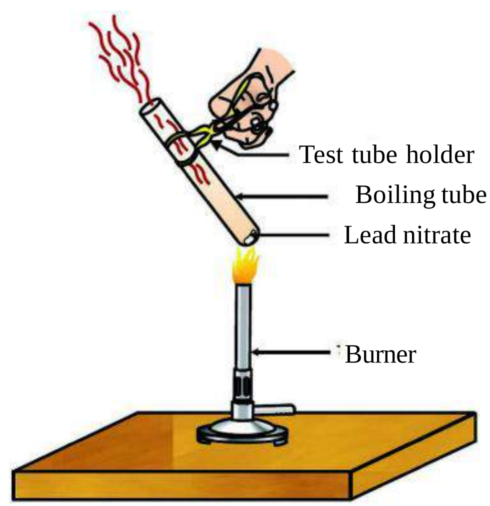


Fig. 7

You will observe the emission of brown fumes of nitrogen dioxide. The reaction that takes place is:

$$2Pb(NO_3)_2 \longrightarrow 2PbO + 4NO_2 + O_2 \; ....\; (34)$$

In this reaction, heat is required for the decomposition of the reactant. The reactions in which heat is absorbed are known as endothermic reactions.

Do the following activity

Take about 2 g barium hydroxide and 1 g of ammonium chloride in a test tube and mix with the help of a glass rod. Touch the bottom of the test tube with your palm. Can you feel any change in temperature? Is this an exothermic or endothermic reaction?

Activity-9

- Take about 2 g silver chloride in a china dish and note its colour.
- Place this china dish in sunlight for some time (Fig.8). Observe and note the colour of the silver chloride after some time.

Fig. 8 : In the presence of sunlight silver chloride becomes grey and forms silver metel

You will see that white silver chloride turns grey in sunlight. This is due to the decomposition of silver chloride into silver and chlorine by light.

$$2AgCl \longrightarrow 2Ag + Cl_2 \quad .... (35)$$

This reaction takes place in the presence of sunlight. Such reactions are known as photochemical reactions.

All such the decomposition reactions that require energy either in the form of heat, light or electricity for changing the reactants into products are known as endothermic reactions.

10.5 Making chemical equations more informative

Chemical equations can be made more informative by including the following properties of the reactants and products: -

1.	Physical state	2.	Change in heat	3.	Evolution of gas
4.	Precipitation	5.	Different conditions		

1. **Mentioning the physical states-** To make a chemical equation more informative, the physical states of the reactants and products can be mentioned along with their chemical formulae.The gaseous, liquid, aqueous and solid states of reactants and products are represented by the notations (g), (l), (aq) and (s), respectively. Now the unbalanced equation (34) can be rewritten as-

$$2Pb(NO_3)_2(s) \xrightarrow{heat} 2PbO(s) + 4NO_2(g) + O_2(g) \quad .... (36)$$

2. **Mentioning changes in heat-** Heat is released during exothermic reactions and absorbed during endothermic reactions. See the following examples:

$$C(s) + O_2(g) \longrightarrow CO_2(g) + Q \quad \text{Exothermic} \quad .... (37)$$

$$N_2(g) + O_2(g) \longrightarrow 2NO(g) - Q \quad \text{Endothermic} \quad .... (38)$$

In exothermic reactions, the heat released (Q) is added to the product side by using a plus sign (+). In endothermic reactions, a minus sign is used to show the heat absorbed.

3. **Showing the evolution of gas-** If the reaction involves evolution of a gas then it is shown using an upward arrow (↑).

$$Zn(s) + H_2SO_4(aq) \longrightarrow ZnSO_4(aq) + H_2\uparrow \quad .... (39)$$

4. **Showing the formation of a precipitate-** If a precipitate is formed during a reaction it is shown using a downward arrow (↓).

$$AgNO_3(aq) + NaCl(aq) \longrightarrow AgCl\downarrow + NaNO_3(aq) \quad .... (40)$$

5. **Mentioning different reaction conditions–** Sometimes different reaction conditions such as temperature, heat, catalyst, pressure etc. can be mentioned above or below the arrow in the equation.

$$6CO_2(g) + 6H_2O(l) \xrightarrow[\text{chlorophyll}]{\text{sunlight}} C_6H_{12}O_6(aq) + 6O_2(g) \quad .... (41)$$

$$2AgCl(s) \xrightarrow{\text{sunlight}} 2Ag(s) + Cl_2(g) \quad .... (42)$$

Similarly, try to make the different equations given in the chapter more informative.

Questions

1. Identify which substance is getting oxidized and which is being reduced in the following reactions
2. How are changes in heat (release, absorption) shown in chemical equations. Explain using examples.

Keywords

reactant, product, combination reaction, decomposition reaction, displacement reaction, double displacement reaction, oxidation, reduction, exothermic, endothermic,redox

What we have leant

- A new substance is always formed during a chemical change.
- Chemical equations are a way of showing chemical reactions.

- A complete chemical equation represents the reactants, products and their physical states symbolically.
- According to the law of conservation of matter, a chemical equation must be balanced so that the numbers of atoms of each element involved in a chemical reaction are the same on the reactant and product sides of the equation.
- In a combination reaction two or more substances combine to form a new single substance.
- Decomposition reactions are opposite to combination reactions. In a decomposition reaction, a single substance decomposes to give two or more substances.
- A displacement reaction is one in which an element displaces another element from its compound.
- Ions are exchanged between reactants in double displacement reactions.
- Oxidation is the gain of oxygen or loss of hydrogen or loss of electrons.
- Reduction is the loss of oxygen or gain of hydrogen or gain of electrons.
- Reactions in which heat is given out along with the products are called exothermic reactions.
- Reactions in which energy is absorbed are known as endothermic reactions.

Exercises

1. Choose the correct option :

(i) Which of the following reactions s taking place when hydrogen chloride is formed by reaction between hydrogen and chlorine

(a) Decomposition (b) Displacement

(c) Combination (d) Double displacement

(ii) $Fe_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Fe$ This reaction is an example of

(a) Combination (b) Decomposition

(c) Displacement (d) Double displacement

(iii) $2PbO(s) + C(s) \longrightarrow 2Pb(s) + CO_2(g)$ Which statement is true about this reaction

(1) Lead is undergoing oxidation

(2) Carbon dioxide is undergoing oxidation

(3) Carbon is getting oxidized to carbon dioxide

(4) Lead oxide is being reduced to lead

(a) 1 and 2 (b) 3 and 4

(c) 2 and 3 (d) all

(iv) $NaCl(aq) + AgNO_3(aq) \longrightarrow AgCl\downarrow + NaNO_3(aq)$

The given chemical reaction is

(a) Displacement (b) Combination

(c) Decomposition (d) Double displacement

2. Fill in the blanks

(a) Substances on the LHS in a chemical equation are called .... and those on the RHS are known as..................................

(b) is an example of .... reaction.

(c) The arrow between the reactants and products in a chemical equation shows the .... of a reaction.

(d) The type of reactions where heat is absorbed during the formation of products are .... reactions.

3. What is a chemical equation? Why should chemical equations be balanced?

4. Write balanced chemical equations for the following reactions:

(a) Potassium metal reacting with water to give potassium hydroxide and hydrogen gas.

(b) Nitrogen gas combines with hydrogen to form ammonia.

(c) Hydrogen sulphide gas burns in air to give water and sulpur dioxide.

(d) Barium chloride reacts with aluminium sulphate to give a solution of aluminium chloride and a precipitate of barium sulphate.

5. Balance the following chemical equations.

(i) $C_3H_8 + O_2 \longrightarrow H_2O + CO_2$

(ii) $C_6H_{12}O_6 \longrightarrow C_2H_5OH + CO_2$

(iii) $Hg(NO_3)_2 + KI \longrightarrow HgI_2 + KNO_3$

(iv) $HNO_3 + Ca(OH)_2 \longrightarrow Ca(NO_3)_2 + H_2O$

6. Write the balanced chemical equation for the following and identify the type of reaction in each case.

(a) Magnesium + iodine $\longrightarrow$ magnesium iodide

(b) Magnesium + hydrochloric acid $\longrightarrow$ magnesium chloride + hydrogen

(c) Zinc + copper nitrate $\longrightarrow$ zinc nitrate + copper

(d) Sodium hydrogencarbonate $\longrightarrow$ sodium carbonate + carbon dioxide + water

7. Why are decomposition reactions called the opposite of combination reactions? Write equations for these reactions.
8. Write one equation each for decomposition reactions where energy is supplied in the form of heat, light or electricity.
9. What is the difference between displacement and double displacement reactions? Write equations for these reactions.
10. Give two examples of redox reactions.
11. Explain the chemical reactions that take place in the presence of sunlight.
12. What do you understand by precipitation reactions? Explain using examples.
13. Explain exothermic and endothermic reactions through examples.
14. Hanif burnt a magnesium ribbon using a spirit lamp and on the basis of his observations he said that the type of chemical reaction taking place is combination as well as exothermic as well as oxidation. Do you agree with Hanif? Give reasons for your answer and explain.

Chapter 11

Gravitation

In the chapter of force and motion, you have come across several such examples where an object moves towards the surface of earth. Like when a stone is thrown upwards, away from the surface of earth, it comes back to the earth's surface. Drops of rain, dry leaves, dust particles, everything falls back on the surface of earth. Have you ever thought why does every object fall back on earth?

Why does the velocity of a pebble increase on reaching the surface of earth when its thrown from a height above the earth's surface?

You learnt in earlier classes that several earth-like planets in solar system revolve around the sun and moon-like satellites revolve around the planets. In such a situation, why does earth not fall on the sun or moon does not fall on the earth?

Activity-1

Tie a wooden block with a thread. Hold the free end of the thread with your hands while you drop down the other end which is tied to the block. What happend?

Now slowly move the block in a circular motion, as shown in the fig.1. Move it faster and see what happens. Do you feel more pull on your finger?

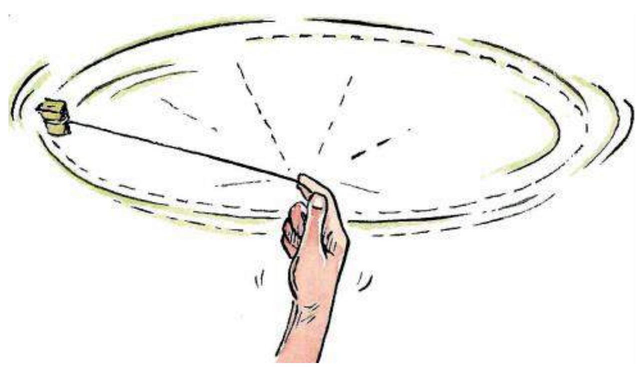


Fig. 1 : circular motion of the wooden block

If you drop the thread while moving the block fastly or if the thread breaks off, to which direction does the block go? Does the block keep moving in a circular path even after the thread breaks off? Have you thought about the direction of motion of the block? Discuss amongst yourself.

Experiment carefully and find out what happens if we gradually reduce the speed of the motion of the block.

1.1 Concept of Gravitation

In the above activity you saw that a thread holds the block moving in a circular path even when it moves in a very high speed. But there is no such strong thread between the earth and the moon which keeps the moon connected. Then what is the force which causes the moon to revolve around the earth continuously?

For a long time people thought that attracting the moon and other objects is a characteristic property of earth and thats why the moon and all other stars revolve around the earth. But this belief did not agree with various observation of our solar system and other planets. It also did not coincide with the coppernicus theory of sun centric solar system or with kepler's laws which were based on several observations of solar system. According to them, if sun is at the centre and planets are revolving around it just like moon revolves around the earth, then we must believe that the way earth attracts moon, sun must also attract earth towards it.

In this regard, Sir Isaac Newton studied various works of other scientists and made several observations to conclude that the force of attraction does not only exist between the earth, moon and the sun but also between all small-big things of this world. Stones, dust particles, water molecules, planets, stars etc. all exert a force of attraction on each other due to their masses. This property of attraction due to mass is called as gravitational force.

According to Newton, the force of attraction existing between any two bodies of the universe depends upon their masses and the distance between them.

As shown in fig. 2, consider that two bodies A and B are placed at a 'distance r' from each other. They are attracting each other with a force of attraction 'F'. The masses of bodies A and B are 'm_1', and 'm_2' respectively. According to Newton's law the force acting between them must be directly proportional to the product of their masses.

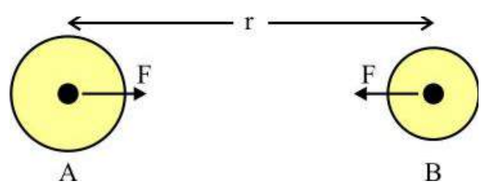


Fig. 2 : Gravitational force between two bodies

That means, $F \alpha\, m_1 \times m_2$ ....(1)

Also, the force between the two bodies is inversely proportional to the square of the distance between them.

$$F \alpha \frac{1}{r^2} \quad ....(2)$$

$$F \alpha \frac{m_1 \times m_2}{r^2} \quad ....(3)$$

$$F = G\frac{m_1 \times m_2}{r^2} \quad ....(4)$$

The value of G was unknown at the time of Newton. In 1797, Cavendish placed two bodies of known masses at a certain distance and found out the force of attraction between them. Using the eq. (4) he then calculated the value of G..

Here G is a universal gravitational constant. The value of G in SI units is 6.67×10^{-11} Nm^2/kg^2.

Suppose that the distance between two bodies is doubled, then what will be the force between the two? And what happens when the distance is trippled? We can see that the value of force decreases with the increase in distance.

- Can you tell what effect will the increase or decrease of the value of G have on our daily lives? What would have happened if there was no gravitational force? Discuss with your friends in a group.

Example 1. The mass of earth is 6×10^{24} kg and the mass of sun is 2×10^{30} kg. If the average distance between the earth and the sun is 1.5×10^{11} m then calculate the force exerted by the sun on the earth. What will be the force exerted by earth on the sun?

Solution : The force exerted by earth on the sun and the force exerted by sun on earth are equal. By calculating one of the two forces we can find the other.

According to eq (4), the force of attraction between the earth and the sun,

$$F=G\frac{m_e\times m_s}{r^2}$$

Where m_e = mass of earth = 6×10^{24} kg;

m_s = mass of sun = 2×10^{30} kg;

r = average distance between earth and sun = 1.5×10^{11} m; G = 6.67×10^{-11} Nm^2/kg^2

Hence;

$$F=\frac{6.67\times10^{-11}\times6\times10^{24}\times2\times10^{30}}{(1.5\times10^{11})^2}N$$

$$F=\frac{6.67\times6\times2\times10^{-11}\times10^{24}\times10^{30}}{(1.5^2\times10^{11})^2}N$$

$$=\frac{6.67\times6\times2\times10^{-11+24+30-22}}{1.5^2}N$$

$$=\frac{6.67\times6\times2}{1.5^2}\times10^{21}N = 35.57\times10^{21}N$$

Therefore the earth and the sun attract each other with a force of 35.57×10^{21} N.

Activity-2

Calculate the force of attraction between you and a friend sitting at a distance of 1 m from you. Do you feel this force? If not then why?

11.2 Gravitational acceleration 'g'

In the chapter on motion you read that when a body is subjected to a force, an acceleration is produced in the body. The acceleration produced in a body due to earth's gravitational force is called as gravitational acceleration. Gravitational acceleration is denoted by 'g'.

From eq. (4) and with the help of Newton's law of motion we can find out the value of 'g'. Suppose that a body of mass 'm' is placed on surface of earth. Earth exerts a force of 'F' on that body.

From eq. (4)

$$F = G\frac{M \times m}{R^2} \quad \text{................(5)}$$

M : mass of earth, R = distance of earth's surface from its centre, m = mass of the body

How much acceleration will be produced in the body due to the gravitational force?

According to second law of motion by Newton, if the acceleration is 'g' then,

$$F = mg \quad \text{................(6)}$$

From eq. (5) and (6), we get

$$mg = G\frac{M \times m}{R^2}$$

$$g = G\frac{M}{R^2} \quad \text{................(7)}$$

With the help of eq. (7) we can calculate the value of 'g'. Mass of earth is $M = 6 \times 10^{24}$ kg and radius is $R = 6.4 \times 10^6$ m.

On calculating, we get the value of $g = 9.81 \text{ m/s}^2$. For simplification we will put the value of g as 10 for all mathematical calculations in this chapter. Is the value of 'g' same at all places on earth?

Does the value of 'g' depend on the mass of the body, volume, nature, density, position above the surface of earth or the distance from the centre of earth? Which all factors amongst these are more important?

Is the value of 'g' on the equator of earth and the poles same? Where will its value be greater? Discuss with your friends.

11.3 Free fall

As shown in the fig. 3, a boy throws a ball upwards from the surface of earth. The path of the ball moving upwards and then downwards is shown as ABCDE. Here A is the initial position of the ball P, C is its maximum height and E is its final position.

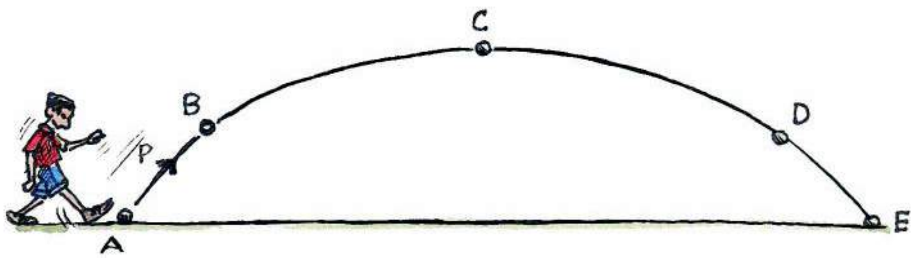


Fig. 3 : The path of the motion of ball P

- Can you state which forces are applied on the ball P at the positions B,C,D and E.
- Other than gravitational force is there any other force working on the ball P which is responsible for the motion of the ball?
- Is the same force exerted on the ball when it is kicked? If yes, then for how long is it applied?
- How much acceleration is produced on the ball due to this applied force? If in this path, the ball P is subjected to only gravitational force by earth then why is the path of the motion of the ball as shown in the figure? All these questions are obvious.

It is always considered that if a body is in motion, there must be a force applied on the body in the direction of motion. But this is not always the case. You have seen in the chapter of force and motion that it is not necessary that if a body is in motion then there must always be a force acting on it. From the second law of motion we also saw that the force exerted on a body is directly proportional to the change in its momentum. But it is not necessary that it is always in the direction of momentum. If it is in the direction opposite to momentum it will decrease the momentum.

In reality, every moving object is subjected to a force exerted by wind in the opposite direction. But this force is very little and therefore it is always negected by us for simplicity.

When we apply a force on an object to throw it upwards, we actually provide it with an initial velocity. This initial velocity and momentum requires force. We exert a force in the beginning while throwing the object, but the question is does this applied force still exist on the object after it leaves our hand?

According to first law of motion, application of force produces motion and due to inertia the body keeps moving upwards. After it leaves our hand, the only force acting on the body is gravitational force. Thus, the acceleration produced in the body is only due to this gravitational force.

That situation in the motion of an object where only the gravitational force exists is called as free fall. Can you think of more such situations where the body is in a state of free fall? Discuss in a group.

You have read about the equations of motion in the chapter on motion. On replacing the acceleration 'a' by 'g' in those equations, we show that this acceleration is produced due to earth's gravitational force.

Equations of motion with gravitational acceleration.

1. $v = u + gt$
2. $v^2 = u^2 + 2gh$, (h = height of object from the surface of earth)
3. $h = ut + \frac{1}{2}gt^2$

Let us understand this using some examples. Suppose you drop down two objects A and B having different masses from a height of 100 m. above the surface of earth. The masses of A and B are 2 kg. and 10 kg. respectively. What will be their speeds after covering a distance of 10 m? After covering the next 10 m what will be their speeds? Calculate their speeds after every 10 m distance and fill in the following table 1.

Table 1 : Position, time and speed of objects during free fall.

Travelled distance	**Speed of object A**	**Speed of object B**	**Time taken by object A to cover the distance (s)**	**Time taken by Object B to cover the distance (S)**
0				
10			$\sqrt{2}$	
20	20 (approx)			
....				
100		$20\sqrt{5}$		$2\sqrt{5}$

On the basis of this table draw a graph between position-time, speed-time and position-speed of the object.

Does the mass of an object affect its speed?

Example 2. A stone is dropped from the top of a 20 m. tower. What will be its velocity just before touching the surface of earth? Calculate time taken by the stone to reach the earth's surface. Take the value of 'g' as $10 m/s^2$.

Solution :(i) Height of tower, $h = 20$ m

initial velocity of the stone $u = 0$

$g = 10 m/s^2$

$$s = ut + \frac{1}{2}gt^2$$

$\Rightarrow 20 = 0 \times t + \frac{1}{2} 10t^2$

$\Rightarrow 5t^2 = 20$

$\Rightarrow t^2 = 4$

$\Rightarrow t = 2s$

Hence, time taken by the stone to reach the earth's surface is 2 sec.

(ii) Velocity of the stone-

$v = u + gt$

$= u + 10 \times 2$ m/s (u=0)

$= 20$ m/s

Hence, the speed of stone reaching the earth's surface is $20ms^{-1}$.

Example 3. A ball thrown upwards vertically comes back to the thrower in 6 sec. Tell-

1. What was the velocity of the ball thrown?
2. What was the maximum height reached by the ball?
3. Position of the ball after 4 sec.?

Solution :(i) initial velocity of ball, u = ?

final velocityof ball, v = 0

Time taken by the ball to reach the maximum height t = 3 sec.

Object goes upwards in first 3 sec., and in next 3 sec. it comes downwards

So, total time taken by the ball to cover the complete distance is = 3s + 3s = 6s

Velocity of the ball

$v = u - gt$

$o = u - 10 \times 3$ m/s

$u = +30$m/s

(ii) Maximum height attained by the ball.

$s = ut - \frac{1}{2}gt^2$

$= 30 \times 3 - \frac{1}{2} \times 10 \times 3^2$ m

$= 90 - 45$ m

$= 45$ m

(iii) Distance covered by the ball in 1 sec. of returning.

$$s = ut + \frac{1}{2} gt^2$$

$$= 0 + \frac{1}{2} \times 10 \times 1^2 m$$

$= 5$ m

So, position of ball after 4 sec. is 45 m – 5 m = 40 m.

Question

1. An object of mass 'm' is dropped from a height 'h' above the surface of earth. What will be its velocity just before reaching the surface of earth?

2. As shown in the fig. 4. Throw a ball vertically upwards with a speed of 5 m/s. How much height will the ball reach and after how long will it return back to your hands. In which position of the ball, its speed will be minimum and what will be its value?

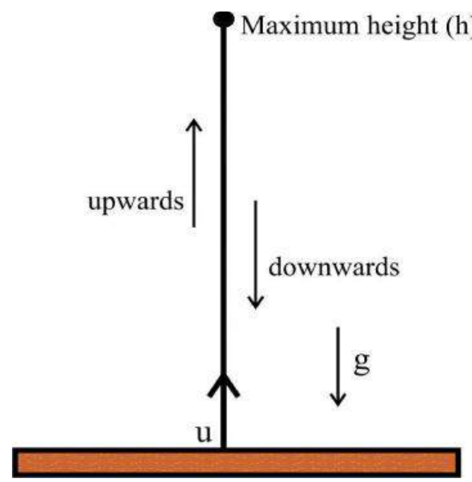


Fig. 4 : Speed of ball

11.4 Mass and Weight

You know that inertia depends upon mass. The total quantity of material in an object is known as its mass. If the total measure of the quantity of the object remains unchanged then the mass of that object remains constant at all positions. Mostly we measure an object on the basis of its mass, for example, 2 kg. of rice, 1 kg. of pulses, 3 kg. of sugar etc. If we take 2 kg. mass of rice to the moon, we will find that the mass of rice will remain 2 kg. on the moon as well. The SI unit of mass is kilogram (kg.)

The force by which an object is attracted towards the earth is called the weight of an object. The SI unit of weight is Newton (N).

From the eq. (6) we know that the earth exerts a force 'mg' on an object of mass 'm' kg. placed at a certain position on earth. That means, the weight of the object having 'm' kg. mass will be 'mg' on that particular position on earth.

Do you think the weight of an object will be same at all positions on earth? Will the weight of the object remain constant on the earth, moon and the sun?

Question

1. Mass of the moon is $M_{moon} = 7 \times 10^{22}$ kg. and its radius is $R_{moon} = 1700$ km. Using the eq. (7), find out the value of acceleration on the surface of moon for an object of mass 'm'.
2. Compare the weight of an object of mass 'm' on the surface of earth and the moon.
3. The distance between the centres of earth and the moon is 3.84×10^5 km. How much force will they exert on each other?

Activity-3

Find out the masses of three of your classmates. Calculate and find the force exerted on them by earth. How will the forces exerted on them change if they were taken to the moon?

11.5 Centre of Gravity

You might have seen a child or a person walking on a thick rope in a fair or somewhere near your house. How does that person balance himself on that rope?

While walking on the rope, he spreads both of his hands or takes support from a horizantal stick in his hand. Have you ever wondered why he does this?

Fig. 5

Activity-5

Can you get up from a chair without bending?

Sit comfortably on a chair as shown in the fig.6. Now without bending your legs try to get up from the chair.

- Are you able to do it? If not then why?

Activity-6

Try to balance a long bamboo stick on your palm.

In which situation is this possible?

Here we will introduce you to the concept of 'centre of gravity'.

The average or balanced position of weight distribution is known as centre of gravity. This point where the total weight of the object appears to be concentrated at is called as centre of gravity.

Fig. 6

Activity-7

To find the centre of gravity.

Take a metre scale. Now using your index finger try to balance it horizontally at different points. What do you see? Can you balance the scale at its middle point? Why does this happen?

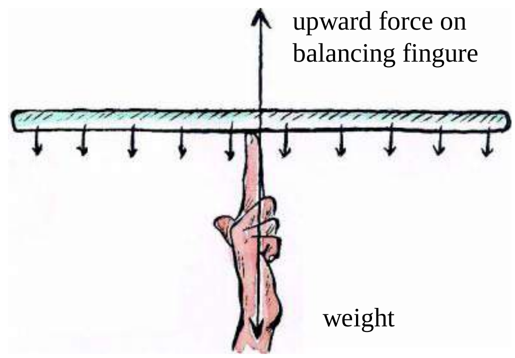


Fig. 7

The centre of gravity of an object having fixed shape is at its centre. The complete weight of the scale is considered to be concentrated at that point. By just giving a support to that particular point, the complete scale can be supported.

We can easily find the centre of gravity of an object by balancing it. The small arrows shown in the figure represent the gravitational forces acting on the scale. the sum of all those forces is equialent to the resultant force at the centre of gravity.

The complete weight of the scale is concentrated at this particular point. Thus a single force acting at this point in upward direction balances out the metre scale.

- How can we find out the centre of gravity of any object?

The centre of gravity of a freely suspended object is right below its suspension point.

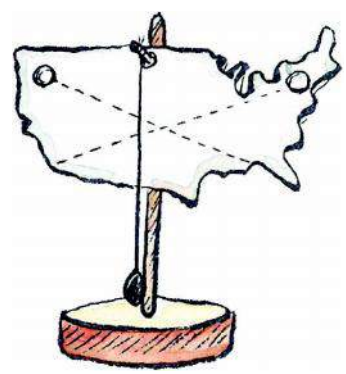


Fig. 8

If a vertical line passing through the point of suspension is drawn then the centre of gravity would lie somewhere on this line. To know its exact position suspend the object from some other point and draw another vertical line from that point. The point of coincidence of these two lines is the centre of gravity.

Similarly the centre of gravity of a person walking on a rope is right in his centre. By taking support from a long wooden stick he tries to shift the centre of gravity downwards (towards his knee or legs) so that he can easily walk on the rope.

Activity-8

To find out the centre of gravity of a ring.

In the above activity it is explained that how to find centre of gravity. On the same basis we can find out the centre of gravity of a ring.

- Where will be the centre of gravity of a ring?

- Can a body have its centre of gravity outside it?
- Can the centre of gravity be somewhere where there is no mass?

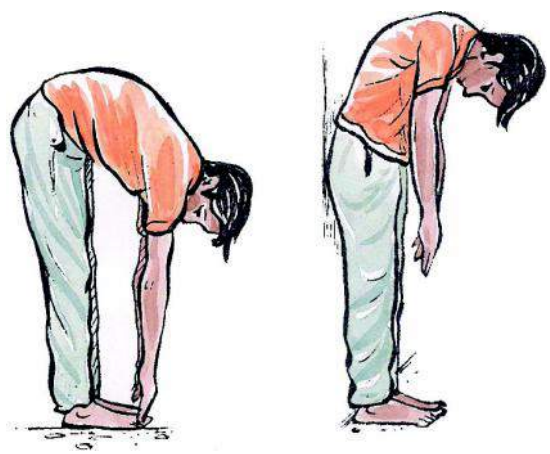
Stability

It is essential to know the centre of gravity for stability. Draw a line vertically downward from the point of centre of gravity for any object having any shape, if the line lies within the base of the object, then the object will remain stable.

But if the centre of gravity is outside the base of the object than the object will be unstable.

Activity-9

Change in centre of gravity and its affect.



(a) (b)

Fig. 9

Where is your centre of gravity when you are standing straight?

Try touching your toe. Try doing the same while standing close to a wall (as shown in the fig. 9 (b).

- In the position shown in fig. 9 (b) are you able to touch your toe? If not then why?
- In both the cases what difference do you see in the centre of gravity of your body?

Think

- Where will be the centre of gravity of a sphere and a triangular table?
- Can a body have more than one centre of gravity?
- Why does the leaning tower of pisa not fall?
- Why do you bend forward when you lift a heavy load on your back?

What we have learnt

- Due to their masses, all the objects in the universe exert a force of attraction on each other. This property of attraction due to mass is called as gravitational force (It is a central force).
- The universal gravitational constant is denoted by G. The value of G is 6.67×10^{-11} Nm^2/kg^2.
- The value of gravitational acceleration is 9.81 m/s and is denoted by g.
- A freely falling body falls on earth with an acceleration 'g'.
- The mass of a body is constant. But the weight of a body depends upon the gravitational acceleration acting on it.

Keywords :- Gravitation, Universal gravitational constant, Mass, Free path, Centre of gravity..

Exercise

1. Multiple choice questions-

(i) The gravitational force between two bodies does not depend on-

(a) The distance between both the bodies.

(b) Product of their masses

(c) Sum of their masses

(d) Gravitational constant

(ii) The value of G is-

(a) $7.67 \times 10^{11} Nm^2/kg^2$ (b) $6.67 \times 10^{11} Nm^2/kg$

(c) $6.67 \times 10^{-11} Nm^2/kg^2$ (d) $5.67 \times 10^{11} Nm^2/kg^2$

(iii) The value of gravitational acceleration on the surface of earth is-

(a) 9.8 m/s^2 (b) 8.8 m/s^2

(c) 4.8 m/s^2 (d) 8.9 m/s^2

(iv) According to universal law of gravitation, the force acting between two bodies of masses m_1 and m_2 placed at a distance R is-

(a) $F = G\dfrac{m_1 m_2}{R^2}$ (b) $F = G\dfrac{m_1 m_2}{R^4}$

(c) $F = Gm_1m_2/R$ (d) $F = G\dfrac{M}{R}$

(v) A body is moving upwards opposing the gravitational pull of earth. What will be its velocity at the highest point reached?

(a) 0 (b) $u^2/2g$

(c) h/t (d) 2gh

2. Fill in the blanks-

(i) On earth, the weight of a body having 10 kg. mass will be ....

(ii) A body falling from rest from a height h will have a velocity of ....

(iii) Value of universal gravitational constant is ....

(iv) The value of gravitational acceleration in SI units is ....

(v) If two objects of different masses are dropped from a same height, they will reach the surface of earth at .... time.

3. What will be the gravitational force between earth and an object of 1 kg. placed on its surface. Here, the mass of earth is 6×10^{24} kg, and distance from the earth to the earth's surface is 6400 km.

4. What will be the gravitational force between two objects if-

(i) The mass of one object is doubled.

(ii) The distance between the objects is tripled.

(iii) Mass of both the objects is doubled.

5. Why does a sheet of paper fall slower than a ball made up of that sheet.

6. What is the importance of the universal law of gravitation.

7. Why does earth not travel towards the moon, if moon attracts the earth?

8. A ball is thrown vertically upwards with a speed of 49 m/s. Calculate-

(i) Maximum height of the ball

(ii) Total time taken by the ball to reach the earth's surface.

9. If a body is thrown vertically upwards at a speed of 10 m/s then after how much time and with what velocity will it reach back to us?

10. The force of gravitation between two bodies is F. In what situation will the force between the two become 4 F?

11. Why do two objects having different mass reach the surface of earth simultaneously? Is the force of gravitation acting on both of them equal?

12. Derive an equation to find the acceleration produced due to earth on an object of mass 'm'. Also find its value.

Chapter 12

Work and Energy

In the earlier chapters we have discussed about some main concepts of science like-motion of an object, motion due to force, laws of motion and gravitation. Work and energy are also important concepts of science which let us to understand several natural phenomenon and also helps us to describe them. In this chapter we will study about them.

In our daily life we use the words 'work' and 'energy' in several contexts. For example, he works in the fields, he is very energetic etc. Energy is needed to perform any kind of work. Humans and machines also use energy to do work. For example- a student uses energy to ride a bicycle from his house to his school. In the same way, electric bulb uses energy to produce light.

Think

- Where does the consumed energy go?
- Can we do a work without consuming energy?

We will try to understand such questions in this chapter.

12.1 Work

Generally any kind of useful physical or mental hardwork in our daily life is considered as work. For example- A student spends a lot of time in studying during exams. He reads books, solves question papers, discusses with classmates etc. In common language, he does a lot of hard work. Similarly singing a song, talking with friends, playing in school, having discussions etc, all are considered as work.

Fig. 1 : Thinking is not physical work

But the definition of work in terms of science is different.

In science, to do work, following two conditions are necessary

- a force must be applied on the object.
- The object must be displaced or its position must change.

Physical work takes place only when some displacement occurs in the presence of applied force. So all other types of work are not physical work. Similarly saying that a person is energetic, is a totally different concept from energies like electrical energy, heat energy or kinetic energy. In this chapter we will only study about physical work and physical energy.

Examples of physical work

Pick up a book. For this you need to apply some force and the position of the book gets changed. Therefore in the language of science, it can be called as work. The force applied to pick up the book acts against the gravitational force and thats why the motion of the book changes.

Now lets think about such daily life examples which are called as work in our common language. During exams, a student works very hard. But according to the scientific definition of work, here the condition of application of force and displacement are not fulfilled. Hence this hard work done by a student will not be considered as work done in terms of science.

Fig. 2

Similarly, singing a song, discussions etc. will also be not considered as work in terms of science. For example if you hold up a chair for 10 minutes, are you doing any work? From your tiredness you might say that you have worked a lot. But according to the definition of physical work you have not done any work on the chair while you keep holding it at one position. Offcourse you applied some force to keep the chair lifted up, but here did not occur any displacement in the position of that chair. And since no displacement of the chair took place so the force applied by you did not do any work on the chair.

When you picked up the chair, the position of chair did change, and so some physical work did take place at that time. But after that, no physical work took place to hold the chair in its position.

Following are some situations. In which of these work is taking place and in which it is not? Also state your reasons.

Fig. 3

Fig. 4

1. You pushed a very large stone, but it did not move.
2. You reached the second floor of a building by climbing stairs.
3. A traveller pulls his luggage to some distance on a platform.
4. Stopping a moving bicycle.

Activity-1

- You can see some chairs, tables, benches etc in your classroom. Pick up all these one by one, and raise them to a certain height. To raise which one of these you had to do the most work and why?

Work done by a constant force

If we know the amount of force applied and the displacement, we can calculate the work done.

Suppose that on applying a constant force F on a body it moves from its inital point to a distance S, as shown in the fig. 5.

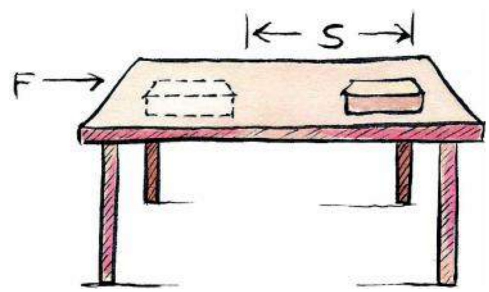


Fig. 5

According to the scientific definition of work, the magnitude of work is the product of applied force and the displacement of object in the direction of applied force.

So, work done = force × displacement of object in the direction of force.

$W = FS$

Therefore work done is a scalar quantity.

We know that the SI unit of force is Newton (N) and that of displacement is metre (m). So, the unit of work done will be Newton × metre (Nm). It is also known as Joules (J).

If we put F = 1 Newton (N) and S = 1 metre (m)

in the equation $W = FS$

$F = 1$ Newton (N)

$S = 1$ metre (m)

$W = FS$

$W = 1N \times 1m$

$= 1$ Nm (Newton-metre)

or 1 Joule (J)

Hence, 1 joule is that quantity of work which is done when 1 Newton force is applied and 1 m displacement takes place in the direction of force.

Example 1 : A girl applies a force of 4.5 N on a book kept on a table. The book moves 30 cm in the direction of applied force. Calculate the work done on the book by the applied force.

Solution : Force applied on the book $F = 4.5\ N$

displacement in the direction of force $S = 30\ cm.$

$$S = \frac{30}{100}\ m$$

$$S = 0.3\ m$$

Work done $W = F \times S$

$$W = 4.5\ N \times 0.3\ m$$

$$W = 1.35\ J$$

Example 2 : A person picks up an object of mass 20 kg. to a height of 3 m. Calculate the work done by him on that object. ($g = 9.8\ m/sec^2$)

Solution : mass of object $m = 20\ kg.$

displacement $S = 3\ m.$

force $F = mg$

$$= 20kg \times 9.8\ m/sec^2$$

$$= 196\ N$$

Work done $W = F \times S$

$$= 196N \times 3\ m$$

$$= 588\ J$$

- A box filled with books is placed near a wall. even after several efforts by you the box does not move. (according to fig. 6). Calculate the work done according to the equation $W = FS$.

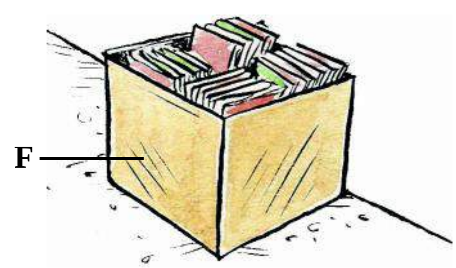


Fig. 6

- Think about several other such situations where there is no displacement on application of force.
- Can you think of such a situation as well where there is displacement in the absence of any force? Discuss with your teachers.

Think about one another situation-

Suppose that you apply a force F on an object and it moves a distance S before it stops.

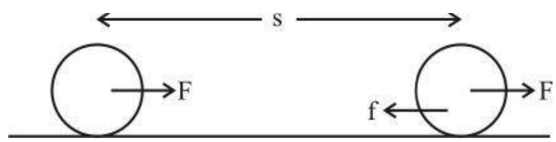


Fig. 7

1. When you exert a force (F) on the object, it displaces in the direction of force. Here the work done by the force is positive. Hence, W= FS.
2. A force of friction (f) acts on the object in a direction opposite to the direction of its motion. Due to this, the objects stops after a distance S. In this situation, the work done by frictional force on that object is negative. Here, the angle between both of them is 180°.

   Hence, W = –fS

Therefore, if the force applied and displacement are in same direction, the work done is positive while if the displacement is in opposite direction to the applied force, the work done is negative.

Example 3 : On rolling a spherical object, it displaces to a distance of 4 m. A frictional force of 15 Newton acts on it. Calculate the work done by the frictional force.

Solution : Frictional force applied on the object f = 15 N

Displacement of object S = 4 m

Since the direction of frictional force is opposite to the direction of displacement, therefore work done by the frictional force-

$$W = -(f \times S)$$

$$W = -(15 \times 4) \text{ Nm}$$

$$W = -60 \text{ J}$$

Example 4 : A woman of 60 kg. climbs 20 stairs to reach the first floor of a building. The height of each stair is 23 cm. Calculate the work done by the gravitational force on the woman.

Solution : mass of the woman = 60 kg.

gravitational force acting on her = 60 kg. × 9.8 Nm/s^2

height of each stair = $\frac{23}{100}$ m

Total height of 20 stairs $h = 20\times\frac{23}{100}$ m

Work done by gravitational force $W = -mgh$

$= -60 \times 9.8 \times 20 \times \frac{23}{100}$

$= -2704.8$ Nm

$= -2.70$ KJ

Activity-2

Throw a ball upwards. For this, you will need to apply some force. A force of gravitation continuously acts on a ball moving upwards, and this force is opposite to the direction of motion. Think and tell-

1. Which force acting on the ball does positive work?
2. Which force on the ball does negative work?
3. Support your answer with reasons.

1. A student picks up an object of mass 'm' in vertical direction to a height h and moves a distance 'd' horizontally (as shown in fig. 8).

   How much work will be done by the student in the given situation.

   Come, lets try to understand this-

   Work done by the student in picking the object of mass m to a height h

   w = mgh ....(i) (here the directions of force and displacement are same)

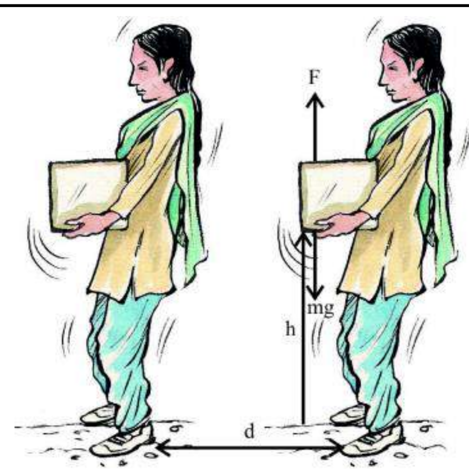


Fig. 8 : Student picks up an object

When the student walks in horizontal direction while holding the box, and his motion is uniform, then, the acceleration of box is zero. So the force acting on the box in this direction will be zero and work done on the box will be W = 0 .... (ii)

12.2 Energy

You must have seen that working of electric bulb, tubelight, television, electric fans etc. requires electricity. To run a train, bus, car, motorbike etc. we need to use petrol, diesel etc. Have you ever thought-

- Why do electrical equipments stop working when the flow of electricity stops.
- Why do vehicles not move without petrol, diesel etc.
- Why can't plants cook their food in the absence of sunlight.
- What is the relationship between energy and work?

You have read about 'energy' in your previous classes. We find energy in several forms-like electrical energy, light energy, sound energy, mechanical energy, chemical energy, nuclear energy etc. Electrical equipments gain energy from electricity. Similarly vehicles gain energy from petrol and diesel. Plants get energy from the light coming from the sun and so make their food.

In this chapter, we will study only about mechanical energy. Mechanical energy are of two types.

(i) Kinetic energy (ii) Potential energy

12.2.1 Kinetic energy

Activity-3

1. Take a heavy ball of metal.
2. Drop it from a height of 20 cm. on a tray filled with wet sand.
3. Measure the depth of the pit formed in the sand.
4. Now repeat this activity by dropping the ball from a height of 40 cm and 100 cm one by one.
5. Measure the depth of the pit formed in each case.

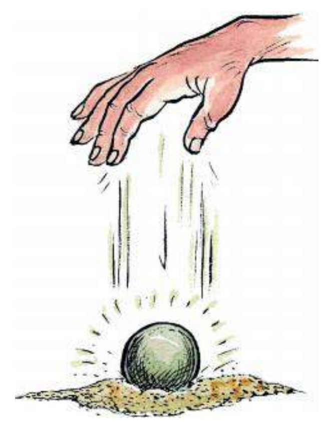


Fig. 9

Try answering the following questions based on this activity-

1. The ball forms a pit in the sand due to which reason?
2. Arrange your observations based on the depth of the pit formed by dropping the ball from different heights. Does the depth of pit increase on increasing the height from which ball is dropped?
3. On dropping the ball from which height is the pit formed deepest?

The energy of an object due to its motion is called kinetic energy. The kinetic energy of an object changes with its speed. An object moving at higher speed has more kinetic energy than the object of same mass moving at a lower speed. For this reason when a ball moving at a high speed strikes the wickets, the wickets are thrown away at a distance Whereas a ball coming slowly does not throw away the wickets.

Mathematical representation of kinetic energy

The kinetic energy of any object at rest is zero. Therefore kinetic energy of a moving object is due to its motion. We can see that the kinetic energy of a moving object is equal to the work done on the object to achieve its velocity.

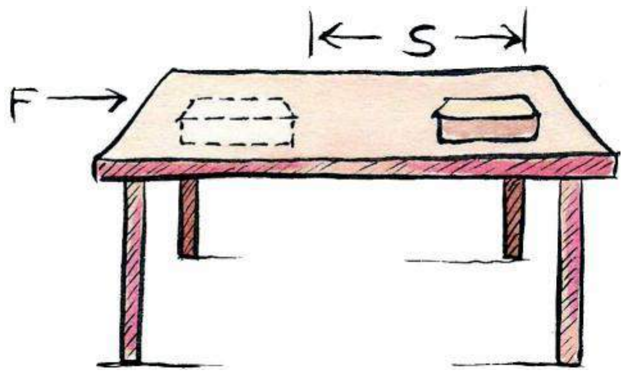


Fig. 10 : A moving object

Kinetic energy and work done

An object of mass 'm' is placed at a horizontal surface. On applying a constant force 'F', the object displaces a distance 'S'. Then, the work done on the object is

W = FS .... (i)

Let the acceleration created on the body be 'a' due so the applied force. We have studied the equations of motion in our previous lesson. Following is a relation between the constant acceleration 'a' of a moving object when its initial velocity is 'u', final velocity is 'v' and displacement is 's'.

$v^2 - u^2 = 2as$ .... (ii)

$s = \frac{v^2 - u^2}{2a}$ .... (iii)

We know from the second law of motion,

F = ma .... (iv)

Putting the value of S and F from eq. (iii) and (iv) into eq. (i),

We can write the work done as :-

$$w = ma \times \frac{v^2 - u^2}{2a}$$

$$w = \frac{1}{2}m\left(v^2 - u^2\right)$$

If the body starts from rest then u = 0,

So, $w = \frac{1}{2}mv^2$

Suppose the work done is equivalent to the change in kinetic energy. If the object starts from rest then the work done is equal to the kinetic energy.

We can say that the kinetic energy of a body of mass 'm' moving at a velocity 'v' is-

$$E_k = \frac{1}{2}mv^2$$

SI unit of energy is Joules.

Discuss

1. Can the kinetic energy of an object be negative?
2. Which of the two is easier to stop; a truck loaded with more goods or a truck loaded with lesser goods?
3. When will the kinetic energy of a car change more: When the velocity of car changer from 10 m/s to 20 m/s or when it changes from 20 m/s to 30 m/s.

Examples 5 : A body of mass 20 kg. is at a constant motion with a velocity of 5 m/s. What will be its kinetic energy?

Solution : mass of object = 20 kg.

Velocity of object = 5 m/s

Kinetic energy $= \frac{1}{2}mv^2$

$= \frac{1}{2} \times 20 \times 5^2$

= 250 J

So the kinetic energy of object is 250 J.

Example 6 : If the mass of car is 200 kg. then how much work will be done to increase its velocity from 36 km/h to 72 km/h.

Solution : mass of car m = 200 kg.

initial velocity of car u = 40 km/hr.

(convert all the values in SI units)

$$u = \frac{(36 \times 1000)\,m}{(60 \times 60)\,s}$$

$$u = \frac{360}{36} = 10 \text{ m/sec}$$

similarly, final velocity of car

$$v = \frac{(72 \times 1000)\,m}{(60 \times 60)\,s}$$

$$v = \frac{720}{36} \text{ m/sec}$$

$$= 20 \text{ m/s}$$

initial kinetic energy of car

$$E_{k1} = \frac{1}{2} mu^2$$

$$= \frac{1}{2} \times 200 \times (10)^2$$

$$= \frac{1}{2} \times 200 \times 100$$

$$= 10000 \text{ J}$$

final kinetic energy of car

$$E_{k2} = \frac{1}{2} mv^2$$

$$E_{k2} = \frac{1}{2} mv^2$$

$$= \frac{1}{2} \times 200 \times (20)^2$$

$$= \frac{1}{2} \times 200 \times 400$$

$$= 40000 \text{ J}$$

So, the work done = change in kinetic energy

$$= E_{k2} - E_{k1}$$

$$= 40000 - 10000$$

$$= 30000 \text{ J}$$

$$= 30 \text{ KJ}$$

Discuss

1. What do you mean by kinetic energy of an object?
2. The kinetic energy of a body of mass 'm' moving at a velocity 'v' is $\frac{1}{2}mv^2$. If its velocity is doubled, then how much will be its kinetic energy?
3. If the velocity and mass of an object is twice the velocity and mass of another object, then how much will be the ratio of their kinetic energies?

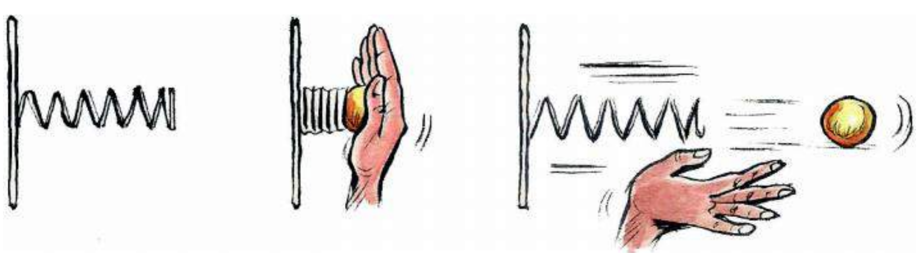
12.2.2 Potential energy

Activity-4

1. Take a toy car.
2. Rotate its key for once or twice.
3. Now place it on the floor,
   - Does it start moving? If yes then why?
   - What happens if we rotate the key 4-5 times?

Fig. 11

According to the figure shown, when we place a ball on a spring attached to a wall horizontally (Fig. 12 a) and press the spring, it contracts (Fig. 12 b). Now when you remove your hand from the spring, the ball is thrown off (Fig. 12 c).



(a) (b) (c)

Fig. 12

Fig. 13

Something similar happens in a spring balance. on attaching a weight, the spring is pulled and on leaving it, it gets back to original shape.

See fig. 13. On pulling a catapull, the rubber of the catapult also gets back to a no pull position just like a pressed spring. For this it throws a stone to a very far off distance.

A body stores energy due to work done. This stored energy is called potential energy of the object. Therefore, the energy stored in an object due to its position is called its potential energy. This energy converts into other forms of energy and enables the body to do its work. When you press a ball against a spring, you are bringing a change in the position of the spring. This energy gets stored in the spring, in the form of potential energy. This gets converted into kinetic energy and allows the spring to throw away the ball.

- Can you explain the process of throwing a stone using a catapult?

Gravitational potential energy

When we place an object above the surface of earth, then the potential energy of that object increases. To raise the object upwards, work is done against the gravitational force of earth. The work done to raise the object to a certain height is stored as its potential energy. The energy stored due to work done against gravitational force is called as gravitational potential energy.

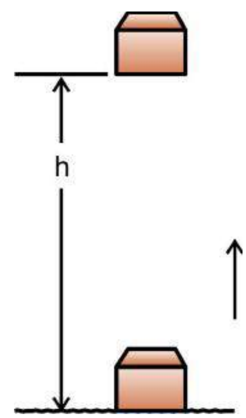


Fig. 14

If some force is needed so raise an object of mass m upwards, the minimum required force will be equal to the weight mg of the object. The energy stored in the object increases according to the work done in raising it. Suppose that the work done against gravitational force to raise the object to a height h is 'w'.

Then, work done $w = \text{Force} \times \text{displacement}$

$= mgh$

Since the work done on the object is mgh, so the potential energy of the object is also mgh. We will call this potential energy E_p.

$$E_p = mgh$$

Example 7 : A body of mass 50 kg. is raised to a height of 8 m. above the earth's surface. Calculate the energy stored in this object. Here $g = 9.8\ m/s^2$

Solution : mass of an object $m = 50$ kg.

Height of displacement $h = 8$ m

gravitational acceleration $g = 9.8\ m/s^2$

equation : potential energy $E_p = mgh$

$= 50 \times 9.8 \times 8$

$= 3920$ Joules

So, the potential energy is 3920 Joules.

> **Also know this**
>
> Potential energy of an object depends on the earth's surface or the zero-level chosen by you. The potential energy of an object w.r.t. one surface will be different than the potential energy of the same object w.r.t. some other surface.

Example 8 : A body of mass 5 kg. is placed at a certain height from the surface of earth. If the potential energy of the body is 400 J, then find out the height of the body w.r.t. earth $g = 9.8\ m/s^2$.

Solution : mass of object $m = 5kg$

height of displacement $h = ?$

Potential energy of object $= mgh = 400\ J$

gravitational acceleration $g = 9.8\ m/s^2$

potential energy of object $Ep = mgh = 400\ J$

$$5 \times 9.8 \times h = 400$$

$$h = \frac{400}{49}$$

$$h = 8.16\ m$$

Object is placed at a height of 8.16 m.

Question

1. Find out the potential energy of a book placed at there positions A, B and C as shown in the fig. 15.

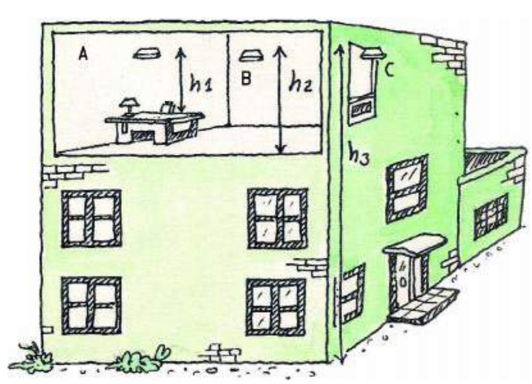
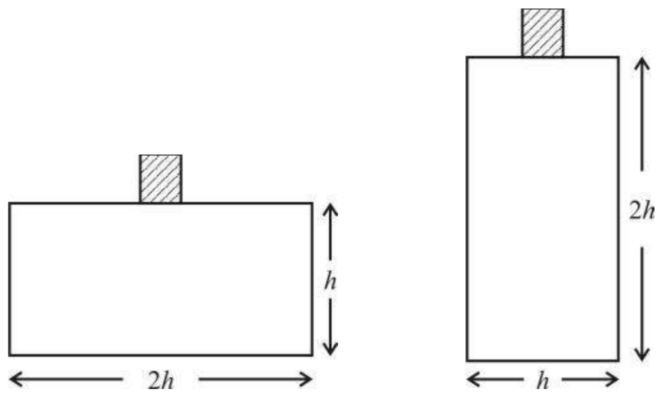


Fig. 15

2. A cuboidal box is shown in the figure 16. Its width and height are 2 h and h respectively. What will be the potential energy of an object of mass m placed on the box in the following two situations?



(a) (b)

Fig. 16

Disscus

1. In the process of using a bow and arrow, why do we have to pull the arrow backwards by using a thread or rubber?
2. Can the gravitational potential energy of an object be negative?

12.3 Law of conservation of mechanical energy

Suppose an object of mass m is made to fall fully from a height of h. Initial potential energy of the object is mgh and kinetic energy is zero as its initial velocity is zero.

In this way, the total energy of the object is mgh.

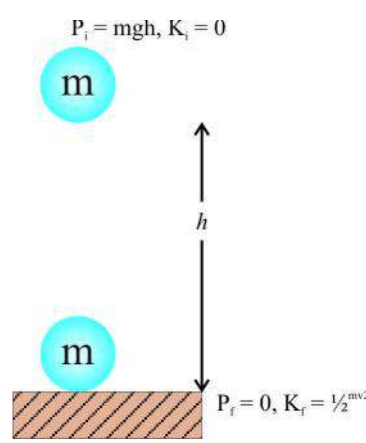


Fig. 16

When this body falls, its potential energy changes into kinetic energy. If the velocity of an object at a given time is v, then kinetic energy will be $\frac{1}{2}mv^2$. As the object starts falling, its potential energy drops down and kinetic energy increases. When the object is about to reach the earth's surface its final velocity is v and this is its maximum velocity. So, now the kinetic energy is maximum and potential energy becomes minimum. We know that the sum of kinetic energy and the potential energy on all points is same. That means,

$$\text{potential energy} + \text{kinetic energy} = \text{constant} \quad \text{or,} \quad mgh + \frac{1}{2}mv^2 = \text{constant}$$

The sum of kinetic energy and potential energy of an object is its mechanical energy. We can see that in a freely falling body, the decrease in potential energy at a point is equivalent to the increase in kinetic energy of that object.

Through several such examples, observations and arguments we can state that energy can neither be created nor destroyed. It can only be converted from one form to another. Thus, the total energy of universe remains constant. This is the law of conservation of energy.

Come, lets try to understand it through an activity.

Activity-5

A body of 30 kg. falls freely from a height of 5 m. Calculate the value of potential energy and kinetic energy at all the points and fill the following table.

$g = 9.8\ m/s^2$

(Calculate velocity at different heights using the equations of motion.)

Height of body (metre)	**Velocity of body (at different heights)**	**Potential energy $E_p = mgh$**	**Kinetic energy $E_k = \frac{1}{2}mv^2$**	**Total energy $E_p + E_k$**
5	0			
4	2			
3	4			
2	5			

If we see the results of above activity, we see that the total mechanical energy of the body remains constant in all the situations.

Discuss

What would have happened if the conversion of energy was impossible? According to one belief, life on earth could have been impossible without energy conversion. What do you think? Do you agree with this?

Do in a group

A person of mass m jumps in a swimming pool from a height of 10 m. (fig.18) Using the law of conservation of mechanical energy, calculate the velocity of the man when he is at a height of 5 m. from the surface of water.

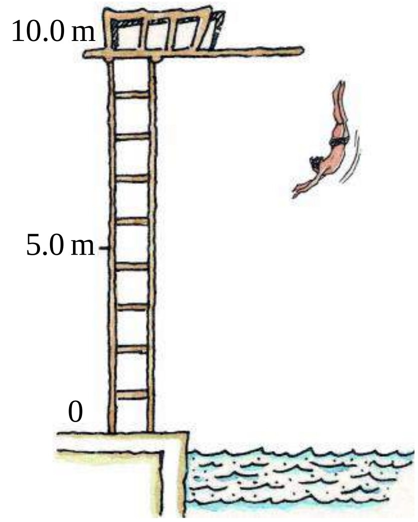


Fig. 18

12.4 Power

The water tank at Ramesh's and Rakhi's house are of same shape and height. Both of them make use of electric motor to fill water in their tanks. The tank at Rakhi's house fills quicklier than Ramesh's tank. What could be the reason behind this?

Sometimes we see that it takes more time to grind pulses in the grinder at our house, as compared to our neighbour's grinder. Why is it so?

Is the total work done in both the cases different? Or are the abilities of both the grinders to grind is different?

It is possible that different machines take different amount of time to do some work. This means that their rate of doing work is different. This rate of doing work is called power. We talk about the power of machines like motorbike, motorcar, electric pump, electric bulbs, tube light, electric saw, fodder cutter, tractors etc. Their power show that how quickly they convert their energies and do work.

The rate of doing work or rate of energy conversion is called power. We will write it in mathematical form as follows.

Power = work/time

P = w/t

The unit of power is watt (w). If a person does 1 Jouls work in 1 second then the rate of energy consumption is 1 J/s and power is 1 watt. So, 1 watt = 1 J/s

Or 1 watt = 1 J/s

If the power is large, we measure it in kilowatts.

1 kilowatt = 1000 watt

1 kw = 1000 watt or 1000 J/s

If we want to find out how much energy is consumed by a machine then we will have to see what is its power and for how long is it working.

Energy consumed $p = w/t$

i.e., $w = p \times t$

If p = 1 kw and t = 1 h then energy consumed is 1 kwh.

That means 1 kwh (kilowatt hour) is that quantity of energy which is consumed to use a source of 1 kw for 1 hour. The energy consumed in houses, workshops, industries etc. is generally expressed in kilowatt hour (kwh). For example, the electric energy consumed in one month is expressed in units. Here, 1 unit means 1 kwh.

1 kwh = 1 kw × 1 h = 1000 w × 3600 sec.

= 3600000 J

$= 3.6 \times 10^6$ J

Example 9 : A woman completes a work of 300 J in 5 sec. How much energy did she spend?

Solution : Work done by woman 300 J

Time taken to do work 5 sec.

Therefore, power spent by woman $p = w/t$

= 300/5

= 60 W

Example 10 : A boy of 50 kg. mass climbs 30 stairs in 10 sec. If the height of each stair is 15 cm. Then calculate his power. $g = 10\ m/s^2$

Solution : mass of boy = 50 kg

mg = 50 × 50 × 10

$= 500\ kg.\ m/s^2$

Total height of 30 stairs

h = (30 × 15)/100

= 4.50 m

Time taken to climb stairs = 10s

$$\text{Power} \quad p = \text{work done/time}$$
$$= mgh / t$$
$$p = (500 \times 4.50) / 10$$
$$= 225\ W$$

Power is 225 W.

Question

- What do you mean by power?
- Define 1 watt power.
- If a bulb consumes 990 Joules electric energy in 10 sec, how much will be its power?

Example 11 : A bulb of 60 watt is used daily for 10 hours. Calculate the units of energy used by bulb in a day.

Solution : Power of electric bulb = 60 watt 0.06 kW

Usage time = 10 hours

Thus, energy spent by bulb = power × time of usage

= 0.06 kw × 10h

= 0.60 kWh

= 0.60 units

So, bulb will consume 0.60 units of energy daily.

Activity-6

- Observe carefully the electric meter used in the electric circuits at your home. Note the reading on your metre everyday at 7 a.m.
- How many units are consumed each day?
- Tabulate your observations each day for a month.
- Compare your observations with your monthly bill.

What we have learnt

1. Work done on an object is equal to the product of measure of the force applied on it and the displacement caused in the direction of applied force. Unit of work done is Joule (J).
2. If the direction of applied force and the direction of displacement are same, then the work done will be positive and if the direction of applied force and direction of displacement are opposite, then the work done will be negative.
3. Energy gives the object, the ability to do work. Unit of energy is Joule (J).
4. The energy contained in an object due to its motion, is called kinetic energy. The kinetic energy of an object of mass m, moving with a velocity v will be $\frac{1}{2}mv^2$
5. The energy contained in an object due to the change in its shape or position is called its potential energy. The potential energy of an object of mass m, raised to a height h is called gravitational potential energy 'mgh'.
6. According to the law of conservation of energy, energy can neither be created nor it can be destroyed. It can only be converted from one form to another. The total energy before the conversion and after the conversion remains constant.
7. The rate of doing work or the rate of energy conversion is called power. The SI unit of power is watt (w).
8. 1 kwh is that quantity of energy which is spent in using a source of 1 kw for 1 hour.

Keywords

work,energy, kinetic energy, potential energy, energy conservation, power

Exercise

1. Pick an appropriate option

   (i) If an object displaces 2 m in the directin of 10 N applied force, the work done on the object by the force is,

   (a) 15 J (b) 20 J (c) .20 J (d) 5 J

(ii) A body of mass 5 kg. is in a constant motion at 2 m/s. What will be its kinetic energy?

(a) 10 Joule (b) 15 Joule (c) 5 Joule (d) 20 Joule

(iii) A body of 12 kg. mass is placed at a certain height from the surface of earth. If its potential energy is 480 J, then what will be its height w.r.t. to earth's surface?

(a) 6 meter (b) 9 meter (c) 5 meter (d) 4 meter

(iv) You burn a bulb of 100 w daily for 5 hours. What will be the energy spent in units by the bulb in one day?

(a) 0.4 unit (b) 0.5 unit (c) 0.05 unit (d) 0.01 unit

2. Fill in the blanks-

(i) SI unit of work is ....

(ii) 1 kwh is equivalent to .... joules.

(iii) The total energy of an object remains ....

(iv) If the direction of applied force of an object and its displacement are opposite then its work will be ....

3. What do you understand by kinetic energy? Establish the equation for kinetic energy for an object in motion.

4. The energy consumed at a house is 250 units in one month. How much will it be in Joules?

5. (a) What is energy conservation law? Explain.

(b) The potential energy of a freely falling body drops gradually. Does it contradict the law of energy conservation? Explain with reasons.

6. Explain potential energy and establish its equation.

7. (a) If the velocity of a particle is doubled, what will be its kinetic energy?

(b) If the work done on the particle is zero, then what will be its velocity?

8. On applying brakes of a car which is moving at a speed v, it stops after covering a distance d. Calculate, what will be the distance covered by the car after applying brakes if it was moving at a speed of 2 v.

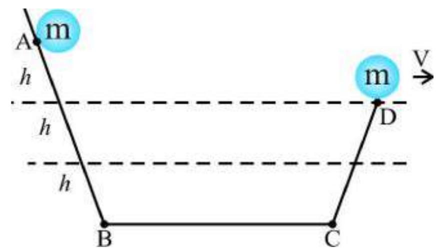
9. A man holds a sack of rice on his head for 30 minutes and gets tired. Has he done any work? Explain your answer with reasons.

10. On applying a force of 8 Newton on a body, it moves in the direction of motion and displaces for 4 m. Calculate the work done.

11. A body of 10 kg. mass is raised against the gravitational force of earth to a height of 10 m. How much work is done in this case?

12. Two body of masses 10 kg. and 15 kg. are raised to a height of 5 m. and 2 m. respectively above the surface of earth. Calculate the change in their potential energies.

13. By using the information given in the figure calculate the velocity of the ball at the position D. (use the law of conservation of mechanical energy).



14. On applying a force of 15 N for 6 sec. a man displaces a box by 8 m. Calculate his power.

15. To change the energy of a body of 0.5 kg. by 1 joule, we will have to raise it to what height? ($g = 10$ m/s^2).

Chapter 13

Our Health

13.1 Meaning of Health

Did it ever happen to you that in spite of yearning to do something of your choice you did not managed to do it because you were not feeling well? Like- participating in a cricket match, going to watch a movie, going to a fair or participating in any programme of your school.

We often use the term health knowing or unknowingly in our expressions like -'My health is not well today' or 'my mind is not healthy enough for any work.'

Let us try to understand, what health is.

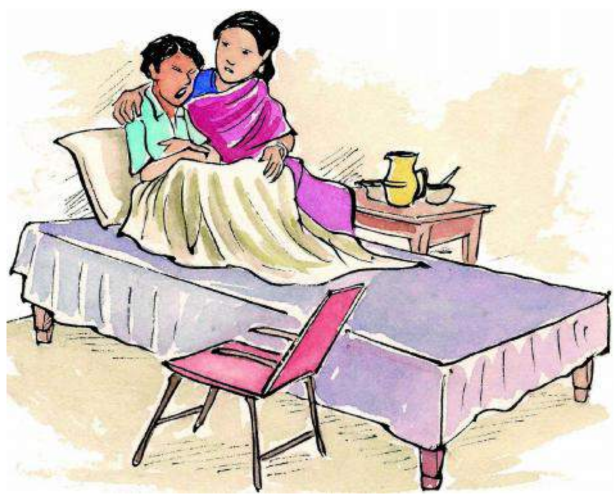


Fig. 1

- Discuss with your friends and make a list of all such situations when you do not feel healthy.

Generally we say that feeling healthy is feeling good. Being healthy for us is being able to do our daily work properly. Thus health is such a state of well-being mentally and physically that enables us to perform our duties skillfully, ably and efficiently.

13.2 Health and disease

Staying healthy would have different implications for different people.'Good health' for a dancer may mean being able to dance properly with graceful postures. On the other hand, good health for a person who plays the flute may mean having enough breathing capacity in his/her lungs to control the notes from his/ her flute. A player who can perform efficiently even in adverse conditions is healthy.

We can be unhealthy often without there being a simple cause in the form of an identifiable disease. We would say that the persons involved in the above mentioned work are unhealthy if they failed to perform them properly.

If this is what we mean by 'health', what do we mean by 'disease'? The word is actually self-explanatory - we can think of it as 'disease' or disturbed ease. Disease, in other words, literally means being uncomfortable. However, the word is used in a more limited meaning. We talk of disease when we can find a specific and particular cause for discomfort. This does not mean that we have to know the absolute final cause; we can say that someone is suffering from diarrhoea without knowing exactly what has caused the loose motions.

- Differentiate between being healthy and unhealthy.

13.3 Factors that affect health

Our health depends upon our home, neighborhood, organisms and condition of the environment around us.

- Does every house in your locality have a supply of clean drinking?
- Where is the waste generated from your house thrown?
- How is the waste generated in your colony managed?
- How often are the roads and drains of your colony cleaned?

We all need to consciously try to keep our surroundings clean. Consider what would happen if no agency is ensuring that waste is collected and disposed. What would happen if no one takes responsibility for clearing the drains and ensuring that water does not collect in the streets or open spaces? So, if there is a great deal of waste thrown in streets, or if there is open drainwater lying stagnant around where we live, the possibility of poor health increases. These situations increase the incidence of being unhealthy.

Thus harmful organisms like certain bacteria, viruses, fungi, helminthes and nematodes may be the cause of our ill health. Natural calamities like flood, earthquake and famine may also affect our health.

13.4 Expression of diseases on the basis of symptoms

Let us now think a little more about diseases. In the first place, how do we know that there is a disease? In other words, how do we know that there is something wrong with the body? There are many tissues in the body, as we have studied in the Chapter- 'Multicellular Structure: Tissue'. These tissues make up physiological systems or organ systems that carry out body functions. Each of the organ systems has specific organs as its parts, and it has particular functions. So, the digestive system has the stomach and intestines, and it helps to digest food taken in from outside the body. The musculoskeletal system, which is made up of bones and muscles, holds the body parts together and helps the body move.

When there is a disease, either the functioning or the appearance of one or more systems of the body will change for the worse. These changes give rise to 'symptoms' and signs of disease. Symptoms of disease are the things we feel as being 'wrong'. So, having a headache, cough, loose motions, a wound with pus; are all symptoms. These indicate that there may be a disease, but they don't indicate what the disease is. For example, a headache may mean just examination stress or, very rarely, it may mean meningitis, or any one of a dozen different diseases.

Signs of disease are what physicians will look for on the basis of the symptoms. Signs will give a little more definite indication of the presence of a particular disease. Physicians suggest for tests to confirm the disease further.

13.5 Confirmation of Disease

Unhealthy conditions are expressed by symptoms. Symptoms like having pain in limbs or feeling weak do not confirm the presence of a disease. Confirmatory tests can only ascertain the type of disease. Nowadays several forms of tests are possible medically and by such tests on certain samples of our body like mucous of cough(sputum), blood, urine and stool a disease may be confirmed.

- Find out from a doctor what all can be determined from test of mucous, blood, urine and stool.

One disease many symptoms

Ill state of our body can be expressed in many ways like having cough, cold, fever, loose motion, headache, stomach ache, pain in limbs etc. These symptoms indicate a diseased condition. Diseases can have more than one symptom for example the symptoms of Tuberculosis(T.B.) are- cough and cold, headache, pain in limbs, feeling of breathlessness, loss of weight etc..

One symptom many diseases

A symptom most often can be due to different types of diseases. Headache can be due to tuberculosis or due to migrane or just common cold.

Activity-1

Find out the following in your locality (make a table to collect information)

- The persons suffering from a disease (write their names in a column, write the names of the disease that the doctor has told them they are suffering from in the next)
- Write the symptoms of the diseases in a third column
- What are the diseases that people with the same symptom have?

13.6 Grouping of Diseases on the basis of duration of infection

Often when we have a fall while riding a bicycle or while playing and get hurt, the infection there heals within a few days. Similarly common cold also lasts only for a few days. There are some diseases that take a long for example if our normal cut would become badly infected it would take a long time to heal. Thus we may group diseases on the basis of duration of infection as following -

13.6.1 Acute diseases

Some diseases that last for very short periods of time or with treatment they are cured in a short period of time. In general, health is not affected adversely due to them. These are like common cold, flu etc.

13.6.2 Chronic diseases

Ailments that can last for a long time, even after prolonged treatment often lasting a lifetime are chronic diseases. An example is T.B. Due to prolonged infection the patient loses weight, feels weak, develops breathing problems etc.

Without proper treatment in proper time an acute disease may also turn to a chronic one. For example if cough and cold becomes persistent, it may take the form of a kind of asthma.

13.7 Disease and its causes

There can be several causes of diseases. They may be mainly grouped as immediate or contributory.

If a small child in a certain area is suffering from loose motions, we may say that it may have been caused by polluted water containing a virus. In such a situation the immediate cause is the virus present in water. But other children of the area drank the same water and did not have loose motion. The reason for this could be that the child suffering from the disease did not have immunity against the virus.

Thus, when the child came in contact of the virus she/he developed the disease. Now why did the child not have immunity? A reason for this could be malnourishment i.e. the child did not have proper food to develop immunity. The body of the child may thus have lack of nutritional ingredients. It could also be possible that some characters inherited by the child renders her/him more prone to the virus. Thus lack of food and heritable causes which do not cause the disease in the lack of the virus are contributory causes.Another contributory cause may have been the conditions due to which the child did not get clean water.This may have been because the family lives in a place where due to lack of cleanliness, water may have become polluted.

- Did you or any of your family members ever suffer from diarrhea?
- Make a list of reasons for having diarrhea.
- Separate out the immediate causes from the contributory ones.

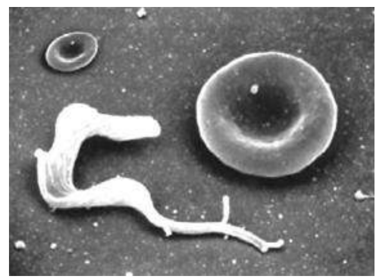
13.7.1 Infectious(communicable) diseases and its causes

Other than the duration of the infection, diseases may also be grouped on the basis of the mode of spread of the cause. Infectious and non-infectious diseases come under this category. You are often asked to stay away from the patient so that you may not get infected.

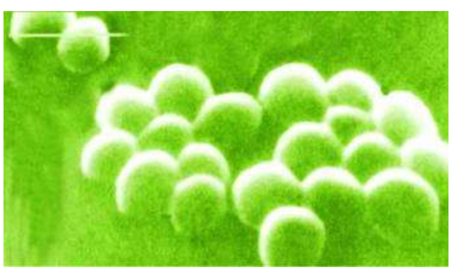
We had studied in the example of the child having diarrhea that the immediate cause could have been a virus. There are several other organisms that are immediate causes of diseases like bacteria, protozoa, fungi, worms etc. People who come in contact with a patient who is suffering from a disease caused by any of these organisms may also get infected and contact the disease. Thus these are called infectious causes or agents of the disease. Most of the diseases caused by such agents are called as infectious diseases. Common cold, T.B., cholera, plague, skin diseases etc. are examples of infectious diseases.

- Doctors nurses and other health workers are more in contact with patients than other people. Find out how they keep themselves safe from getting infected.

Leishmania- the protozoan causing kala-azar. The organisms are oral-shaped, and each has one long whip-like structuroe. Adividing organism has been shown by arrow and the cell of immue system (lower right has griped its whips to destroy it.



Trypanosoma- the protozoan responsible for sleeping sickness. The organism is lying next to a saucte-shaped red blood cell to give an idea or shape.



Staphyloccci, the bacteria which can cause acne 5 micrometer scale is shown at top left.

Adult roundworm (ascaris lumbriciodes)- It is found in our small intestine. The ruler next to it shown four centimeters to give us an idea of scale.

Fig. 2 : Different infectious agents

13.7.2 Non infectious(non-communicable) diseases and their agents

There are some diseases that are not caused by infectious agents but their causes vary. They are not caused by external causes like microbes that can spread in the community. Instead, these are mostly caused by internal, non-infectious causes. For example, sickle cell anemia and some types of cancers are caused by genetic abnormalities. Similarly, high blood pressure can be caused by excessive weight and lack of exercise. You can think of many other diseases like this where a person who comes in contact with a patient suffering from these diseases does not get infected. Thus these diseases are called as non- infectious diseases.

- Discuss with your friends whether it is fair to always stay away from a person suffering from a disease?

Do you know?

Peptic ulcers and the Nobel prize

For many years, everybody used to think that peptic ulcers, which cause acidity- related pain and bleeding in the stomach and duodenum, were because of lifestyle reasons. Everybody thought that a stressful life led to a lot of acid secretion in the stomach, and eventually caused peptic ulcers. Then two Australians made a discovery that a bacterium, Helicobacter pylori, was responsible for peptic ulcers. Robin Warren (born 1937), a pathologist from Perth, Australia, saw these small curved bacteria in the lower part of the stomach in many patients. He noticed that signs of inflammation were always present around these bacteria. Barry Marshall (born 1951), a young clinical fellow, became interested in Warren's findings and succeeded in cultivating the bacteria from these sources. In treatment studies, Marshall and Warren showed that patients could be cured of peptic ulcer only when the bacteria were killed in the stomach. Thanks to this pioneering discovery by Marshall and Warren, peptic ulcer disease is no longer a chronic, frequently disabling condition, but a disease that can be cured by a short period of treatment with antibiotics. For this achievement, Marshall and Warren (seen in the picture) received the Nobel prize for physiology and medicine in 2005.

13.8 Means of Spread of a disease

We had studied that when we come in contact with a patient suffering from an infectious disease, the possibility to get infected increases.

- How do infectious diseases spread from an affected person to someone else?

Infectious diseases may spread through various mediums like air, water, food and sexual contact.

Diseases like common cold, pneumonia and tuberculosis can spread through the air. This occurs through the little droplets thrown out by an infected person who sneezes or coughs. Someone standing close by can breathe in these droplets, and the microbes get a chance to start a new infection.

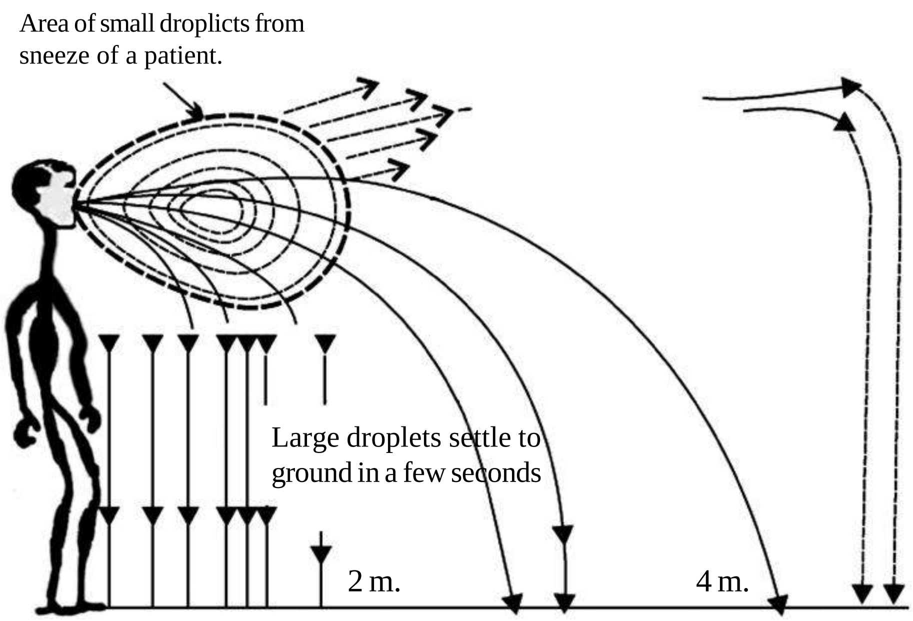


Fig. 3 : Transmission of air borne infections and the distance of maximum infection

We all have had the experience of sitting near someone suffering from a cold and catching it ourselves. Obviously, the more crowded our living conditions are, and less ventilated our homes, it is more likely that such airborne diseases will spread.

Infected or undercooked food like undercooked meat can also be a cause of several infections. Food affected with fungi may be a cause of severe food poisoning.

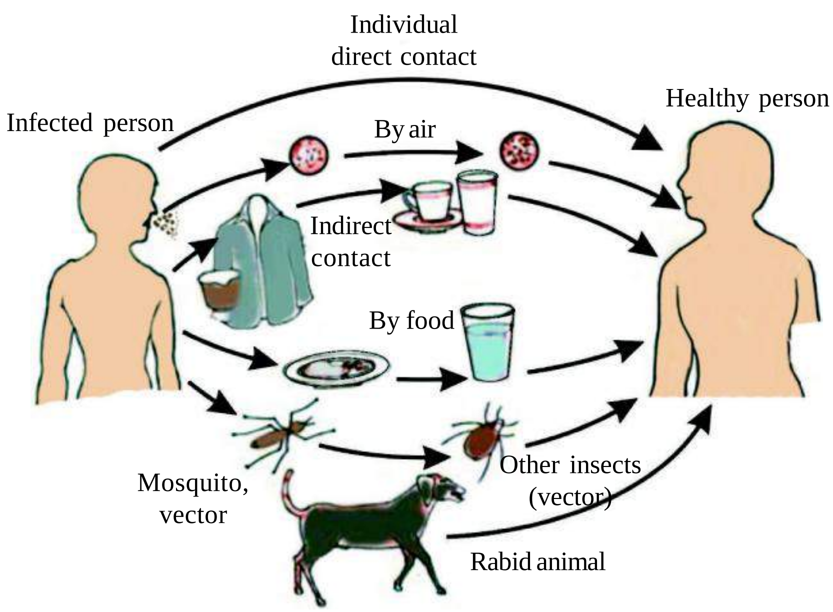


Fig. 4 : General means of spread of infection

Some diseases spread mainly by sexual contact like syphyllis, and AIDS(Acquired Immunodeficiency Syndrome) caused by Human Immunodeficiency Virus (HIV). AIDS can also spread through blood-to-blood contact with infected people by blood transfusion or use of AIDS infected needles during injection or other surgical instruments during an operation or from an infected mother to her baby during pregnancy or through breast feeding.

- How do non-infectious diseases occur in humans?

13.9 Organ specific and tissue specific manifestation

We have studied that disease-causing micro organisms enter the body through air, water, food and physical contact. Where do they go then? They may go to any part of our body. There are many possible places, organs or tissues, where they could go. Do all microbes go to the same tissue or organ, or do they go to different ones? Different species of microbes seem to have evolved to different parts of the body. In part, this selection is connected to their point of entry. If they enter from the air via the nose, they are likely to go to the lungs. This is seen in the bacteria causing tuberculosis. If this bacteria reaches our bones via blood they cause breakdown of bones weakening them and causing the disease called as bone T.B. If they enter through the mouth, they can stay in the gut lining like typhoid causing bacteria. Or they can go to the liver, like the viruses that cause hepatitis.

An infection by HIV, that comes into the body via the sexual organs, will spread to lymph nodes all over the body. Malaria-causing microbes, entering through a mosquito bite, will go to the liver, and then to the red blood cells.We can imagine what the symptoms and signs of an infection will be if we know what the target tissue or organ is, and the functions that are carried out by this tissue or organ. If the lungs are the targets, then symptoms will be cough and breathlessness. If the liver is targeted, there will be jaundice. If the brain is the target, we will observe headaches, vomiting, fits or unconsciousness.

In addition to these tissue-specific effects of infectious disease, there will be other common effects too. Most of these common effects depend on the fact that the body's immune system is activated in response to infection. An active immune system recruits many cells to the affected tissue to kill off the disease-causing microbes. This recruitment process is called inflammation. As a part of this process, there are local effects such as swelling and pain of the infected part, and general effects such as fever and swelling of lymph nodes.

Do you know?

Immune System

All the life processes involved in identifying unwanted parts and infection causing agents and destroying them categorically without affecting the healthy cells and tissues of the body comprise the immune system. This system works against different disease causing agents (from viruses to worms) and helps in proper functioning of the body.

In certain situations the infected tissues may show an extreme general effect. Like in HIV infection, the virus goes to the immune system and damages its function. Thus, many of the effects of AIDS are because the body can no longer fight off the many minor infections that we face everyday. Like common cold can become pneumonia. Similarly, a minor gut infection can produce major diarrhoea with blood loss. Ultimately, it is these other infections that kill people suffering from AIDS.

It is also important to remember that the severity of disease manifestations depend on the number of microbes in the body. If the number of microbes is very small, the disease manifestations may be minor or unnoticed. If the number of the microbe is large, the disease can be severe enough to be life-threatening. The immune system is a major factor that determines the number of microbes surviving in the body.

- 'Immune system plays a major role in prevention of diseases.' Explain this statement with respect to AIDS

We live in an environment that is full of many other creatures apart from us. It is inevitable that many diseases will be transmitted by other animals. These animals carry the infecting agents from a sick person to another potential host. These animals are thus the intermediaries and are called vectors. The commonest vectors we all know are mosquitoes. In many species of mosquitoes, the females need highly nutritious food in the form of blood in order to be able to lay mature eggs. Mosquitoes feed on many warm-blooded animals, including us. In this way, they can transfer diseases from person to person or from other animals to humans.

13.10 Prevention and Treatment

Based on what we have learnt so far, it would appear that there are two ways to treat an infectious disease -

1. by reducing the effects of the disease
2. by killing the cause of the disease.

For the first, we can provide treatment that will reduce the symptoms. The symptoms are usually because of inflammation. For example, we can take medicines that bring down fever, reduce pain or arrest loose motions. We can take bed rest so that we can conserve our energy. This will enable us to have more of it available to focus on healing. But this kind of symptom-directed treatment by itself will not destroy the infecting microbe and the disease will not be cured and may recur. For example if we take medicine to reduce fever caused due to an infection the fever goes away for sometime only to recur again.

For that, we need to be able to kill off the microbes(virus, bacteria, fungi) by identifying them. These days there are several ways of testing that can give very specific results. Thus by testing the sputum(mucous of cough), blood , urine or stool etc. the infective agent is determined and the doctor prescribes medicines accordingly. For example blood tests confirm the presence of malaria and the patient is then given a certain dosage of drugs that can cure malaria. It is essential to take a complete dosage of the drugs for a particular time period for complete cure.

13.11 Prevention of diseases

We can lead a healthy life if we make conscious efforts to take such measures that would reduce chances of having diseases.

- Write about some ways that can prevent us from having a disease.

Leading a healthy life begins with a clean environment.Thus it is important to keep our surroundings free from dirt and filth so that we may keep a check on several disease causing agents. Sufficient amount of proper food and regular exercise will also keep us healthy.

We have studied in this chapter that diseases have a direct effect on the immune system of our body. If the immune system of our body is strengthened, we can remain healthy for a long period of time. These days several efforts towards ways of strengthening the immune system are being made so diseases may be ward of even before their infection. You may have heard about vaccination which is one of the ways of strengthening our immune system.

Do you know?

Developing immunity

Traditional Indian and Chineese medicinal systems sometimes deliberately rubbed the skin crusts from smallpox victims into the skin of healthy people. They thus hoped to induce a mild form of smallpox that would create resistance against the disease. Two centuries ago, an English physician named Edward Jenner, realised that milkmaids who had had cowpox did not catch smallpox even during epidemics. Cowpox is a very mild disease. Jenner tried deliberately giving cowpox to people (as he can be seen doing in the picture), and found that they were now resistant to smallpox. This was because the smallpox virus is closely related to the cowpox virus. 'Cow' is 'vacca' in Latin, and cowpox is 'vaccinia'. From these roots, the word 'vaccination' has come into our usage.

- Were you ever vaccinated? Find out from your parents the vaccines that were administered to you.

Vaccination is the process by which immunity towards specific disease is developed in our body. A mild controlled amount, usually in-active form of the disease causing microorganism is introduced in the body that alerts the immune system making it produce enough of agents that can fight against the disease causing microbe during an actual infection.

Fig. 5 : Oral vaccination of Polio

Key words

Communicable diseases, non-communicable diseases, vectors, immune system, bacteria, virus, inflammation, vaccination, human immunodeficiency virus, acquired immune deficiency syndrome, chronic disease, acute disease

What we have learnt

- Health is a state of physical, mental and social well being when a person is able to do one's work efficiently according one's ability.
- Disease means disturbed ease.
- Public cleanliness is important for individual health.
- Acute disease on treatment is cured in a short period of time like fever due to a minor injury while chronic diseases require prolonged treatment and last for a long time; example tuberculosis.
- Contributory causes for having a disease may be contaminated water or lack of nutritive elements in food.
- Diseases caused by infective agents are called as infectious diseases. For example- Cholera, typhoid, AIDS,TB
- Weakening of the immune system by AIDS eventually leads to death of the patient.
- The immune system keeps the body healthy by categorically destroying unwanted and disease causing agents.
- Immunity towards diseases caused by bacterial or viral infection like tetanus. whopping cough, diphtheria, polio, measles can be developed.
- Vaccination can prevent the cause of several infectious diseases.

Exercise

1. Choose the correct option

(i) Which of the following is an infectious disease -

(a) Night blindness (b) Diabetes (c) Blood pressure (d) Cholera

(ii) What causes AIDS

(a) Virus (b) Bacteria (c) Fungus (d) Helminth

(iii) Which disease is not infectious-

(a) Typhoid (b) leprosy (c) Small pox (d) blood cancer

2. Suggest two conditions necessary for having good health.
3. Write any two causes of diseases.
4. During the past one year how many times did you fall sick? What was the disease?
    - (a) What changes would you make in your daily routine to ward off these diseases?
    - (b) What changes would you like to bring in your surroundings to save yourself from having the disease once again?
5. A child fails to tell whether she is sick. How will you find out-

    (a) whether she is sick? (b) what her sickness is?
6. What is the difference between infectious and non -infectious diseases? Give an example of each.
7. In which of the following situations you have maximum chance of falling sick -why?
    - (i) During your examinations.
    - (ii) You have travelled by bus or train for two days.
    - (iii) Your friend is suffering from measles
8. What is immunity? How does it affect our health? Explain with an example.
9. Give an example to justify that 'Prevention is better than cure'.

Annexure

Warning

Ill effects of smoking- Smoking affects the lungs adversely. Nicotine of tobacco affects lungs fatally. The internal lining of alveoli is ruptured, the gaseous exchange is affected as more carbon dioxide is produced and the layer of gaseous exchange is affected. This creates pressure on the heart and the incidence of heart failure increases.

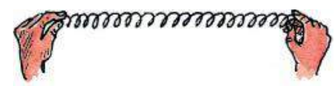
Tobacco is prepared from the extracts of the leaves of *Nicotinum tabaccum*. Taking tobacco in any form can cause cancer on lips, internal lining of mouth, tongue, in the trachea, lungs etc.

Ill effects of drinking- People often faint after consuming too much alcohol. Alcoholism causes loss of concentration, affects the liver adversely and has ill effects on the brain among several other adverse effects. A person may have jaundice, hepatitis and liver cancer.

Other intoxicating substances like ganja, bhang, opium, cocaine are all dangerous to health as they cause hallucinations, mental agitation, hypnosis and loss of memory. The addiction towards these has become a chronic problem of society these days.

Chapter 14

Sound



In our daily life, we hear several sounds, like the sound of birds and animals, the sound of machines and vehicles, the sound of T.V. and telephone, etc. Some sounds are such that we human cannot hear them, but some animals and birds are able to hear it.

There are several questions related to sound like-

1. What is sound? How is it produced?
2. How does sound produced by a source reach our ears.
3. A person standing outside cannot hear clearly the sound of a person sitting inside a closed car, a closed bus or a closed room. But when you knock on the door or window of a car, the sound can be heard on both the sides. Why is it so?

In this chapter, we will try to find answer to all such questions. Also, we will do activities and experiments related to this.

14.1 How is sound produced?

Acitivity-1

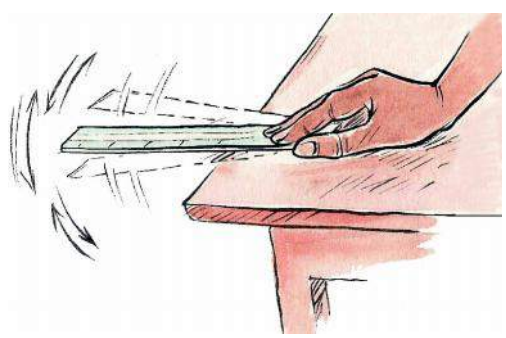


Fig. 1 : Vibration in a metre scale

1. Take a meter scale.
2. Press one end of the scale on a table for some time, keeping 40 cm of the scale free. (as shown in fig. 1).
3. Now press the free end of the scale and leave it. We see that the scale starts to vibrate and a sound is produced. Now repeat this activity by keeping 30 cm, 20 cm and 10 cm of scale free. What did you experience? Does the length of scale left free affect the sound produced?

Activity-2

Fig. 2 : Metallic wire tied between two hooks

1. Tie a matallic wire tightly between two hooks (as shown in fig. 2). Note that there should not be any knot in the wire.

2. Vibrate it using your finger.

Can you hear some sound? If yes, then is this sound different than the sound produced in activity-1.

Activity-3

1. Take a tunning fork.
2. Vibrate this fork by beating it once on a rubber pad.
3. Bring the vibrating tunning fork close to your ear.

Can you hear its sound? Touch one side of the vibrating tunning fork with your finger. What did you experience? Discuss with your friends.

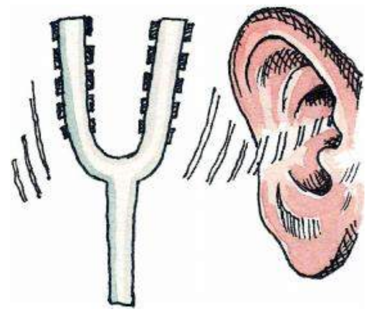


Fig. 3 : Vibrations in a tuning fork

In the above activities you saw that sound is produced in a body due to vibrations. Different types of sounds are produced in different types of objects (materials). Sound depends on the elasticity of a material. Elasticity is that property of a material, due to which it resists any change in its shape or size. That means, when an object changes its shape or size, or tries to change it due to applied force, then the object tries to resist this change and tries to get back to its original shape due to its property of elasticity.

The more elastic a material is, it will try to get back to its original shape quicklier. For example, matallic objects are more elastic as compared to objects made of rubber. Hence it is difficult to pull, bend or change their shape in comparision with rubber. This property of material affects the sound produced from them.

The length of vibrating objects also affects its sound. We cannot listen to the sound of vibration of an object below its minimum required length.

14.2 How does sound reach us?

We saw that sound is produced from vibrating things. When a certain thing vibrates, it exerts a force on the particles of nearby media which are in direct contact with it. So the particles of this medium get displaced from their balanced position or position of rest and start exerting force on the particles of other medium in their vicinity. After displacing the nearby particles, the initial particles get back to their original position. In this manner, energy gets transferred from one particle to another and sound travels forward. This same process continues until sound reaches our ear.

Is sound a form of wave?

Come, lets understand this based on the activity-3 done earlier.

In activity-3 when you vibrate a tunning fork, the arms of tunning fork start to vibrate towards left and right respectively. When they vibrate towards left, they create an area of high pressure by pushing the particles of air surrounding it. This area is called compression (Fig. 4). Now when they again vibrate backwards and return they create an area of low pressure which is called a rarefaction.

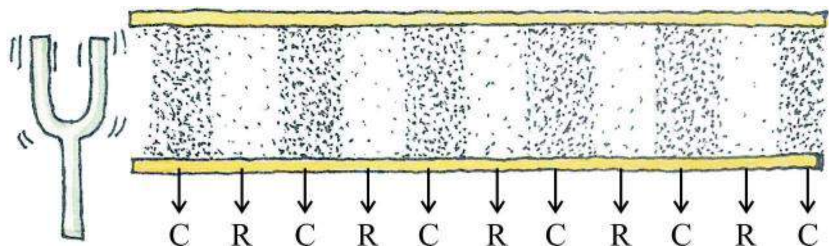


Fig. 4 : L Series of compressions and rarefactions in a vibrating tunning fork. (C shows compression while R shows rarefaction)

When a tunning fork vibrates continuously, a series of compression and rarefaction is formed in air. These compressions and rarefactions form a wave which transmits through a medium.

As energy is transferred from one particle to another during the transmition of sound therefore, sound is a type of mechanical wave.

Does sound transmission in solids, liquids and gases occur similarly?

Activity-4

1. Put one ear near the top surface of one of the ends of a wooden bench.

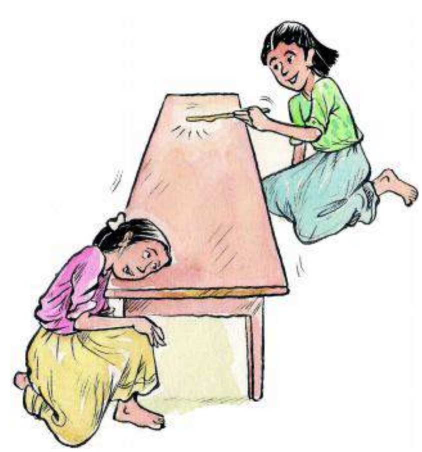


Fig. 5 : hearing sound through a solid medium

2. Ask your friend to knock on the other end of the bench.

   Can you hear the sound?

   In this case sound reaches your ears through which medium?

3. Now raise your ear away from the bench, and ask your friend to knock on the bench once again.

   In this situation, sound reached you through which medium?

What was the difference between the sounds produced in both the situations? Discuss with your friends.

Discuss

1. The sound of a motor boat can be heard louder under the water as compared to above the surface of water.

Transmission of sound depends upon the density of the particles of the medium. If the density is more, the pressure developed in the medium due to vibration will be more and so the transmission of sound will be quicklier. The particles in solids and liquids are closer as compared to gases. Their density is greater than gases, therefore the displacement of particles due to vibration is quicklier and energy wastage during energy transmission is lesser. For this reason sound travels faster in solids and liquids as compared to gases. In a similar way, transmission of sound in solids is faster as compared to liquids and energy loss is lower, hence we are able to hear the sound clearly.

In terms of elasticity, such substances in which force of attraction between particles is more, are more elastic as it is difficult to bring any change in the positions of such particles. On creating any disturbance in such particles, they quickly try to come back to their original positions and those particles which quickly come back to their original positions are again ready to move vibrate faster. Such mediums which have higher elasticity (eg. steel) have sound transmission faster as compared to mediums with lower elasticity (eg.- rubber). For this reason, the sound transmission in solids is fastest and in gases it is slowest.

Discuss

1. What effect will be produced on sound if we move upwards above the surface of earth.
2. Can you hear sound in space? Give reasons.
3. On a rainy day, we hear the sound of thunder after we see the lightening, why is it so?

Sound and Medium

Until now we studied that transmission of sound depends upon the density of different mediums. Think what will happen if there is no medium. Will the sound reach you? The following experiment was done to test this.

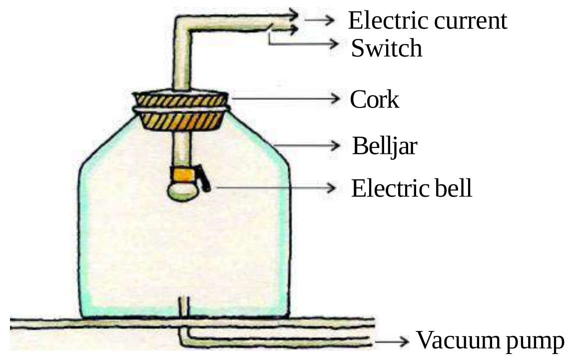


Fig. 6 : Experiment of Belljar

Experiment

An electric bell and a glass belljar was used, as shown in fig. 6. The bell was hung inside the belljar and it was connected to a vacuum pump. On pressing the bell switch, its sound was heard. When the air inside the jar was slowly pumped out using the vaccum pump the sound got lower, even though the same amount of electric current was passed through it. When the complete air inside the bell jar was pumped out, no sound could be heard.

The conclusion made through this experiment was that sound can not travel in vacuum and hence we always need some medium to hear sound.

> Sound waves do not travel in vacuum because there are no particles present in vaccum for compression and rarefaction.

Think

If there is no atmosphere on the moon, will astronauts be able to speak to each other.

14.3 Types of waves (on the basis of direction of vibration)

We know that when transmission of waves occur, there is no transfer of particles of medium. They only vibrate with respect to their mean position. On the basis of the direction of vibration of particles with respect to the direction of wave propagation, waves can be of two types-

1. longitudinal waves 2. transverse waves

Activity-5

(a) Formation of longitudinal waves.

1. Take a slinky (plastic spring toy).
2. Hold both the ends of slinky and pull and push them to and fro one by one.
3. Now mark a point anywhere on the slinkey and repeat the above steps. Notice the mark carefully.

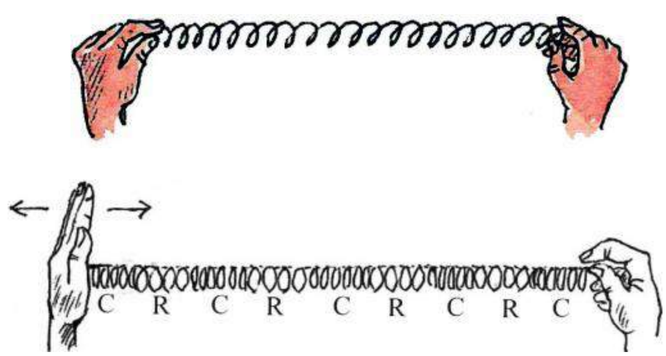


Fig. 7 : formation of longitudinal waves in the slinky (here C is compression and R is rarefaction)

In this activity you saw that on pushing and pulling the slinky to and fro, the mark on the slinky also moves in a direction parallel to the direction of propagation of displacement.

Hence, the waves in which the vibration of particles of the medium is in a direction parallel to the direction of wave propagation, are called as longitudinal waves. The transmission of sound waves takes place in a similar way. Hence, sound waves are also longitudinal waves.

Activity-6

(b) Formation of transverse waves-

1. Take a slinky (spring plastic toy).
2. By keeping one end of the slinky fixed, move the other end up and down.

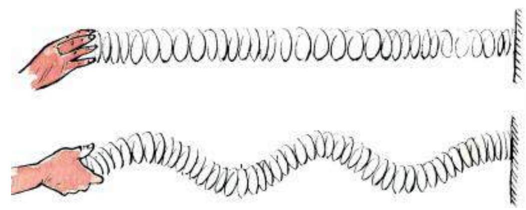


Fig. 8 :

Is the wave formed in this activity different from longitudinal wave?

On moving the slinky up and down, the vibration of particles is vertical to the direction of wave propagation. The wave formed in this activity is called transverse wave.

Hence, the wave in which the particles of the medium vibrate on their mean positions in a direction vertical to the direction of propagation of wave is called transverse wave.

14.4 Characteristics of sound waves

The nature of waves can be defined based on four measures- wavelength, frequency, amplitude and velocity.

Following is a picture showing the sound waves.

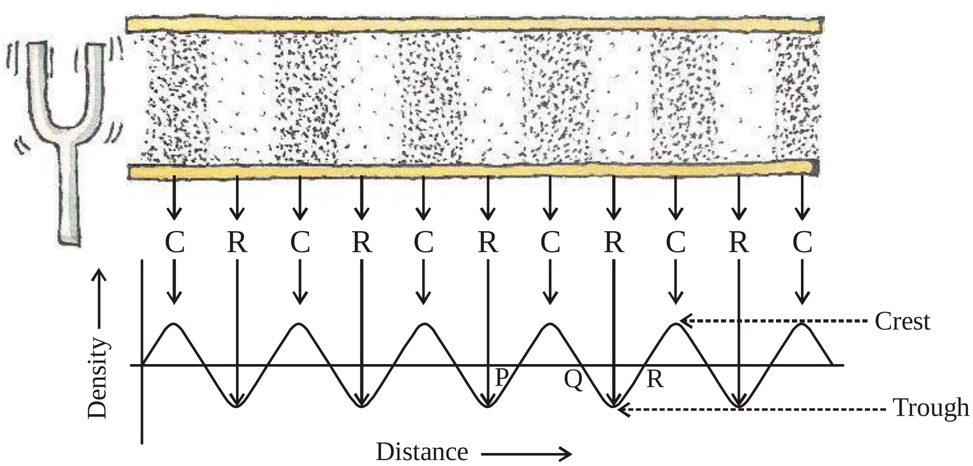


Fig. 9

We know that in a sound wave, compression and rarefaction occur consecutively. The density of air particles in compression is maximum while it is minimum in rarefaction.

This graph is drawn for longitudinal waves between the density of particles in a medium and the distance travelled by a wave. The part PQ in the graph is compression while QR is rarefaction. Similarly the raised part in a transverse wave is called crest and the deep pit is called as through.

Various defining words related to a wave are as following-

1. Wave length

The distance between two consecutive compressions (or crests) or two consecutive rarefactions (or throughs) is called wave length. Its SI unit is metre. It is denoted using λ (Lambda).

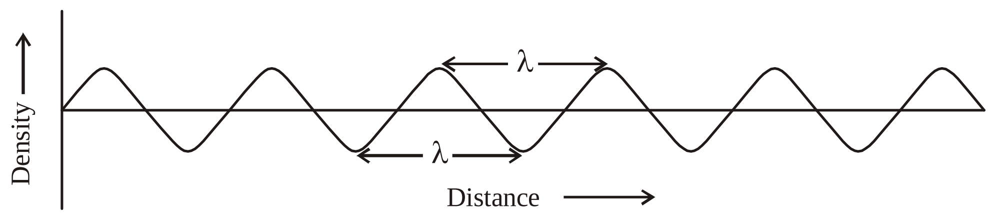


Fig. 10 Wavelenth in density - distance graph

2. Amplitude

When a sound wave travels through air, the particles of air vibrate forming areas of compression and rarefactions. As a result of this, the density of air in an area increases beyond normal and reaches its maximum or sometimes it reduces below the normal and becomes minimum. Therefore, the maximum or minimum densities of particles at the mean position of the medium is called amplitude. It is denoted using the letter A. The loudness or softness of sound mostly depends on the amplitidue of the sound wave.

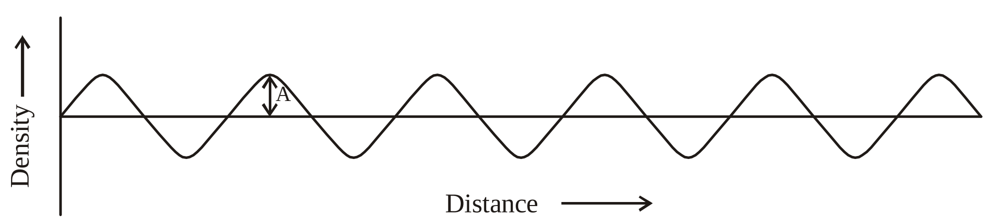


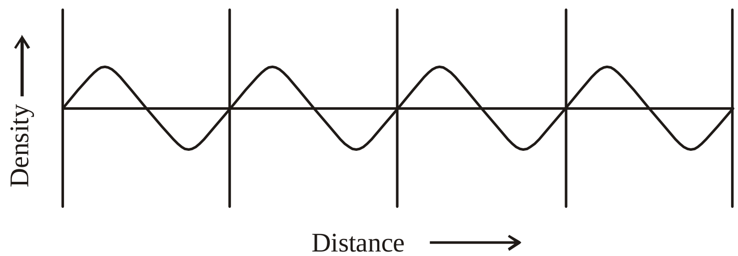
Fig. 11 Amplitude in density - distance graph

3. Time period

The time taken by two consecutive compressions or rarefactions to pass through a point is called time period of the wave. In other words, the time taken for the complete vibration of a density of a medium is called the time period of the sound wave. It is denoted using the letter T. Its SI unit is second.

4. Frequency

We know that when sound travels through a medium, the density of medium changes between the maximum and minimum values. One vibration is completed when the density moves from maximum value to minimum value and then reaches back to maximum value.



Number of vibrations in 1 second = 4

Fig. 12

The total number of such vibrations in a unit time are called as frequency of the sound wave.

If we count the number of compressions and rarefactions passing through the wave in a unit time, then we can find out the frequency of the wave. It is generally denoted by the greek letter υ. Its SI unit is hertz (Hz). The sharpness (pitch) of sound depends upon its frequency.

$$T = \frac{1}{\upsilon} \quad \text{or} \quad \upsilon = \frac{1}{T}$$

Example 1 : Find the time period of a wave of 500 Hz.

Solution : According to the question υ = 500 Hz

As we know, time period $T = 1/\upsilon$

$= 1/500$

$= 0.002$ seconds

5. Speed of sound waves

The distance covered by one compression or one rarefaction in a unit time is called the speed of waves.

We know that speed = distance/time

The distance travelled by a wave to complete one vibration is equal to its wavelength and time is equal to time interval.

Hence, $v = \lambda/T$

$\because \upsilon = 1/T$

So, speed $= \upsilon \lambda$

That means speed = frequency × wavelength

Remember that the speed of sound waves only depends upon the nature of medium and does not depend on its wavelength or frequency.

Example 2 : A sound forms 40,000 compressions and 40,000 rarefactions per second while passing through a gaseous medium. If the first compression is formed at a distance of 1 cm from the source, then find the velocity of the wave.

Solution : We know that frequency is equal to the number of compressions and rarefactions in one second.

Hence, frequency υ = 40000 Hz

Wavelength λ = istance between two compressions or two rarefactions

= 1 cm - 1/100 m.

as velocity of waves $v = \upsilon \lambda$

= 40000 x1/100

= 400 m/s

14.5 Hearing range

On the basis of hearing range, sound can be divided into following 3 categories.

1. audible range, 2. infrasound range, 3. ultrasound range

Audible sound- We cannot hear sounds of all frequencies. The hearing range of sound in human is 20 Hz to 20 KHz. We can only hear sound having frequencies within this range. Children below 5 years of age and dogs can hear upto 25 Khz.

Infrasound- The sound having frequency below 20 Hz is called infrasound. For example, the sound produced inside the earth's core at the time of earthquake, chemical and nuclear reaction sounds, etc. If we were able to hear at infrasound range, we could hear the vibrations of a pendulum just like we can hear the vibrations of flapping of wings by a bee hovering near our ear.

Ultrasound- The sounds above 20 KHz are called as ultrasounds. Such sounds are produced by dolphins, bats etc. The hearing organs of insects and moths are very sensitive. They can hear the sound of high frequency produced by bats and thus can protect themselves from bats around them and avoid becoming a prey.

14.6 Applicationis of Ultrasound

Ultrasounds are waves of high frequency. These waves can travel in a straight path even in the presence of obstacles. Ultrasounds are widely used in industries and medical fields.

Ultrasound is generally used to clean parts located in hard to reach places, for example, odd shaped parts, electronic components etc. Objects to be cleaned are placed in a cleaning solution and ultrasonic waves are transmitted into the solution. Due to the high frequency, the particles of dust, greese and dirt get detached and drop out. The object thus gets thoroughly cleaned.

Ultrasounds can be used to detect cracks and flaws in metal blocks. Ultrasounds are also used in the technique of 'echocardiography'. In this technique ultrasonic waves are made to reflect from various parts of the heart thereby forming an image of the heart.

Ultrasonography

Ultrasound scanner is an instrument which uses ultrasonic waves for getting images of internal organs of the human body. A doctor can get an image of the patient's organs such as the liver, gall bladder, uterus, kidney etc. It helps the doctor to detect abnormalities, such as stones in the gall bladder and kidney or tumors in different organs. In this technique the ultrasonic waves travel through tissues of the body and get reflected from a region where there is a change of tissue density. These waves are then converted into electrical signals that are used to generate images of the organ. These images are then displayed on a monitor or printed on a film. This technique is called 'ultrasonography'. Ultrasonography is also used for examination of the foetus during pregnancy to detect defects and growth abnormalities. Ultrasound is also used to break small 'stones' formed in the kidneys into smaller parts.

SONAR (Sound navigation and Ranging)

Sonar is a device that uses ultrasonic waves to measure the distance, direction and speed of underwater objects. Sonar consists of a transmitter and a detector installed on a boat or ship (as shown in fig. 13). The transmitter produces and transmits ultrasonic waves. These waves travel through water and after striking the object on the sea-bed, get reflected back and are sensed by the detector. The detector converts the ultrasonic waves into electrical signals. By finding the speed of sound in water and the time interval between transmission and reception of ultrasound we can find the distance of the object. Let the time interval between transmission and reception of ultrasound signal be t and the speed of sound through water be v. The total distance 2d travelled by the ultrasound is then $2d = v \times t$

Time = distance/velocity

$$t = \frac{2d}{v}$$

Hence, depth $d = \frac{vt}{2}$

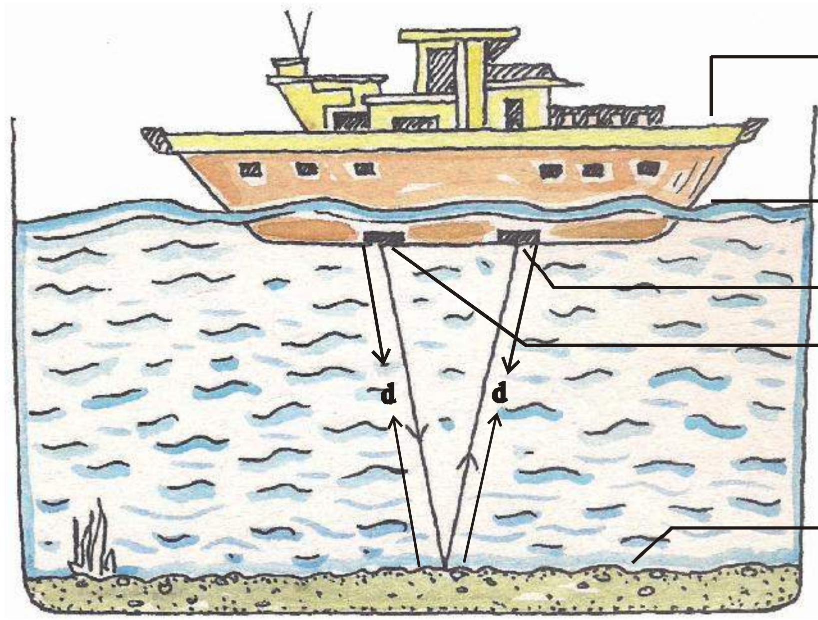


Fig. 13 : SONAR

Example 3 : An investigating team transmits an ultrasound signal to the sea bed. The signal is received back in 6 sec. If the velocity of sound in sea water is 1500 m/s then find out the depth of sea?

Solution : Suppose depth of sea is 'd' m.

So, the distance travelled by signal = 2 d

and time taken = 6 s

speed of sound = 1500 m/s

$$\text{as Speed} = \frac{\text{Distance}}{\text{Time}}$$

So, distance = speed × time

$2d = 1500 \times 6$

$d = (1500 \times 6) / 2$

Hence, depth of sea d = 4500 m = 4500/1000 km = 4.5 km

What we have learnt

- The vibration of a source produces sound.
- Sound travels in a medium in the form of longitudinal waves as successive compressions and rarefactions.
- In sound propagation, only the sound energy travels forward, not the particles of medium.
- Sound cannot travel in vacuum.
- The distance between two consecutive compressions or two consecutive rarefactions is called the wavelength.
- The time taken by the wave for one complete oscillation of the density of the medium is called the time period, T.
- The number of complete oscillations per unit time is called the frequency (υ), $\upsilon = \frac{1}{T}$
- Speed of sound = frequency × wavelength ($v = \upsilon \lambda$)
- The audible range of hearing for human beings is in the frequency range of 20 Hz-20 KHz.
- Sound waves with frequencies below audible range are called 'infrasonic' and above audible range are called 'ultrasonic'. Ultrasound has many medical and industrial applications.
- SONAR technique is used to detect things hidden under the surface of sea.

Keywords

disturbance, wave, wavelength, hearing range, amplitude, freequency, time period, compression, rarefaction

Exercise

1. Choose the correct option-

   (i) When sound waves propagate through a medium, then from one position to another-

   (a) Particles of the medium travel

   (b) Transfer of energy from one particle to another takes place.

   (c) Transformation of energy takes place.

   (d) None of these.

(ii) Sound below the frequency of 20 Hz is called-

(a) amplitude (b) inaudible/infrasound

(c) ultrasound (d) none of these

(iii) The distance between consecutive compressions or rarefactions is called-

(a) amplitude (b) frequency

(c) speed of wave (d) wavelength

(iv) Establish a relation between velocity of transferred wave (v), its frequency and wavelength.

(a) $v = \frac{3}{a}$ (b) $v = 3a$

(c) $v = \frac{a}{3}$ (d) none of these

(v) Sound waves do not travel in-

(a) solids (b) liquids

(c) gases (d) vacuum

(vi) If the time period of a vibrating object is 0.05 s, the frequency of waves produced will be-

(a) 5 Hz (b) 20 Hz

(c) 200 Hz (d) 2 Hz

2. Fill the following blanks-

(i) The hearing range of sound in humans is ....

(ii) SI unit of wavelength is ....

(iii) Distance between consecutive compression or consecutive rarefactions is called.................

(iv) Velocity of sound depends on ....

3. What happens to the velocity of sound in a medium if the sound wave frequency is doubled?

4. The frequency of sound produced by source A is twice to the frequency of sound produced by source B. Compare the wavelengths of both the sounds.

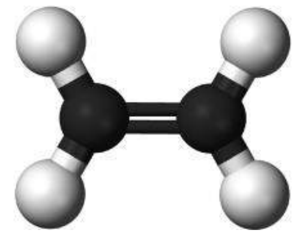
5. Which characteristic of sound helps you to identify your friends by his voice while sitting in another room?

6. Sound is produced by colliding two metals, first in air, then in water. Say which medium will produce louder sound when both metals are collided from same distance.

7. What is sound and how is it produced?
8. Explain compressions and rarefaction with help of diagrams.
9. Explain with help of an activity that sound propagation requires a medium.
10. Explain that sound waves are longitudinal waves.
11. Write notes on (i) ECG (ii) ultrasonography (iii) Sonar
12. Explain with diagrams velocity, frequency and wavelength of waves. Also establish a relation between them.
13. A sound wave travels at a speed of 3329 m/s. If its wavelength is 1.5 cm, what is the frequency of this wave? Will it be audible?
14. The speed of sound in air at a certain temperature is 340 m/s and its wavelength is 0.017 m. If the same sound source is dipped in water what effect will be produced on its wavelength? If the speed of sound in water is 1480 m/s, calculate.
15. What steps will you take to reduce the pitch of the sound produced by a 'sitar'?
16. A longitudinal wave whose wavelength is 1 cm, propagates in air at a velocity of 330 m/s. Calculate the frequency of wave. Can a normal human being hear this sound wave?

Chapter 15

Hydrocarbons



We read about different covalent compounds in the chapter on chemical bonding. We were introduced to covalent compounds of hydrogen with different elements like nitrogen, oxygen and carbon. Recall that the covalent compound of nitrogen and hydrogen is called ammonia and water is one of the covalent compounds of hydrogen and oxygen. What are the names of the covalent compounds formed by hydrogen and carbon? We saw some of them in the previous chapter such as methane, ethane, ethene etc. In fact, there are many more compounds formed by carbon and hydrogen and not just these three. The compounds of carbon and hydrogen are known as hydrocarbons. Nitrogen, oxygen etc. make one or two covalent compounds with hydrogen but carbon makes a large number of hydrocarbons with hydrogen. Let us try to understand why carbon forms such a large number of covalent compounds with hydrogen.

15.1 Catenation

Methane is the simplest compound of carbon. The molecular formula of methane is CH_4 and its structural formula is depicted in Fig.1.

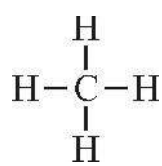


Fig.1 : Structure of methane molecule

Here, one atom of carbon is bonding with four hydrogen atoms.If we remove a hydrogen atom from methane we get the methyl group which is written as -CH_3. What if we replace one hydrogen of methane by a methyl group? We then get the following structure (Fig.2).

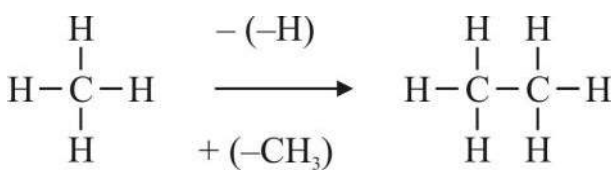


Fig.2 : Structure of ethane molecule

This molecule is ethane and its molecular formula is C_2H_6. In ethane too, we can replace one hydrogen atom by a methyl group. The molecule obtained will have a chain of three carbon atoms.

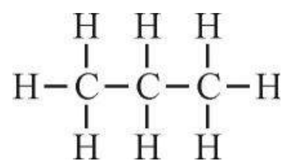


Fig.3 : Chain having three carbon atoms

In this way we can keep extending the chain by increasing the number of carbon atoms in it. This property of an element where its atoms bond with each other to give long chains is known as catenation. Sulphur and silicon also show catenation but they form shorter chains, not to the extent formed by carbon. Only carbon is known to be capable of forming very long chains of its atoms. One of the reasons for catenation in carbon is that carbon forms strong bonds not only with hydrogen and many other elements but also itself. Because of this catenation property of carbon, the number of hydrocarbons is very large.

15.2 Using condensed structural formulas to represent hydrocarbons

So far we have been using structural formulae to show the structures of hydrocarbons. In structural formulas, a single bond between carbon atoms is shown by a dash (Fig.1,2.3), a double dash (=) is used to represent a double bond (Fig.4a) and three parallel dashes (≡) are used to represent a triple bond (fig. 4b).

Fig. 4 : a and b

These structures take a lot of space and it is not always convenient to draw them. So, we use a simpler way of showing structures known as condensed structural formulas. In these structures all single bonds between atoms are omitted, that is, not shown. Then the structure of ethane can be written as CH_3CH_3. We can simplify the formulas even further if we have two or more identical groups of atoms in the molecule. For example, $CH_3CH_2CH_2CH_2CH_2CH_3$ can bewritten as $CH_3\ (CH_2)_4\ CH_3$.The identical group or the group being repeated is placed inside a bracket and the number of times it repeats is written as a subscript outside the bracket. Thus, the number after the bracket gives the number of times the group is found at that position inside that molecule. The double and triple bonds are shown in condensed structural formulas so the formula of ethene is $H_2C{=}CH_2$ and that of ethyne is $HC{\equiv}CH$.

15.3 Alkanes

We know that methane is the simplest hydrocarbon. We get ethane if we extend this carbon chain by one. We can get keep extending the carbon chain to get longer and longer straight or *continuous* chains.

Table-1 : Condensed structures, molecular formula and names of alkanes

No. of carbon atoms (n)	Condensed structure	Molecular formula	Name				
			Root	+	Suffix	=	Name
n=1	CH_4	CH_4	Meth	+	ane	=	Methane
n=2	CH_3CH_3	C_2H_6	Eth	+	ane	=	Ethane
n=3	$CH_3CH_2CH_3$	C_3H_8	Prop	+	ane	=	Propane
n=4	$CH_3(CH_2)_2CH_3$	C_4H_{10}	But	+	ane	=	Butane
n=5	$CH_3(CH_2)_3CH_3$	C_5H_{12}	Pent	+	ane	=	Pentane
n=6	$CH_3(CH_2)_4CH_3$	C_6H_{14}	Hex	+	ane	=	Hexane

Look carefully at the molecular formulas of the structures given in table-1. Do you see any relation between the molecular formulas with the number of carbon atoms, n?We find that all these hydrocarbons have the general molecular formula C_nH_{2n+2}. Compounds with this general formula are called alkanes. Alkanes are compounds of only hydrogen and carbon without any double bonds or triples bonds. The atoms in alkanes are connected to each other by single bonds only.

15.4 Naming of straight chain alkanes

An alkane (in fact, any hydrocarbon) is named according to the number of carbon atoms present in the carbon chain. The names of any continuous chain alkane can be divided into two parts. The first part or the prefixgives the number of carbon atoms in the longest continuous carbon chain. The longest chain is also known as the root or parent chain. The second part is the suffix which tells us the type of bonds present between the carbon atoms ofthe hydrocarbon. Let us understand through a few examples.

In alkanes where n=1, that is where the number of carbon atoms is one, the root is meth- and the suffix is –ane. Thus, the name of the alkane is meth+ane= methane. Similarly, if the alkane has the number of carbon atoms in the longest chain, n=2,3,4,5 or 6, then eth-, prop-, but-, pent- and hex- are used as roots and –ane is the suffix (table-1).

Questions

1. Draw the structural formula of an alkane where n=3. Name it.
2. Write the condensed structural formula of $CH_3CH_2CH_2CH_2$ CH_3
3. C_7H_{16} is called heptane. Identify the root part and suffix in the name.

Look at the molecular formula of methane, CH_4 and ethane, C_2H_6. They differ by a $–CH_2–$ group. Again, look at structural formula of ethane CH_3CH_3 and the next member in the series, propane $CH_3CH_2CH_3$. It is clear that they also differ by a $–CH_2–$ (methylene) group. You can verify this for other pairs of adjacent alkanes, such as propane and butane, butane and pentane, pentane and hexane as well. Each time, the molecules differ by a $–CH_2–$ group. A series of compounds related in this manner is said to form a homologous series. As we have seen, alkanes all have the general formula C_nH_{2n+2} (where n is the number of carbon atoms) and successive members differ by a $–CH_2–$ group. So, we can say that alkanes form a homologous series.

Calculate the molecular weights of methane and ethane and find the difference between them. Also find the difference in molecular weight between ethane and propane, propane and butane, and butane and pentane. Can you see any relation between the molecular weights of members of homologous series of alkanes?

15.5 Trends in physical properties

We have seen that the molecular weights of members of homologous series of alkanes differ by 14 u. Does this have any effect on their physical properties? Let us look at the table showing the boiling points of some alkanes-

Table -2 : Boiling points of the first six alkanes

Name of alkane	Boiling point °C
Methane	–162
Ethane	–89
Propane	–42
Butane	–0.5
Pentane	36
Hexane	69

We can see that the boiling points of the alkanes are gradually increasing as we increase the number of carbon atoms. We can say that straight chain alkanes with longer chains have higher boiling points than shorter chains and that the boiling point of the alkane depends on its molecular weight. In general, the physical properties of homologous members show a gradual and regular change.

Questions

1. What is a homologous series? Explain through examples.
2. Which among butane, propane and pentane will have the highest boiling point? Explain.

15.6 Branching and Structural Isomerism

So far, we extended the carbon chains by replacing a hydrogen from a terminal carbon atom with a methyl group. The hydrocarbons so formed involve continuous chains of carbon atoms. But we can also form branches in the alkanes. When a carbon atom in an alkane is bonded to more than two other carbon atoms, a branch in carbon chain occurs at that position. Let us go back to the example of $CH_3CH_2CH_3$. It has three carbon atoms, two of them are terminal and one is in the middle. The two terminal carbon atoms are chemically equivalent. To increase the carbon chain we can replace the H from either the middle carbon or the terminal carbon. That is we can extend the chain in two ways. If we replace the hydrogen atom from the terminal carbon we get the structure shown in fig.5 and if we replace the hydrogen from the middle carbon we get the structure shown in fig. 6.

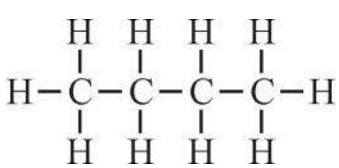


Fig. 5 : Butane

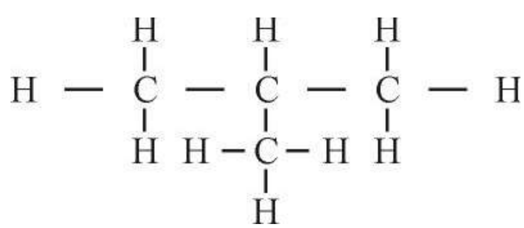


Fig. 6 : 2-methylpropane

Both of these have the same molecular formula C_4H_{10}, that is, the same number and type of atoms.But their structures are different which means that they represent molecules of different compounds. Existence of many different compounds which have the same molecular formula is called as isomerism. The different compounds are called isomers of each other. We can see that there are two possible isomers with the molecular formula C_4H_{10}.

One of them is called butane (fig.5). How do we name the other (fig.6) compound?

We first try to find the longest, continuous chain. It need not be straight, but it should be the longest. In the structures shown in fig.7, the longest chain has three carbon atoms. Note that although it looks as if the structures are different, both molecules are same.

Fig. 7

We see that the longest chain (also called the parent chain) in the second structure has three carbon atoms and so the root will be prop–. Then, we look for the branching point where the substituent is attached and name the substituent at the branching point. Here it is methyl group. Now, we start numbering the carbon atoms in the longest chain so that the branching carbon gets the lowest number. In our example, it does not matter from where we start counting because the branch position will always be at carbon number 2 (Fig.8).The position number of the alkyl group is 2.

Fig. 8 : 2-methylpropane

Now, we can name our compound. When writing the name of the compound,we first write the number of the branching carbon to which the substituent is attached followed by a dash (-). After the dash, the name of the alkyl substituent is written followed by the root to which the suffix is added at the end. Therefore, our compound is 2-methylpropane.

We have already discussed that compounds having the same molecular formula but different structures are called structural isomers. Structural isomerism can be of many types. The types of isomerism seen in butane and 2-methylpropane is called chain isomerism because it arises from differences in the parent carbon chain.

Questions

1. Draw the isomers of C_5H_{12}. (Hint: - three isomers are possible)

Similarly, six isomers are possible for hexane. The number of possible isomers for a given molecular formula increases with the number of carbon atoms present in it.

15.7 Alkene and alkyne

We have already seen homologous series of alkanes. Let us explore whether hydrocarbons having double or triple bonds also make homologous series. The simplest hydrocarbon with double bond that we have seen so far is ethene (also commonly known as ethylene). The structural formula of ethene is $CH_2=CH_2$ and the molecular formula is C_2H_4. Notice that the prefix in ethene is eth– which denotes two and the suffix is –ene. We can replace one of the hydrogen atoms of ethene by a methyl group. We will get $CH_2=CHCH_3$. It is known as propene and has the molecular formula C_3H_6. In general, hydrocarbons containing carbon-carbon double bonds are known as alkenes.

We can see that ethene and propene differ by a methylene group. Just as in the case of alkanes, one way of extending the carbon chains in alkenes is by substituting a hydrogen at a terminal (end) carbon by a methyl group.

Table-3 : Condensed structures, molecular formula and names of alkenes

No. of carbon atoms (n)	Condensed structure	Molecular formula	Name				
			Root	+	Suffix	=	Name
n=2	$H_2C = CH_2$	C_2H_4	Eth	+	ene	=	Ethene
n=3	$H_2C = CH\ CH_3$	C_3H_6	Prop	+	ene	=	Propene
n=4	$H_2C = CH\ CH_2\ CH_3$	C_4H_8	But	+	ene	=	Butene
n=5	$H_2C = CH\ (CH_2)_2\ CH_3$	C_5H_{10}	Pent	+	ene	=	Pentene
n=6	$H_2C = CH\ (CH_2)_3\ CH_3$	C_6H_{12}		?			

It is clear from the table that alkenes have the general formula C_nH_{2n}. They also differ by a methylene group and hence can be said to form a homologous series.

While naming alkenes, we follow the root-suffix rule where the suffix –ene is used to denote alkenes and the root gives the number of carbon atoms in the parent chain of the alkene. So butene means an alkene (-ene) with 4 carbon atoms (but-). *Can you give the name of a six carbon alkene?*

We can do something similar with ethyne (commonly called acetylene). It is the simplest hydrocarbon having a triple bond. Hydrocarbons having triple bonds between carbon-carbon atoms are called alkynes. Their naming is quite simple as we use the prefix-suffix rule where the suffix is –yne and the root gives the number of carbon atoms in the parent chain. Thus propyne would mean an alkyne with three carbons atoms.

In the table given below, the names of first three alkynes have been given. Try to complete the table using what you have learnt so far.

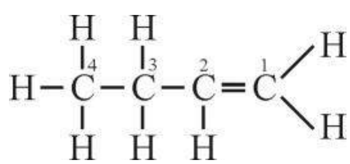
Table-4 : Condensed structures, molecular formula and names of alkynes

No. of carbon atoms (n)	Condensed structure	Molecular formula	Name				
			Root	+	Suffix	=	name
n=2	$HC \equiv CH$	C_2H_2	Eth	+	yne	=	Ethyne
n=3	$CH_3C \equiv CH$	C_3H_4	Prop	+	yne	=	Propyne
n=4	$CH_3\ CH_2\ C \equiv CH$	C_4H_6	But	+	yne	=	Butyne
n=5	?	?	?				
n=6	?	C_6H_{10}	?				

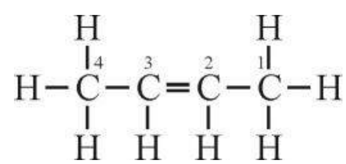
From table-4 it is clear that alkynes follow the general molecular formula C_nH_{2n-2}. Since two successive members of the alkyne family differ by a $-CH_2-$ group therefore alkynes also form a homologous series.

15.8 Isomerism in alkenes and alkynes

Try to draw the structure of the alkene C_4H_8. Where will you place the double bond between the carbon atoms? It is clear that the double bond can be in two different positions. We can either have a double bond between the first and second carbon atoms (Fig.9a) or between the second and third carbon atoms (Fig.9b).



(a) but-1-ene



(b) but-2-ene

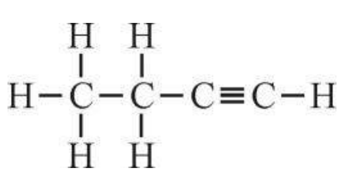
Fig. 9 : (a) and (b)

Both the structures are for alkenes and have the same molecular formula C_4H_8 but the position of atoms is different, so the two molecules are isomers of each other.

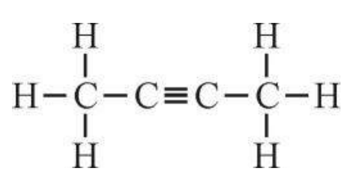
This type of isomerism arising from difference in position of a double bond is called position isomerism. Just like chain isomerism, position isomerism is also a type of structural isomerism. Here, the molecular formula of both compounds is same but their properties are different because of difference in structures. Their names are also different.

Structure shown in fig.9 a is called but-1-ene. For naming the alkene, the first part indicates the number of carbon atoms in the longest continuous chain. This is followed by a number, in this case 1, showing the position of the double bond which is followed by –ene showing that the hydrocarbon belongs to the alkene family. Numbers and words are separated by dashes. Similarly, structure shown in fig.9b is called but-2-ene.

Position isomerism is also seen in alkynes. For example, C_4H_6 (Fig.10 a and b) has two position isomers.



(a) but-1-yne



(b) but-2-yne

Fig. 10

The two structures shown above are position isomers. The first part of their name, but- shows that the longest continuos chain in the molecule has four carbon atoms and –yne shows that it is a member of the alkyne family. The number in between shows the positon of the triple bond in the molecule.

15.9 Types of hydrocarbons on the basis of bonding

So far we have studied about three types of hydrocarbons - alkanes, alkenes and alkynes. We saw that alkenes have a double bond between any two carbon atoms and alkynes have a triple bond between two carbon atoms.The number of double or triple bonds can be more than one. However, in alkanes only single bonds link the different atoms whether carbon to a carbon or carbon to a hydrogen. We use this difference in types of bonds as a means to classify hydrocarbons. Hydrocarbons having multiple bonds are called unsaturated hydrocarbons. Therefore, alkene and alkynes are unsaturated hydrocarbons whereas, alkanes are called saturated hydrocarbons.

All structures that we have studied so far have either continuous chains or branched chains of carbons. However, it is also possible for carbon atoms to join together and form rings. The smallest carbon ring that can be formed has three members (Fig.11).

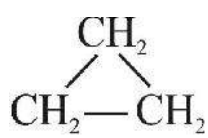


Fig. 11 : Cyclopropane

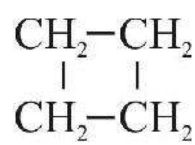


Fig. 12 : Cyclobutane

In this molecule, each carbon is bonded to two other carbon atoms and two hydrogen atoms. The molecular formula of this molecule is C_3H_6. Is the molecular formula similar to the molecular formula of an alkene? We can also have a 4 membered ring with the formula C_4H_8(Fig.12).

In both the molecules, the carbon atoms are arranged together to form rings and only have single bonds between the different atoms. The general formula of these can be written as C_nH_{2n}. This class of hydrocarbons is known as cycloalkanes. C_3H_6 is known as cyclopropane and $C_4H_8$is known as cyclobutane. Note that the molecular formulas of cycloalkanes and some alkenes are same therefore it is important to know the structure of a compound before we can name it. Many more similar cycloalkanes are possible.

Questions

1. How many straight chain isomers are possible for the molecular formula C_5H_8 . Draw their structures.
2. Group the following into saturated and unsaturated hydrocarbons.

Keywords

hydrocarbon, catenation, bond, alkane, alkene, alkyne, isomerism, saturated, unsaturated, homologous series, chain isomerism, position isomerism, (–) hyphen, suffix, structural formula, parent chain

What we have learnt

- Covalent compounds of only carbon and hydrogen are called hydrocarbons.
- The valency of carbon is four and it forms covalent bonds with other atoms. The properties of carbon compounds are similar to each other.
- The property of elements by which its atoms link to one another forming long chains is known as catenation.
- A family (series) of carbon compounds with the same functional group where the formulas of two adjacent members differs by $–CH_2–$ is called a homologous series. The members of the homologous series are homologues of each other, have the same general formula and show a regular gradation in their physical properties.
- Compounds having same molecular formula but different structures are isomers of each other and this property is called isomerism.
- Isomerism arising from difference in the parent chain of carbon compounds is called chain isomerism.
- Isomerism arising from difference in position of the functional group or a double or triple bond in the carbon chain is known as position isomerism.
- Alkanes only have C-C and C-H single bonds and have the general formula C_nH_{2n+2}.
- Alkenes have C=C bonds and have the general formula C_nH_{2n}.
- Alkynes have C≡C bonds and have the general formula C_nH_{2n-2}.
- In cycloalkanes the carbon atoms of the root part are arranged in rings and they have the general formula C_nH_{2n}.

Exercises

1. Choose the correct option that fits the descriptions given below:-

   (i) This hydrocarbon only has single bonds.

   (ii) Carbon has the ability to form strong bonds with atoms of other elements. But what is more special is its ability to bond strongly with other carbon atoms.

   (iii) Molecules having same molecular formula but different structures.

   (iv) Butane and 2-methylpropane exhibit this type of isomerism.

   (v) Isomerism that can be exhibited by alkenes and alkynes but not alkanes.

   (vi) Members of this series show a regular gradation in their physical properties.

   (Position isomerism, homologous series, alkanes, isomers, chain isomerism, catenation)

2. Fill in the blanks

   (i) Hex-1-ene and hex-2-ene are ……………………..isomers.

   (ii) The boiling point of butane is …………….than propane.

   (iii) The number of carbon atoms in the parent chain of 2-methylpropane is………

   (iv) The number of hydrogen atoms in cyclobutane is………………

   (v) C_2H_6,C_3H_8, C_4H_{10} are members of the ………………..homologous series.

3. Draw the structures of the following:

   2-methylbutane, prop-1-yne, pent-2-ene

4. Write any three characteristics of the alkane family.

5. Differentiate between position and chain isomerism with examples.

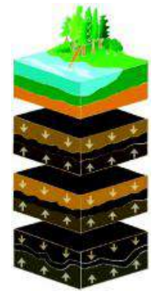
6. What is the relation between the boiling points and number of carbon atoms present in straight chain alkane? Explain.

7. Alkanes, alkynes and alkenes with three or less carbon atoms do not show structural isomerism. Explain.

8. How many structures/isomers are possible for the molecular formula C_4H_8? Draw their structures. (Hint – three are possible).

Chapter 16

Coal, Petroleum and Petrochemicals



We need energy to carry out our daily activities and for doing all kinds of work. This energy is obtained from many different sources. For example, we need electricity to run machines in factories and fuel (diesel, petrol and CNG) is needed to run vehicles. Different types of fuels such as wood, kerosene oil, LPG are used to cook food.

Have you ever wondered from where we get these fuels especially coal, petrol and diesel? Are these fuels produced in laboratories or factories? Where are they made and how? Actually, these fuels were formed from the remains of dead plants and animals that were buried under the earth's crust millions of years ago and therefore, they are called fossil fuels.

16.1 Origins of coal and petroleum

About 28 to 36 crore years ago, during the Carboniferous period, the dead bodies of animals and plants got buried under the soil. Slowly, more and more layers of soil were deposited over them. Deep inside the earth, in the absence of oxygen, they were subjected to high pressure and temperature and were transformed into coal. However, many people believe that coal was formed mainly from plants. There is some evidence to support this argument in the form of the large number of fossils found in coal beds. Most of these fossils are impressions of leaves and other fragile parts of plants (Fig. 1).

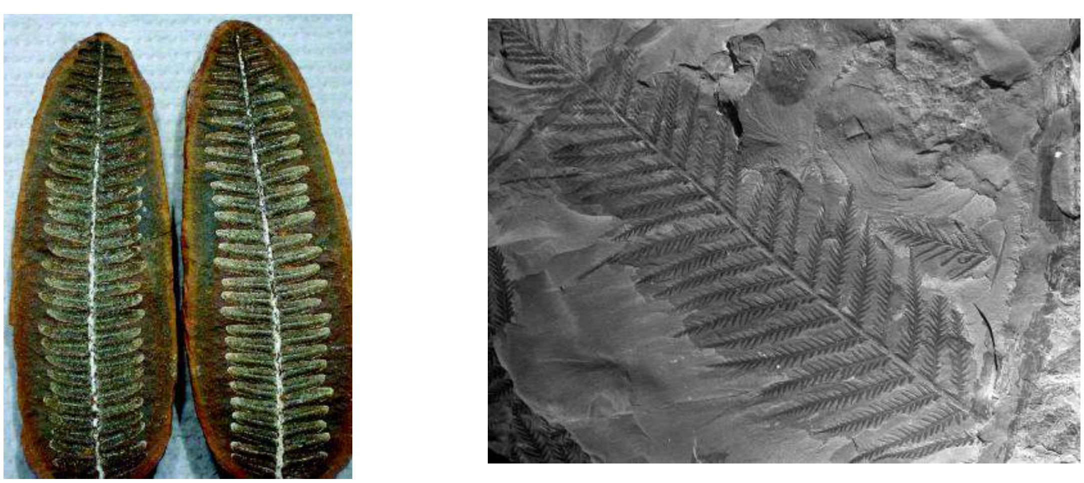


Fig. 1 : Imprints of leaves in layers of coal

It is believed that petroleum was formed from some organisms (plankton) living in the sea. As these plankton died, their bodies got deposited at the bottom of the ocean and were covered by more layers of sand and soil. Over millions of years, in the absence of oxygen and under high pressure and temperature, they were transformed into petroleum.

16.2 Types of Coal

You must have seen wood charcoal. This is a black coloured, brittle substance that is formed in very little time when wood is burnt in an insufficient supply of oxygen. However, the coal that we are talking about in this chapter is also black in colour, but hard as stone.

We have learnt that coal is formed by the decomposition of dead plants that get buried deep inside the earth. The decomposed plants are first converted into peat and because of continuous high pressures and temperatures are subsequently converted into lignite, bitumen and anthracite coal (fig.2).

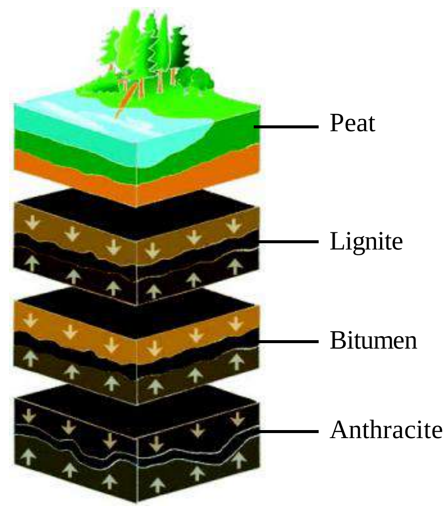


Fig. 2 : Different categories of coal

Coal is mostly made up of carbon and its compounds. Coal is divided into the following categories based on the percentage of carbon in its composition:

1. **Peat -** This is the first stage in the transformation of dead plants into coal. Peat has 25-35% carbon. It is mostly used as fuel.
2. **Lignite -** It is also known as brown coal. Lignite has 35-45% carbon. It is used in thermal power plants to produce electricity.
3. **Bitumen** - This is the most abundant type of coal found in nature. Bitumen is used more than any other type of coal. It has 45-85% carbon. It is mostly utilized in thermal and cement plants, in paper manufacturing units, and in automobile and garment industries. The coke used in steel manufacturing plants is bitumen. Bitumen has more sulfur than any other coal.
4. **Anthracite -** This is an excellent type of coal and also known as hard coal. The amount of carbon in anthracite is more than 85%. Because of the high carbon content it burns for a very long time. It is used as household fuel because it produces very little smoke and ash.

In the types of coal given above, we saw that classification was on the basis of increasing amount of carbon content. You may think that only carbon is present in coal but this is not true. Along with carbon, coal also has mositure, hydrogen, air (oxygen, nitrogen, sulphur) etc.

The amount of heat produced when equal quantities of coal are burnt is called heat or calorific content. Commercial grading of coal is done on the basis of heat content.

16.3 Grades of coal

Grade (G) is used to measure the heating power of coal. It is given in Gross Calorific Value whose unit is kcal/kg.

Table 1 : Grades of coal

Grade	(GCV) (kcal/kg)	Grade	(GCV) (kcal/kg)
G-1	Above 7000	G-10	4301 - 4600
G-2	6701 - 7000	G-11	4001 - 4300
G-3	6401 - 6700	G-12	3701 - 4000
G-4	6101 - 6400	G-13	3401 - 3700
G-5	5801 - 6100	G-14	3101 - 3400
G-6	5501 - 5800	G-15	2801 - 3100
G-7	5201 - 5500	G-16	2501 - 2800
G-8	4901 - 5200	G-17	2201 - 2500
G-9	4601 - 4900		

Different grades of coal are used in different activities. Our state of Chhattisgarh produces many different grades of coal. Let us find out the regions in our state where in coal is found.

16.4 Coal in Chhattisgarh

Chhattisgarh holds an important position in India in terms of coal mining and production. Underground and open coal mines are found in Korba, Raigarh, Sarguja and Korea in Chhattisgarh. In the district of Korba, G-4 and G-5 grade coal is found in the mines of Rajgamar, Bagdeva, Surakachhar and Bankimongra. Further, G - 11 grade coal is found in mines of Gevra, Dipka and Kushumunda. National Thermal Power Corporation (NTPC) and Chhattisgarh State Electricity Board (CSEB) have set up thermal power plants in Chhattisgarh. These thermal power plants use coal. Apart from this, the aluminium plant at Balco, the steel plant at Bhilai, thermal and steel plants in Raigarh and other industrial plants in Siltara (Raipur) also use coal. Because of its great utility and large number of uses, coal is sometimes called black diamond.

Questions

1. What are fossil fuels?
2. How is coal formed?
3. Which type of coal has maximum sulfur content?

So far we have learnt about the fossil fuel coal. Let us now study about another fossil fuel- petroleum.

16.5 Petroleum

The word petroleum has its origin in two words - petra (which means rock) and oleum (which means oil). So, petroleum means oil from rocks. We have already read about how petroleum is formed in a previous section. Petroleum is an oily, dark-coloured liquid with a very distinctive odour. It is usually found at great depths under the earth's surface.

Petroleum is a mixture of many hydrocarbons so it does not have a fixed chemical formula. The different hydrocarbons in the petroleum mixture cannot be separated using simple distillation methods therefore, a special technique called fractional distillation is used for separation.

16.5.1 Fractional distillation of petroleum

You must have seen vapours being formed when water is heated in a container. If we cover the container with a lid, we see some water droplets on the inner surface of the lid. This process is known as distillation. We will first try to understand the distillation of a mixture of two liquids. In distillation, if a mixture of two liquids is heated then both of them are converted into their vapour form . When we cool the vapours, they are converted back into the liquid form.

All liquids continuously evaporate even at room temperatures but on heating the amount of vapour being formed starts increasing. The amount of vapour being formed is inversely proportional to the boiling point of the liquid. This means that more vapour will be formed for the liquid which has a lower boiling point and less vapour will be formed for the liquid with the higher boiling point. When we cool down this vapour mixture, then we get more of the liquid which has a lower boiling point and less amount of liquid which has the higher boiling point. We can understand this further through the following example of liquids A and B:

Liquid A	+	Liquid B	$\xrightarrow{\textbf{on heating}}$	Vapour	$\xrightarrow{\textbf{on cooling}}$	liquid
(Lower boiling point)		(higher boiling point)		(more vapours of A, less vapours of B)		(more A, less amount of B)

If we want to completely separate these two liquids, we will have to repeat the distillation process again and again.

Petroleum is a mixture of many different hydrocarbons whose boiling points are very close to each other. It is very difficult to separate such mixtures using simple distillation methods therefore we have to use a technique for this separation which requires a special apparatus called a fractionating column. This method of separating a mixture of two or more miscible liquids whose boiling points are very close to each other is known as fractional distillation.

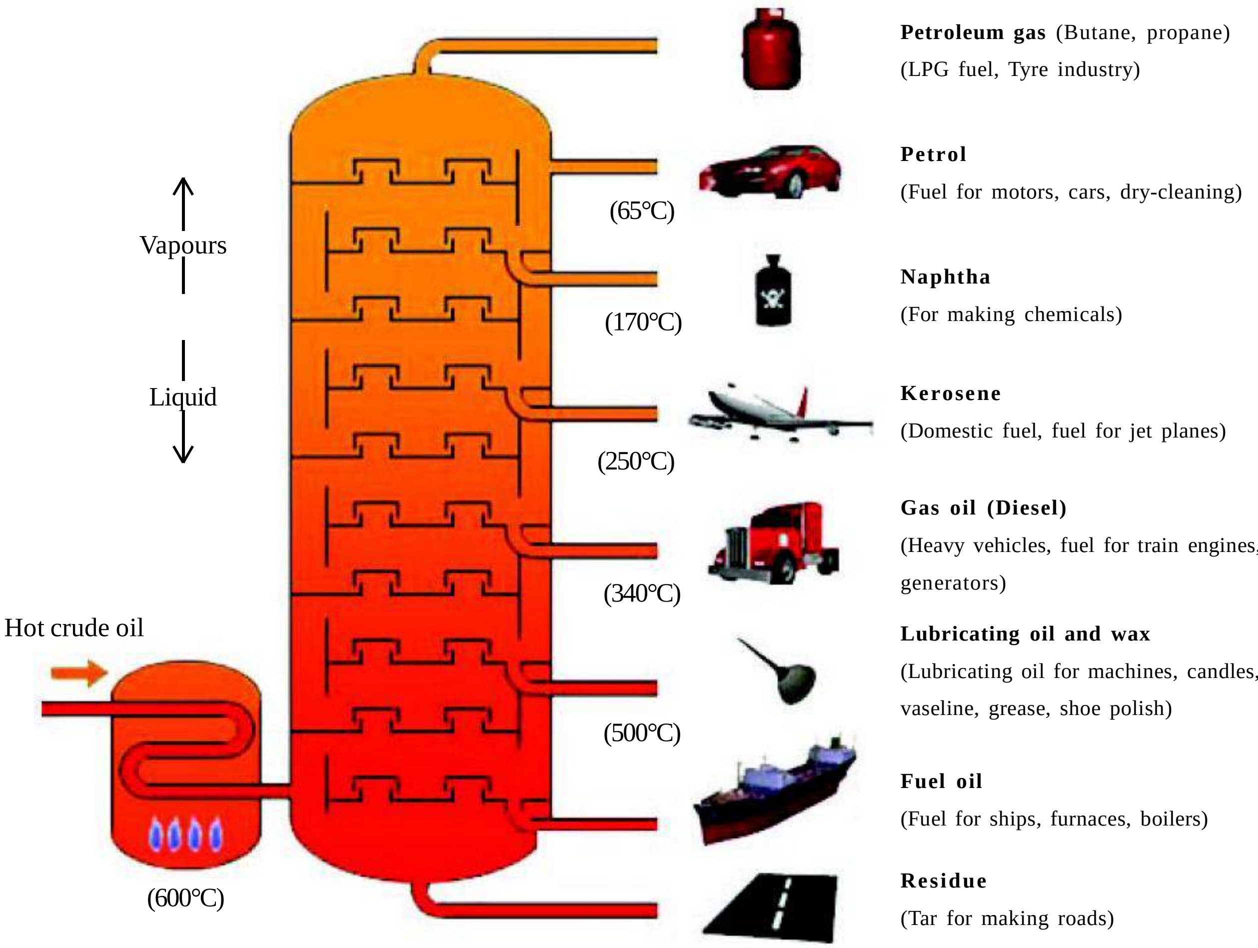


Fig. 3 : petroleum at different levels

In fractional distillation of petroleum, first of all the crude oil is heated in a furnace and the vapours are directed towards the lower part of the fractionating column. This mixture of vapours rises up in the column and then condenses into liquid and comes down. As more and more hot vapours are introduced into the column, the condensed factions again change into vapours. Thus, the distillation process is repeated continuously. In this way, the compounds with lower boiling points get condensed in the upper part of the column and then are collected separately. As we move down the column, liquids with higher boilings points are separated and collected. This is how fractions having different boiling points are separated from petroleum at different levels (Fig. 3).

We have seen that fractional distillation of petroleum yields many important substances at different temperatures in the column. These substances are known as petrochemicals and are used in various industries. Many of the industries in modern times are completely dependent on petrochemicals.

Questions

1. What is fractional distillation?
2. Why is fractional distillation of petroleum necessary? What type of gases are obtained in the upper part of the fractionating column?
3. Why does petroleum not have a chemical formula?

16.6 Petrochemicals

The chemicals obtained from petroleum are called petrochemicals. The story of the initial attempts to use petrochemicals is very fascinating. A long time ago, in the Gulf region, petroleum would seep out slowly, on its own, in small pits. Many of the components of this petroleum mixture could form vapours. So, after sometime most of the mixture would evaporate, leaving behind a sticky substance. This sticky substance was used for waterproofing boats. People also used it to join together bricks and stones while constructing houses. About 200 years ago, kerosene oil was separated from petroleum and from then on it started being used extensively as a fuel and for lighting.

In mid-nineteenth century, a jelly obtained from petroleum was used to treat burns and other wounds, especially by factory workers. This was the basis for using petroleum jelly in cosmetics. Today, petrochemicals are used in industrial production of detergents, fibres (polyester, nylon, acrylic etc.), polythene and other man-made plastics.

Our world has been revolutionized by the use of plastic products in various fields. The plastic industry plays an important role in our country's economy. The importance of plastics is increasing day by day with the wide-spread use of plastic objects.

16.7 Recycling plastic

Plastic objects are thrown away once they are used but they do not get decomposed in the soil. So it becomes necessary to either break-down plastics or make them suitable for reuse. The process of converting waste plastic objects into useful products is known as plastic recycling.

In 1988, different types of plastics were given identification codes by the Society of the Plastics Industry (SPI). Before recycling, plastic items are separated according to their identification codes. There are seven identification codes.

Identification codes are in the form of a number enclosed by clock-wise arrows arranged in a triangle (Table-2). The plastics which have the same identification code are recycled together.

Table 2 : plastic identification code

Identification Code	1	2	3	4	5	6	7
Name of objects	Water bottle, Cold drink bottles, Jam jars	Water pipes, Toys, Juice bottles, Shampoo & cream containers	PVC pipes, Juice bottles				

Activity-1

- Note the identification code of various plastic objects around you.
- Group objects according to their identification codes.
- Did you find objects from each of the seven codes? Look at the codes of objects collected by your friends and discuss which ones are more common..
- Make table 2 in your copy. Write down the names of objects with identification codes 4-7 in the appropriate column of the table.
- Collect information about recycling plastic from different sources. Discuss in the classroom.

16.8 Combustion of fuels

We know that all objects need oxygen to burn. Burning in presence of oxygen is known as combustion. Heat is released during combustion, therefore it is an exothermic process.

The combustion of coal mainly produces carbon dioxide and heat.

$$C + O_2 \longrightarrow CO_2 + \text{heat}$$

If coal is burnt in insufficient oxygen then carbon monoxide is produced.

$$C + \frac{1}{2} O_2 \longrightarrow CO + \text{heat}$$

Ash is the solid left behind when coal is burnt. We find that burning of fuels produces carbon dioxide, carbon monoxide and ash and an excess of all these pollute the environment.

16.9 Effect of increasing use of fossil fuels on the environment

If we continue using fossil fuels at this rate, the environment will be adversely effected.

- A part of the carbon dioxide produced during burning of fossil fuels is used by plants in photosynthesis. But most of it is not used and this is one of the causes of the greenhouse effect which is leading to an increase in the earth's temperature.
- The carbon monoxide produced during combustion of fuels is a poisonous gas because it combines with hemoglobin in the blood at a faster rate than oxygen. If the amount of carbon monoxide in the blood exceeds a certain amount, it can cause death.
- The ash produced during combustion of coal is known as fly ash because it flies out of the chimney (?) and settles down in nearby areas. It can infect and harm lungs and cause silicosis.
- Nitrogen and sulfur are also found in fossil fuels. On combustion of these fuels, oxides of nitrogen and sulfur are also formed. These oxides dissolve in rain water and cause acid rain.

16.10 Conservation of fossil fuels

It takes millions of years for fossil fuels to form. But the current reserves of fossil fuels will last for only about a hundred years. So we must try to stop the misuse of fossil fuels. If we want fossil fuels to be available to future generations we must use it in a balanced manner.

- The community must be informed about ways to prevent misuse of fossil fuels.
- New scientific methods must be used in coal mining so that maximum quantity of coal can be obtained and there is no unnecessary loss.
- CNG (Compressed Natural gas) must be given preference as a fuel for vehicles because it does not contain nitrogen or sulfur.
- Plastics must be used in moderation.
- Efforts must be made for complete overall maintenance of vehicles to minimize use of petroleum products by vehicles. The petroleum conservation and research association (PCRA) of India gives various tips to save fuel while driving. For example : -
  - As far as possible, drive at a uniform and medium speed.
  - Switch off the engine at traffic lights or anytime you have to wait.
  - Check tyre pressure and ensure regular maintenance of vehicles.

Questions

1. What do we mean by the recycling of plastics?
2. What is combustion? Explain.

Keywords

Fossil fuel, coal, petroleum, fractional distillation, recycling, combustion, conservation, plankton, fly-ash, acid rain

What we have learnt

- Fossil fuels are formed by the transformation of the remains of dead animals and plants. Coal and petroleum are two fossil fuels.
- Coal is formed from the dead bodies of plants and animals and petroleum is formed from the dead bodies of sea creatures called planktons.
- The product obtained in the first stage of coal formation is peat. The best quality coal is anthracite.
- For commercial purposes, coals are divided into grades according to their heating potential.
- Petroleum does not have a fixed chemical formula because it is a mixture of various hydrocarbons.
- Fractional distillation is used to separate a mixture of liquids whose boiling points are very close to each other.
- Petroleum gas is obtained at the top-most part of the fractionating column and viscous fluid (tar) is obtained at the lowermost part.
- Various plastics used in daily activities are all petrochemical products.
- The process of converting useless plastic objects into useful products is known as plastic recycling.

Exercises

1. Choose the correct option:–

   (i) Coal is produced from the remains of

   (a) Plants (b) Animals

   (c) Both plants and animals (d) None of these

   (ii) The conditions necessary for formation of fossil fuels are:

   (a) High temperature (b) High pressure

   (c) Absence of oxygen (d) All of the above

(iii) Which type of coal has maximum carbon content

(a) Peat (b) Lignite

(c) Bitumen (d) Anthracite

(iv) What is the identification code found on objects made of PVC?

(a) 1 (b) 2

(c) 3 (d) 4

2. Fill in the blanks

(i) Coal and petroleum are ……………….fuels

(ii) During formation of coal, ………….. is formed in the first stage and ………………..is formed in the last stage.

(iii) The least carbon content is found in .... type of coal.

(iv) Fractional distillation is carried out when there is a very small difference in the .... of liquids in the mixture.

(v) Petroleum is a combination of two words - .... and ....

3. How are fossil fuels formed?

4. Describe the different types of coal in detail.

5. Describe the environmental effects of the excessive use of fossil fuels.

6. The conservation of fossil fuels is a big necessity. Explain.

7. What products are obtained by the fractional distillation of petroleum? What are their uses?

Chapter-17

Habitat

17.1 Meaning of Habitat

We have Kotumsar caves near the banks of Kanker river at Jagdalpur in our state. Long thin conical structures hanging from the roofs and rising from the floors of the caves are formed as lime water trickles down (See Fig.1).

These caves are over a km in length and are located about 35 meters below the surrounding areas. A hand torch carried down into the cave if switched off would result in pitch darkness in the cave.

The amount of oxygen inside the cave is less compared to that outside it. In spite of such adverse conditions, some organisms like bats, a type of fish, insects, millipedes, snails, bacteria, are found etc. in the cave.

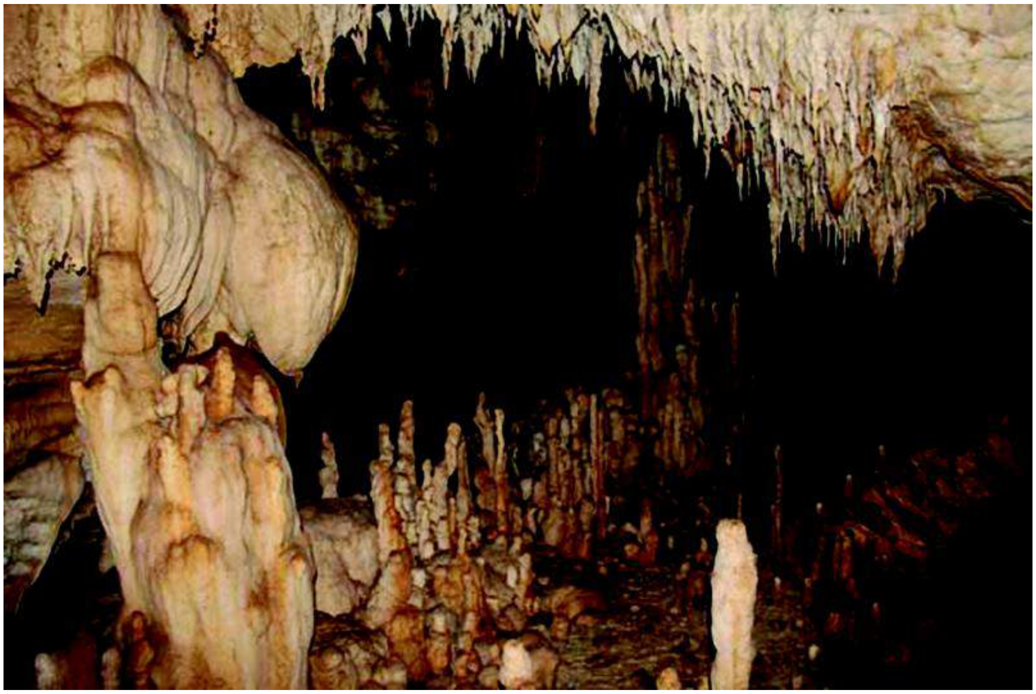


Fig. 1: conical structures, the stalactites and stalagmites of Kotumsar caves.

The temperature inside the cave ranges between 25°C- 32°C throughout the year. The temperature of water inside the cave ranges between 22°C - 30°C. This implies that the temperature of water and air inside the cave is similar. During rainy season, the cave gets flooded.

A particular species of fish is found in these caves. The length of the fish is 2-4cm. Its eyes are very small. The local people call it "kaani machri". Other varieties of this fish are found in mountainous streams. It feeds on microscopic organisms, insects and molluscs. It also feeds on dead and decaying remains of animals and plants. Thus it may be called as a scavenger. These fishes usually live in burrows under the soil of the caves. Though their gaseous exchange occurs in water (with the help of gills) as most other fishes, they often come to the surface of water to fill their mouths with air(since they also have air/swim bladders). They lead their whole life in these caves. They reproduce here and die here. Thus we may say that water of the Kotumsar caves is the habitat of these fishes.

Fig. 2 : kaani machri

- What special features of Kotumsar caves have been described in this section?
- Suppose kani machri flows out from the cave during floods, how do you think it will survive?
- How do Kotumsar fishes differ from other fishes?

The fishes and other living organisms, are the biotic components of Kotumsar. The temperature, water, lime deposits, air, etc. are the abiotic components. The biotic and abiotic components in a habitat affect the survival of organisms living there.

17.2 The Interrelationship between Natural Components in a Habitat

Let us find out about the interrelationship of living and non-living components in a habitat.

Activity-1

Make a list of everything that you do as you wake up in the morning till you go to bed at night.

Make sure to include everything such as air you breathe, the toothbrush you use, milk or tea that you drink. Write the source from which you acquire these products. Like- the cotton clothes we wear are made of yarn that we acquire from the cotton plant. This is the source. Similarly, your plastic slippers are made of plastic which is obtained from the petrochemical industry.

Table 1

S.No.	Items	What it is made of?	Source
1.	Cotton kameez	Yarn	Cotton plant
2.	Slippers	Plastic	Petrochemical industry
3.			

The above table has been prepared based on items of daily use. If this is extended to a month or a year, it would become clearly evident that there are several things both living and nonliving in nature, which we depend upon.

- What are the nonliving components indispensable for us?
- What are the living components without which we cannot survive?

You may have now realized that we depend on many living organisms some more important while others less. Life of organisms depends on many others; thus, there is an interrelationship among organisms. Whether it is you or the rose plant, the lion or fungi all are dependent on other organisms. Each organism is part of a community and dependent upon several living and non-living components.

17.2.1 Interrelationship of Living Components

You have seen that organisms are dependent on each other due to either their reproductive, shelter or food related needs. Food and the energy acquired from them form the main basis of interrelationship of organisms.

Let us take an example to understand this -

The bison is found in the forests along rivers, marshy areas and wetlands of Chhattisgarh. It feeds on grasses and other plants. Food chain (energy flow) shows the dependence of the bison on grass. Food is prepared by grass by the process of photosynthesis. Thus, the flow of energy is from grass to bison (mind it, it cannot be reversed). If a lion feeds on bison, the relation can be shown as follows:

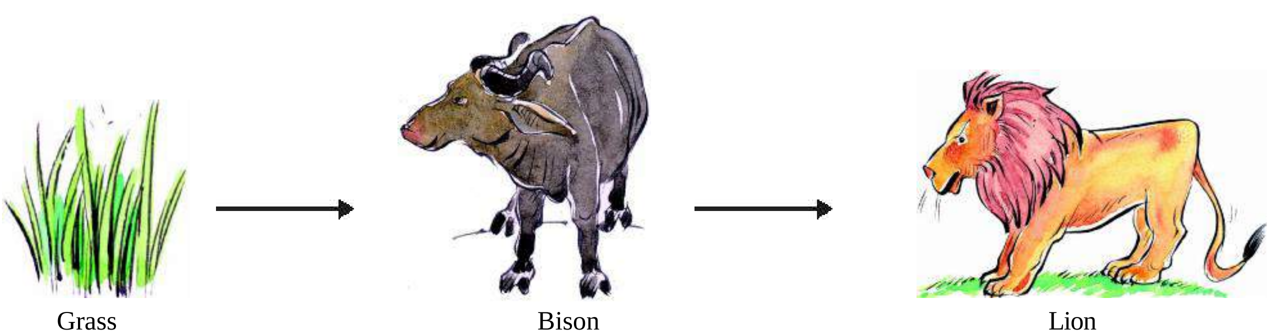


Figure number-3 : Food Chain

- Make a food web including several organisms along with grass, bison and lion.
- What would be the impact on this food web if the bison becomes extinct?
- Draw two food chains including yourself and state the interrelation between them.

Trophic Level

There are organisms in the food chain that are capable of producing food by the process of photosynthesis. These are called as "producers". There are others that depend on these producers (mainly plants) and other organisms for their food. These are the consumers, like the bison and the lion in this food chain. Here the bison is the primary consumer and the lion the secondary. . There can be other consumers in this chain as well, ending with organisms that would feed on dead and decaying matter, helping in their decomposition. These are the 'decomposers'. They break down complex organic matter to simpler ones which are required in nature.

The food chain may thus be written as -

Grass	⇨	Bison	⇨	Lion	⇨	Decomposers
(producers)		(primary consumers)		(secondary consumers)		

*decomposers could be at any level of the food chain depending on what they decompose

Each level of the food chain here is known as a trophic level.

- Make a food chain including organisms of Kotumsar caves

Do you know?

During floods, the caves of Kotumsar are flooded with micro producers and consumers, plant parts, etc. Then the kanimachri feeds on these micro plants and animals. The fish of this cave otherwise feeds on the remains of dead organisms present here (detritus). As the food chain starts with dead and decaying matter rather than producers, it is called as detritus food chain.

Dead organisms and their remains → kanimachri → bat

17.2.2 Interrelationship between Biotic and Abiotic Components

The flow of energy and nutrients appears to be linear while observing a food chain. However, nutrients flow in nearly circular pathways (representing their reuse or conversion into other forms).

Here we come across the biotic components like grass, cow, man, microorganisms and abiotic components such as sunlight, fuel, soil, decomposed substances, etc. The arrows in the diagram denote the direction of nutrient flow as well as the relationship of the components.

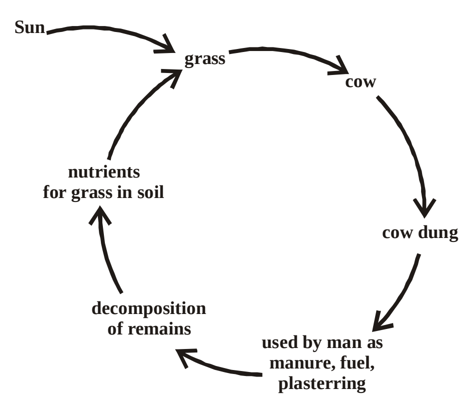


Fig. 4 : A cycle of nutrient flow

17.3 Diversity in Habitat

So far we have discussed the habitat of kani machri, let us now discuss the habitats of some other organisms.

Activity-2

You may have observed some plants that commonly grow in your area. The tendu (ebony), mahua, mango, jamun, babool, neem, ashok, etc. are some examples.

Choose any such plant and collect the following information regarding the same -

- Where did you see the plants of the species that you chose?

  (in the forest/in a field/on hills/near a river/far from a water body/ any other place)
- Write a description on the various elements such as the soil, temperature, water, etc. of the place where these plants grow..
- Write about some needs of the plant like how its pollens, seeds and fruits are dispersed etc. Your description can also include organisms that feed on the fruits of the plant.
- Could you now find out the habitat of the plant chosen by you?
- Try to draw a diagram of the plant.
- Make a list of some organisms from your surroundings that you see in larger numbers as compared to others.

Do you know?

Our intestine is a habitat for some micro organisms. We would not have been able to digest our food without their help. The removal of there micro organisms from our intestine would affect their survival and our health.

17.4 Changing Habitats in a Life Span

Now we shall discuss about an organism that inhabits different places during its life.

Brahmi duck is one such bird commonly known by other names like, Chakwa - Chakwi, Surkhaab, etc. It is not only found in India, but other Asian countries, Africa and Europe. In India, it is usually found during the summer months in the Himalayan regions of Laddakh, Sikkim and Arunachal Pradesh. This is where it breeds. During winter, the Brahmi duck leaves these colder regions of our country and other countries and is usually seen in the warmer regions of Central and Southern India. During this time the brahmi duck is also seen in Chhattisgarh. These birds thus change habitats with changing seasons.The change of habitat in the lifespan of an organism as it travels from one habitat to another in a year is called as "migration". After a certain period of time, the organism returns to its previous habitat (often called as the "permanent habitat").

Fig. 5 : Brahmi Duck

The breeding grounds of Brahmi duck are usually near rivers, marshy areas, grasslands, fresh or saltwater lakes located up to around 5000meters above sea level. A secure shelter to lay eggs and more nutrition is required during the period of reproduction. The duck gets these favorable conditions in the Himalayan areas. Grass, cereals and other seeds, prawns, frogs, insects, etc. of this area are its food. As the food resources deplete with the onset of colder months, the Brahmi duck sets out to other areas rich in food resources. Group consists both of older and younger ducks.

- What is the habitat of a brahmi duck?
- Can brahmi duck be considered as a migratory organism? Why?

17.5 Adaptation to a Habitat

How are organisms adapted to their habitat?

We observe that organisms living and reproducing in a particular habitat have certain characters favorable for their survival. This is adaptation and there are several examples of it. For example fishes living in underground caves are often blind (just like the kani machri). A research done on such a fish, "the Mexican Tetra" has revealed several facts about the adaptation of the fish to its habitat. One of the facts is that the changes in salinity (kharepan) of the waters of the resource have an effect on the size of their eyes. The detailed account of the research has been given in Annexure to this chapter.

Fig. 6 : Mexican Tetra

We have studied so far that all living populations inhabit a habitat that fulfills its basic needs of nutrition, reproduction and shelter. An organism in a habitat is dependent on other organisms and also the non- living components there. A change in the environmental conditions would cause a change in the life style of the organism. Presently, we are changing our environment at a very fast pace which is not only affecting us but also the other organisms coexisting with us. Some of these changes are causes of serious problems faced by the earth.

Keywords

Habitat, migration, biotic component, abiotic component, interrelationship, food chain, food web, trophic level, producer, consumer, decomposer, scavenger

What we have learnt

- The basic needs of any organism are- food, shelter and reproduction.
- Habitat is that area for an organism that fulfills all its basic needs during its lifetime.
- There are several organisms that lead their life in different places and their habitats include different environments.

- There are some organisms that are migratory in nature, i.e., they spend some months of a year in an area and others in another.
- An organism adapted to a habitat will successfully survive and reproduce there.
- A food chain shows the relationship of an organism and its food, representing the flow of energy. It is a sequence of eating and being eaten that starts from producers and proceeds to the final consumers. The ultimate source of energy is the sun (producers as we know fix solar energy).
- Producers, consumers and decomposers are the different trophic levels of a food chain.
- Organisms also have a relationship with abiotic components of a habitat.

Exercise

1. Choose the correct option

   (i) We find kani machri, insects, snails, millipedes, remains of dead organisms and bats in Kotumsar caves. A correct food chain based on this information would be -

   (a) bats - millipede - kanimachri

   (b) remains of dead organisms - kanimachri - bats

   (c) bats - remains of dead organisms - kanimachri

   (d) insects - bats - snails

   (ii) Migratory organisms-

   (a) Lead their life in one place

   (b) Live in a new place every year

   (c) Live a few months in a year in one place and others in another place regularly.

   (d) They change their habitat once in their lifetime but do not return to their permanent habitat.

   (iii) We usually find the following at the first trophic level-

   (a) Producers (b) Primary consumers

   (c) Decomposers (d) Secondary consumers

2. Explain the biotic and abiotic components of the habitat of an organism of your choice.
3. Write an essay on: "what will happen if you reach such an island where there are no biotic components other than you?"

4. If humans were sent to the moon to live there - what all would have to be sent along with them? Make a list of all such things.
5. Make a food chain including a bear. Connect this with other food chains to form a food web.

Annexure

A group of American researchers carried out a study on a cave dwelling fish named "Mexican Tetra". How the fishes may have reached the cave? They speculated that during floods the ancestors of the fish may have entered the cave waters. This is how they may have been exposed to a new environment inside the cave.

First of all, the researchers tried to find out the difference in temperature, pH, dissolved oxygen, salinity, etc. of cave waters and that outside the cave. They found that salinity differed most. The cave waters were less saline as compared to that outside.

The researchers created cave water like conditions in the lab and grew embryos of the Mexican tetra which were not cave dwellers and found a lot of variation in the size of the eye of the fishes grown in cave like conditions. Some fishes had large eyes, while some had very small. There were several intermediate types as well. When the fishes with small eyes were breed, their young ones also had small eyes. It was not that variation did not exist before in the population that were not cave dwellers. It was just that the new environment of the cave may have increased it.

Chapter 18

Waste and its Management

18.1 Notion of Waste

We generate different types of wastes in our daily activities. What could these wastes be? You are given a table below, draw the same in your copy and extend it. if required.

Table 1

S.No.	Wastes generated at home
1.	Vegetable and fruit peels
2.	Plastic
3.	
4.	
5.	

Look at your list carefully.

- Select those things of your list that you can reuse.
- Also select those that others may reuse.

While doing this exercise you may have noticed that the things not useful for us can be of use for others.Take for example, old newspapers that are wastes for us, are raw materials for paper mills. Similarly, plastic and cardboards that we throw away are a source of earning for people who collect wastes.Thus the notion of wastes is directly related to whether something is useful or not.

Fig. 1 : sorting wastes

18.2 What waste and how much?

Let us find out how much waste we generate in a day.

Activity-1

Take a medium sized bucket. Collect most of the wastes generated at home. This is the quantity of waste generated by your family,per day. Now, you may make an estimate of the amount of waste generated by all the people in your locality, colony/city/village.

- Imagine what would happen if this amount of waste generated daily accumulates at a place?
- What are the different problems that would arise out of this?
- How would we resolve problems arising out of this waste or do away with the waste itself?

You may have observed that most of your household waste is composed of vegetable or fruit peels or any leftover food material.

- Do such types of wastes remain as such for a long period of time?

You must have noticed that these kinds of materials usually rot quickly. The process of rotting is mediated by microorganisms. Microorganisms convert complex organic molecules to simple ones. This process of conversion of complex organic molecules to simple ones mediated by microorganisms is called as decomposition. Wastes that can be decomposed in this manner are called biodegradable.

We also have several such materials in our household waste that do not rot or decompose even if left as such in nature for a long time. Take for example, materials made of plastic, metals, glass and electronic devices. Thus materials which are not decomposed by microorganisms are called non-biodegradable wastes.

- What do you think happens to such wastes?

Usually we either throw away such wastes or sell them to people who collect waste.

So far we have discussed about wastes generated at home. There are places other than our homes from where wastes are generated in large amounts daily. These are industrial centers, hospitals and other government or private organizations.

- The person who collects wastes, takes away wastes from our homes but what do you think happens to wastes generated from such organizations?
- What do you think the people who collect waste do with the waste they collect from our homes?

Fig. 2 : Pile of wastes

18.3 Waste Management

18.3.1 By composting

Wastes generated at home contain nearly 50% or even more amount of biodegradable wastes. Why not start managing such wastes at home itself? If we have a space around our homes, we could convert such wastes to useful manure. All we have to do is dig a small shallow hole where we may collect our kitchen wastes for some time. Then cover this hole with a layer of soil and leave the wastes to rot. Ensure to turn the wastes over every 2-3 days. This would turn to manure, called compost, due to the action of organisms. This could take from one month to some years depending upon the type and amount of waste.This type of manure increases water retention in soil and adds nutrients like nitrogen, phosphorus, potassium to the soil enabling proper growth of plants. Earthworms may also be used to convert leaves, rotten fruits and vegetables peels as well as other waste food materials to compost.

Do you know?

Composting with the help of earthworms - A shaded area is chosen for this and the following three layers are laid.

First layer from bottom - Nearly 15cm thick layer of soil

Second layer - Nearly 10cm thick layer of chopped grass

Third layer - Nearly 15cm thick layer of cow dung

Water is sprinkled regularly on this and a good breed of earthworms are added and allowed to grow. As the earthworms pass to the lower layers, the pile is covered with gunny bags which are kept wet by sprinkling water at regular intervals. After around 15 days this mixture is spread out over a larger area. Biodegradable wastes are now added and mixed with this. The area is covered by gunny bags once again and water is sprinkled for another 20 to 30 days. The process of producing compost with the help of earthworms is called vermicomposting.

- Can all wastes generated at home be converted to compost? Why, why not?

18.4 Efforts made towards waste management

18.4.1 Waste management in a city

Surat is one of the cleanest cities of India now. It is located in the state of Gujarat. Plague spread in this city in the year 1994. The disease caused by a bacterium spreads mainly through rats and rat fleas which are vectors of the disease. Rats and fleas multiplied in great numbers due to filthy conditions in the city. Widespread contamination of food, air etc. helped the disease to spread even faster and the whole city was affected by the epidemic. People put the whole blame of this on the Municipal Corporation. It was said that filthy conditions in the city had caused the epidemic to spread at a fast pace. The municipal corporation accepted this and made working plans for cleaning the city and disposing off wastes. The city was divided into 6 zones and a commissioner was appointed for each of these. The department of solid waste disposal in each of these zones issued cards to the citizens. These citizens wrote their grievances and gave it to the department which took action of waste collection and disposal within 24 hours. The card was returned after due action was taken in the area. There was also a provision to levy a fine on people who spread dirt and filth. These actions helped to clean the city within just a period of 18 months.

18.4.2 Waste management in a locality

Three women of a small town named Domloor of Karnataka started a different kind of campaign for waste management. They started a door to door campaign ensuring that people classified and segregated wet and dry wastes at home. Wet wastes were given away to the people who collected wastes from homes, to be carried away for further treatment. The dry waste was further segregated once every week with the help of other members of the community into different classes and passed over to the respective recycling units. People involved in the campaign say that previously wastes were dumped in an area but now most of the wastes are disposed off from the area. All that remains in the area are mostly biodegradable.

18.4.3 Waste management initiated by an individual

Problem of waste management does not end in just cleaning up an area and dumping wastes elsewhere. It is related to several other aspects. In a proper system of waste management solutions to several problems are present. A proof of this has been laid down by Srinivas from Vellore district of Tamil Nadu. After graduating in mathematics, Srinivas was looking for a job. That was exactly when he noticed the increasing amount of waste in his locality, increase in wasteland and unemployment. He acquired an area near the old bus stand in his locality that was now a dump yard from the panchayat and district administration. Srinivas started categorizing wastes into 18-20 categories. Paper, cardboard, iron, aluminum, plastic etc. were sorted out and sold to the waste collectors. Rest of the waste that would largely decompose was also sorted out into groups. He started keeping animals and fed most of the waste that could be eaten by them.

A solution to disposal of waste this also provided rich manure in the form of dung. A part of this dung was used to produce fuel with the help of a gobar gas plant. Some of it was used directly as manure and the rest was mixed with the portion that animals did not eat and was converted to vermicompost using earthworms.

Those wastes that still remained unused were openly left to rot. Seeing the possibility that this could give rise to increase in population of flea, mosquito or other organisms, he took the help of hens, frogs, lizards etc. Water generated in all the processes that he carried out was passed into a small pond where he introduced fishes and ducks. He aerated the water of the pond and used it to irrigate croplands.

Dung cakes (upley) were also made and the ashes of them mixed with lemon and orange peels were used to produce soap.

Egg shells were ground to be used as fertilizer as they mainly contain calcium carbonate. Even bones were grinded and used in the same manner. Hair sorted out from waste was sold away to buyers.

According to the mentioned processes, Srinivas not only managed to recycle wastes and make the city of Vellore clean, his process has successfully eliminated wastes from 40 villages across 4 districts of the state. It is expected to spread to another 6 districts of the state soon.

- Among the mentioned efforts, which one did you like most? Why?
- What can you do to manage waste in your locality based on the given examples?

18.4.4 Waste Management - Our Initiatives

We have observed how waste can be managed in different ways after collection. If we could make an effort such that waste does not collect in large amounts, then it would be more helpful to address the problem of waste disposal.

- Can we make an attempt to reduce production of waste?

Come let us make a list of such materials that we throw away by using them just once while we could have used such materials in their place that could be used over and over again.

Table 2

S.No.	Materials that can be used once	Materials that can be used several times
1.	Plastic cup	Steel or glass cups

By following the alternatives suggested in the table, you could take a meaningful initiative towards waste management.

4 R's towards waste management

- Reduce - Reduce amount of waste production at its source. As for example ensure to use every page of your copy in writing, use your textbook with care and hand it over to your juniors in the forthcoming year.
- Refuse - As for example refuse to use plastic bags
- Reuse - As for example reuse plastic or glass bottles over again for different purposes.
- Recycle -Use vegetable and fruit peels as a feed for animals like cow, goat etc.

By using the 4 R's we can effectively contribute in reducing waste such that less amount of waste may go to landfills. Pollution of our environment and ground water resources can be reduced in this manner.

What we have learnt

- Waste is defined according to whether the material is useful or not.
- Categorizing wastes helps in its disposal.
- Those wastes that can be degraded by living organisms are called biodegradable and those that aren't are called non- biodegradable.
- Most of waste generated at home are biodegradable
- Some of the waste generated at home can be recycled
- Waste management at home is essential
- Manure produced by composting is very useful for agriculture
- We must mainly use 4 R's to deal with the problem due to generation of wastes-

  R- reduce, R- refuse, R- recycle, R- reuse

Keywords

Biodegradable, non-biodegradable, compost/bio fertilizer, decomposition

Exercise

1. Choose the correct option -

   (i) Which is the best level of sorting out wastes among the following?

   (a) At source (b) At community collection area

   (c) At landfill (d) sorting out not required

   (ii) Which substances can be decomposed easily using microorganisms?

   (a) Substances made of metal (b) biodegradable substances

   (c) electronic substances (d) Plastics

   (iii) Organism helpful for composting is

   (a) Earthworm (b) frog

   (c) lizard (d) hen

2. What is waste?
3. Write a note on the process of decomposition.
4. Why should sorting out of waste be done at the source itself?
5. Write about at least 3 problems that will arise due to collection of waste at an area.
6. Define recycling of wastes and write about its advantages.
7. What are the substances needed to prepare compost?
8. What all did you learn about the ways of waste management from the example of Srinivas from Vellore?

Answer key

Chapter 1.		Biodiversity and Classification			
1.	(i) b	(ii) d	(iii) d		
2.	(i) Peptidoglycin		(ii) Monera	(iii) R.N. Whitaker	

Chapter 2.		Matter : Nature and Behaviour			
1.	(i) b	(ii) b	(iii) a	(iv) b	
	(v) b	(vi) d			
4.	(i) Same type	(ii) Tyndall effect		(iii) Solute	(iv) Suspension
	(v) Solution				

Chapter 3.		Atomic Structure	
1.	(i) c	(ii) b	(iii) c
2.	(i) Same	(ii) Electron	(iii) Isobars

Chapter 4.		Motion			
1.	(i) b	(ii) a	(iii) b	(iv) d	
2.	(i) Zero	(ii) displacement		(iii) 20 m/s	(iv) Zero

Chapter 5.		Force and Laws of Motion			
1.	(i) c	(ii) c	(iii) d	(iv) c	
2.	(i) External force		(ii) Zero	(iii) Inertia	(iv) Double
	(v) Vector				

Chapter 6.		Fundamental Unit of Life : Cell		
1.	(i) a	(ii) a	(iii) d	(iv) a
	(v) b			

Chapter 7. Multicelluar Structure : Tissue

1. (i) b (ii) c (iii) d
2. (i) Transport/xylem (ii) Epithilial (iii) Muscular and connective

Chapter 8. Chemical Bonding

1. (i) b (ii) b (iii) c (iv) c
   (v) b
2. (i) Loses, neon (ii) Three (iii) 8, 2 (iv) Covalent, electrovalent
   (v) Soluble, insoluble

Chapter 9. Chemical Formula and Mole Concept

1. (i) a (ii) a (iii) c (iv) a
   (v) b
2. (i) Ionic (ii) 342 (iii) 2 (iv) 6.022×10^{23}
   (v) 18
3. (i) 6.022×10^{23} (ii) SO_4^{2-} (iii) Mg^{2+} (iv) 14 g
   (v) 2 moles

Chapter 10. Chemical Reactions and Equations

1. (i) c (ii) c (iii) b (iv) d
2. (i) Reactants, products (ii) Decomposition (iii) Direction (iv) Endothermic

Chapter 11. Gravitation

1. (i) c (ii) c (iii) a (iv) a
   (v) a
2. (i) 98 N (ii) $v^2 = 2gh$ (iii) $6.67 \times 10^{-11} Nm^2/kg^2$ (iv) m/s^2
   (v) Same (if friction due to air is negligible)

Chapter 12. Work and Energy

1.	(i) b	(ii) a	(iii) d	(iv) b
2.	(i) Joules	(ii) 36×10^5 J	(iii) Constant	(iv) Negative
	(v) ½ mgh			

Chapter 13. Our Health

1.	(i) d	(ii) a	(iii) d

Chapter 14. Sound

1.	(i) b	(ii) b	(iii) d	(iv) b	
	(v) d	(vi) b			
2.	(i) 20Hz to 20 kHz		(ii) Metre	(iii) Wave length	(iv) Medium

Chapter 15. Hydrocarbons

1.	(i) Alkane	(ii) Catenation	(iii) Isomers	(iv) Chain isomers
	(v) Position isomerism		(vi) Homologous series	
2.	(i) Position	(ii) More	(iii) Three	(iv) Eight
	(v) Alkane			

Chapter 16. Coal, Petroleum and Petrochemicals

1.	(i) c	(ii) d	(iii) d	(iv) 3	
2.	(i) Fossil	(ii) Peat, Anthracite		(iii) Peat	(iv) Boiling
	(v) Petra, oleum				

Chapter 17. Habitat

1.	(i) b	(ii) c	(iii) a

Chapter 18. Waste and its Management

1.	(i) a	(ii) b	(iii) a

Scheme of Practical Examination

(Class–9)

Time : 3 hrs. **Total marks : 25**

1.	Any three experiments (One experiment each from biology, chemistry, physics)	15 marks (5+5+5)
2.	Oral questions related to experiment (Viva-voce)	02 marks
3.	Practical records	03 marks
4.	Project (done during the session)	05 marks
	Total	25 marks

Distribution of marks for Biology

1.	List of materials required	01 mark
2.	Method and labeled diagram	02 marks
3.	Presentation	01 mark
4.	Result, precautions	01 mark
	Total	05 marks

Distribution of marks for Physics and Chemistry

1.	List of materials required	01 mark
2.	Theory and formula, labeled diagram	01 mark
3.	Observation, calculation	02 mark
4.	Result, precautions	01 mark
	Total	05 marks

Practical Work

Biology

S.No.	Title
1.	Observing cells in a leaf peel.
2.	Observing human cheek cells.
3.	Observing the arrangement of cells in the longitudinal and transverse section of the plant stem and correlating it to function.
4.	Observing plant parenchyma tissue.

Chemistry

S.No.	Title
1.	Preparation of colloids of starch/gum/milk and testing the formation of colloid using Tyndall effect.
2.	Studying displacement reactions using an aqueous solution of copper sulphate and iron metal (iron nail/ awlpin).
3.	Studying double displacement reaction using the example of reaction between sodium sulphate and barium chloride.
4.	Studying exothermic and combination reactions using the example of reaction between anhydrous lime (CaO) and water.

Physics

S.No.	Title
1.	Using vernier caliper to measure the length/internal and external diameter/depth of a hollow cylinder.
2.	Using a screw guage to determine the diameter of a wire.
3.	Using a simple pendulum to determine the relationship of time period(T) to the length(L) of pendulum and drawing a L vs T2 graph.
4.	Studying the type of motion by drawing position-time graph using asset of given values related to motion.

Practical Work

Biology

Practical Work (Fundamental Unit of Life : Cell)

Objective : Observing cells of the leaf

Materials Required : leaf Rheo/Bryophyllum/etc. slide, cover slip, red ink, microscope.

Method : Take a Rheo leaf. Tear it in a stroke. See the torn portions against light. You would find a violet translucent layer. Take a small portion of this on a drop of water on a slide. Gently cover this with a cover slip(see to it that no bubbles remain add a few more drops of water for this).

Observe this under low magnification first to locate the material try to make a sketch of this, then increase the magnification to observe the cells clearly (try to draw this as well).

Questions :

1. What were the new things that you could see under higher magnification? Does it match with the figure given in your textbook in the chapter on cell(see the chapter to compare).
2. Label the sketch made by you with the help of figure-2 of chapter, "Fundamental Unit of Life: Cell"
3. Write about the structures and arrangement of cells as you observe them under the microscope. You could keep in mind the following points while making your note - shape of the cells, presence or absence of intercellular space, presence or absence of chloroplast, other structures.

Instruction : You could do this experiment with other leaves as well, a thick fleshy leaf will help you to get a better layer of peel.

You may stain the material with ink, alta, safranin etc.

Precautions :

1. Bubbles should not be there in you slide.
2. Wash out excess stain if you stain your sample.

Practical Work (Fundamental Unit of Life : Cell)

Objective : Observe cheek cells.

Materials Required : Slide, cover slip, ice- cream spoon, redink/alta/safranin, microscope.

Method : Use an ice-cream spoon to gently scrape off a layer (inside your mouth) from the inner walls of your cheek. Do not scrape too hard. Spread the scrapings in a drop of water on a slide. Use a few drops of dilute red or blue ink, safranin or alta to stain the scrapings. Observe the slide under a microscope. Try to draw a sketch of what you see. Label it with the help of figure-3 of the

Question : Make a note of the similarities and differences between cheek cells and cells in the leaf peel.

Practical Work (Multicellular Structure: Tissue)

Objective : To observe the arrangement of cells in the transverse section and longitudinal sections of stem of a plant and try to relate it to function.

Materials Required : A plant with soft stem(moneyplant/ small periwinkle/ marigold), a glass, red ink, blade, handlens

Method : Take two stems/stalks of the selected plant (nearly 5-6 inch in length). Small rooted plants would also be a good sample. Observe the transverse and longitudinal section of any one of the stems/stalks. Observe the arrangement of cells in these sections and make a note of it. You may use a hand lens or a microscope for your observations. You may take the help of figure-1a and b of Chapter-7 "Multicellular Structure:Tissue" for this.

Now fill upto 2/3rd of the glass with water. Mix red ink such that the water becomes deep red. Now keep the other stem/stalk in this and leave the set up in the sun for around 2 hours. Take this stalk out of the water and observe its longitudinal and transverse section once again. Compare your observations of sections of both the stems and write the differences that you observe.

Take care to observe the veins and edges of the leaves of the plant kept in red water. Do you find red colour in these areas as well? See if the base of the leaf also has the colour.

Question: What do you think is the pathway of water from the base of the stem to the tip of the leaf? Make a sketch to show the same.

Practical Work (Multicellular Structure: Tissue)

Objective : Observing the plant tissue: parenchyma.

Materials Required : Banana, petri-dish/watch glass/ any bowl, iodine solution, slide, coverslip, microscope

Method : take a small portion of banana pulp in a watch glass and spread it out in a thin layer with a needle. Take a small portion of this on a drop of water on a slide. Spread it out in a thin layer. Add a few drops of iodine to this and cover it with a coverslip. No air bubbles should remain under the coverslip. Now observe this under the microscope and try to make a sketch of this. You may take the help of Activity-6 of Chapter 7 "Multicellular Structures: Tissue" for this.

Precautions :

1. If there are extra drops of iodine, wash it off using water.
2. Observe your slide under both low and high magnification of your microscope.

Chemistry

Practical Work (Matter : Nature and Behaviour)

Objective : Prepare colloids of starch/glue/milk and check colloid formation by Tyndall effect.

Matrials Required : Beaker (250 mL), test tubes, glass rod, burner, tripod stand, wire gauze, droppers, laser light, starch powder/glue/milk and water.

Theory : The solute particles in a colloid are so small that we cannot see them through naked eyes. These particles do not settle at the bottom of the vessel and we cannot even filter them. The particles of a colloide have a tendency to disperse light rays due to which we can see the path of light rays. This effect is known as Tyndall effect. This effect is not shown by a solution.

Procedure : Fill a test tube with water upto half level. Mix about 0.5 g starch powder in the test tube and form a paste. Take 100 ml water in another beaker and boil it. Add 2-4 drops of the paste from the test tube into the beaker, slowly, and stir it using a glass rod. Boil this mixture for 5 minutes and then allow it to cool down slowly.

Shine a laser torch being on the mixture made by this method. Observe the Tyndall effect from a direction perpendicular to the direction of light rays and conclude whether the prepared mixture is a colloid.

Conclusion : Write down the nature of the prepared mixture and give reasons for your conclusion.

Precautions :

1. Test tubes should be clean.
2. While mixing the paste into water, keep strring the mixture continuously with a glass rod.

3. The colloid must be allowed to cool down slowly.
4. The Tyndall effect should be seem from a direction perpendicular to the direction of light rays.

Preparing a colloid of glue :

To form a colloid of glue, grind the solid glue. After this, take 100 ml of water in a beaker and mix 2 g of glue powder into it. Keep stirring it with a glass rod. Warm it once or twice. After the mixture has cooled, shine a light beam on it using a laser torch. Observe Tyndall effect.

Note : Instead of using solid glue, you can also use 15-20 drop of liquid glue.

Precautions: Along with the precautions mentioned above, follow the given measures as well.

1. Use glue powder solid or liquid glue.
2. Warm the colloid lightly and then allow it to cool down. Only then observe Tyndall effect.

Preparing a colloid of milk :

To prepare a colloid of milk, take 100 ml water in a beaker and add 3-4 drops of milk to it. Stir it with a glass rod. Use a laser torch and observe the Tyndall effect.

Practical work (Chemical Reactions and Equations)

Objective : To study displacement reactions using aqueous solution of copper sulphate and iron (iron nail, awlpin).

Materials Required : Test tubes, 3 iron nails or allpins, sandpaper, thread, test tube stand, copper sulphate, water.

Theory : A reaction in which one element displaces another element from the aqueous solution of its compound is called displacement reaction.

$$Fe(s) + CuSO_4(aq) \rightarrow FeSO_4(aq) + Cu(s)$$

In the reaction, iron displaces copper from the aqueous solution of copper sulphate and takes its place, therefore it is a displacement reaction.

Procedure : Take 3 nails of iron or 3 awlpins and clean them using sandpaper. Now mark the test tubes as A and B. Take 10 ml copper sulphate solution in both the test tubes. Tie 2 nails carefully with a thread and drop them into the copper sulphate solution in test tube B and keep for atleast 30 minutes. For comparison, keep a separate nail outside the test tube. After 30 minutes, take out both the nails from the copper sulphate solution. Compare the colours of both the copper sulphate solution (in test tubes A and B). Also compare the colour of iron nail kept outside with the iron nail dropped in the copper sulphate solution. Note your observations in the following table.

Observation Table

S.No.		**Test tube A (nail taken for comparison)**	**Test tube B**		**Result**
			Before experiment	**After experiment**	
1.	Colour of copper sulphate solutoin				
2.	Colour of iron nail				

Result :

- A layer of which product and of which color got deposited in the nail?
- What change did occur to the color of copper sulphate solution and why?
- In this displacement reaction, which ion displaced what ion? Explain it with an equation.

Precautions :

- Test tubes should be clean.
- Nails should be cleaned using sandpaper, before the experiment.
- Nails should be kept totally dipped in copper sulphate solution.
- Copper sulphate solution should not be saturated or concentrated, otherwise the colour of solution will not change.

Practical work (Chemical Reaction and Equations)

Objective : To study double displacement reaction using the reaction between sodium sulphate and barium chloride.

Materials Required : Four test tubes, dropper, test tube stand, barium chloride, sodium sulphate, filter paper.

Theory : A reaction in which exchange of ions takes place between the reactants is called double displacement reaction.

Double displacement reaction takes place between sodium sulphate and barium chloride. Exchange of ions takes place between the ions of both the solutions. Following reaction ocurrs:

$$Na_2SO_4(aq) + BaCl_2(aq) \rightarrow 2NaCl\ (aq) + BaSO_4(s)$$

colourless colourless colourless white precipitate

Procedure : Prepare an aqueous solution of sodium sulphate and barium chloride in two separate test tubes. Fill a test tube ¼ with sodium sulphate solution and with the help of a dropper add few drops of barium chloride solution to it. Mix the solution continuously. Add barium chloride solution until you get a precipitate. Filter this precipitate and divide into three parts. Dissolve these in dilute HCl, dilute HNO_3 and dilute H_2SO_4 respectively. Note your observations in following table.

Observation Table

S.No.	Experiment	Observation	Result
1.	On adding few drops of barium chloride solution to sodium sulphate solution.		
2.	Adding more drops of barium chloride solution to sodium sulphate solution.		
3.	On dissolving white precipitate in dil. HCl, dil. HNO_3 and dil. H_2SO_4 respectively.		

Result :

1. Write down the name, colour and state of the product formed by the reaction between sodium sulphate and barium chloride solutions.
2. Write down the solubility of the white precipitate of barium chloride in dil. HCl, HNO_3 and H_2SO_4.
3. Explain double displacement reactions using equations.

Precautions :

1. Fill only ¼ part of test tube with sodium sulphate solution.
2. Continuously stir the solution while adding barium chloride solution.

Practical work (Chemical Reactions and Equations)

Objective : To understand combination reactions and exothermic reactions using the reaction between calcium oxide and water.

Materials required : Test tubes, 250 ml beakers (borosil), dropper, dry calcium oxide.

Theory : A reaction in which 2 or more than 2 reactants form a product is called combination reaction. A reaction in which heat is produced during product formation is called an exothermic reaction.

Procedure : Take a clean and dry 250 mL beaker and add 5 g of calcium oxide powder to it. Touch the beaker and note your observation. Take some water in a dropper and add 5 mL of water to beaker every minute. Observe the reaction and write down your observations. Repeat the procedure 5 times. Everytime, touch the beaker from outside and write your experience of temperature change in the following table. After half an hour, write the observation of the solution formed in the following table:

Observation Table

S.No.	Experiment	Observation	Result
1.	On adding 5 ml of water first time to calcium oxide.		
2.	On adding 5 ml of water every minute to calcium oxide.		
3.	On touching the beaker before the reaction.		
4.	On touching the beaker after reaction.		
5.	On observing the solution after half an hour.		

Result :

- On the basis of the reaction and the heat produced which type of reaction is this? Explain both the reactions.
- Described the above reaction with an equation.

Precautions :

1. Beaker should be clean. Always use borosil glass beaker for this experiment.
2. Add water carefully.
3. Do not touch calcium oxide with wet hands, you may get blisters. Always handle the pieces of calcium oxide using forceps.

Note : You can get calcium oxide in solid form in a shop selling paints. Always keep calcium oxide in a sealed glass container.

Important equipment used in the lab

Vernier Callipers

Normally we can measure upto 1 mm length by a meter scale. For measuring even smaller lengths a french scientist Pierre Vernier developed Vernier callipers.

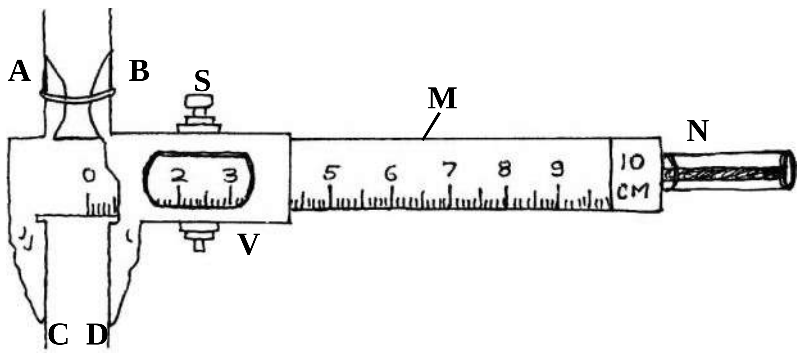


Fig. : Vernier Calliper

1. Construction- Vernier callipers has four main parts.

(i) Main scale- Vernier callipers is made up of steel whose one side has cm. or mm. scale and another is in inches. It is denoted by M in the figure.

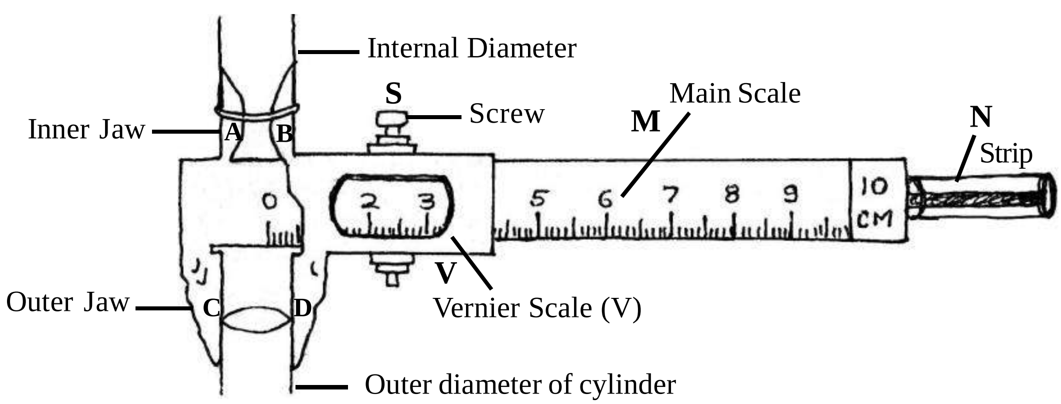


Fig. : Measuring diameter of a glass marble by using a pair of Vernier Callipers

(ii) Vernier Scale- This scale can be moved on main scale with the help of a screw and can be fixed on the main scale at any place to take reading. It is shown as V in the fig.

(iii) Jaws- Vernier callipers has two jaws. One is fixed as shown in figure PC and second jaw QD is fixed on vernier scale (frame). Outer jaws or lower side are used to find out the length or outer radius of any objcet (Rod and Cylinder) and upper jaws (internal) are used to find out internal radius of hollow cylindrical objects. With the help of strip N, depth of any part can be measured.

(iv) **Screw-** Jaws QD can be moved in any direction with the help of screw 'S'.

2. Principle-

The smallest quantity which an instrument can mearuse is called its least count. Therefore the difference between the length of 1 division of main scale and the length of 1 division vernier scale is called Vernier Constant or Least Count. It is the smallest length that can be accurately measured by this instrument.

The value of 1 division of main scale is 'S' unit and value of 1 division of vernier is 'V' unit. Suppose the value of "n" parts or divisions of vernier scale is equal to (n–1) of main scale.

$$(n-1)s = nv$$
$$ns - s = nv$$
$$ns - nv = s$$
$$n(s-v) = s$$
$$s - v = s/n$$

$$\text{Least count} = \frac{\text{Value of division of main scale}}{\text{Total no. of divisions of vernier scale}}$$

This is called vernier constant or least count. Total reading of vernier scale is obtained by multiplying least count with total no. of vernier scale. Total no. of vernier scale will be equal to its total no. of main scale and total no. of vernier scale.

If the value of 1 division of main scale S = 1 mm and total number of divisions of vernier scane n = 10, then least count of vernier callipers will be s/n = 1/10 = 0.1 mm = 0.01 cm.

If the length PQ of any object is to be measured by vernier callipers then the said object must be fixed in between the jaws. Now take the reading of vernier scale as following.

So the length PQ of the object is =

Reading of main scale + value of 5^{th} division of V scale x least count.

$$= 1.2 \text{ cm} + 5 \times 0.01 \text{ cm.}$$
$$= 1.2 \text{ cm} + 0.05 \text{ cm.}$$
$$= 1.25 \text{ cm.}$$

Thus the length PQ of given object is 1.25 cm.

3. Zero error

On coinciding both the jaws of Vernier callipers, the zero of vernier scale and main scale do not meet with each other then their error is called 'Zero Error' of instrument. It is of two kinds :

(i) Positive zero error.

(ii) Negative Zero error.

(i) Positive Zero Error

On coinciding both the jaws, if the zero of vernier scale lies on the right side of the zero of main scale, then the error is called Positive zero Error. To find values of zero error, we observe which division of vernier scale coincides with which division of main scale. This value of division of Vernier scale is multiplied with least-count and then it is subtracted from total reading along with its sign.

True Reading = Total Reading - (Zero error)

Positive Zero Error = 6 × 0.01 cm.

= 0.06 cm.

If Total Reading is 1.25 cm. Then

True Reading = 1.25 – (+0.06)

= 1.19 cm.

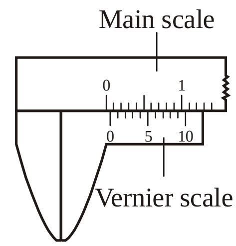


Fig. Positive Zero Error

(ii) Negative Zero Error

On coinciding both the jaws, if the zero of vernier scale lies on the left side of the zero of main scale, then the error is called Negative Zero Error. It is calculated same like positive zero error and the value is subtracted from the previous reading to get the true reading.

True Reading = Total Reading – (Zero Error)

Negative Zero Error = 7 × 0.01

= 0.07 cm

If reading is 1.25 cm then

True Reading = 1.25 – (–0.07)

= 1.18 cm.

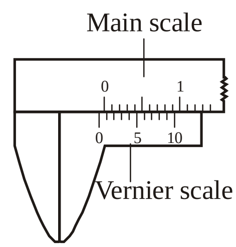


Fig. Negative Zero Error

4. Reading of Vernier Scale

For reading of vernier first we check what is the reading on main scale before zero of Vernier. Then we check which division of vernier matches with which division of main scale. The division of vernier, which matches with division of main scale, is then multiplied with least count of vernier and we get vernier reading. In the given fig. (a) zero of main and vernier scale both are matching and 10 division of vernier is equal to 9 divisions of main scale. Then by above mentioned method least count 0.1 mm or 0.01 cm. is measured in fig. Zero of vernier is nearest to 4 mm division of main scale and 4th division of vernier scale is matching with same division of main scale. So difference is equal to 4 divisions only.

Fig.

Difference for 1 division = 0.1 mm.

For 4 divisions = 0.1 × 4 = 0.4 mm.

Total reading = Reading on main scale + Reading on Vernier scale.

= 4 mm + 0.4 mm = 4.4 mm.

In short, to measure a given length by vernier callipers, the following procedure should be adopted.

1. Least count of the vernier shold be calculated.
2. Value of a sub-division of main scale should be found out.
3. Zero error should be found out.
4. Main scale reading should be taken
5. Vernier scale reading should be taken.

5. Uses of Vernier Callipers

(i) Length, breadth and thickness of any object can be measured.

(ii) To find the internal and external diameter of a solid or hollow vessel.

(iii) To find the depth of a hollow vessel.

Screw Gauge

We know that with vernier callipers we can measure up to 0.01 cm or 0.1 mm acurately but sometimes we have to measure even smaller quantity like 0.001 cm or 0.01 mm. For this we use even micro measuring instrument than vernier, it is known as screw gauge. It is based on principle of micro-meter screw and with its help we can measure up to third decimal accuracy.

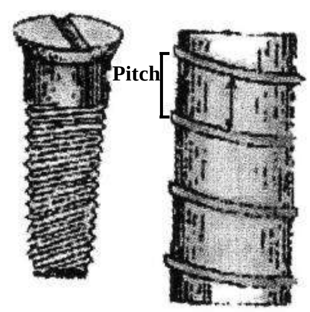


Fig. Ring interval

Principle of screw gauge

When a screw with uniform threads rotates clockwise through a nut, its tip moves forwards and backward in a straight line. This linear displacement is directly proportional to the circular displacement rotated by screw.

For one compete rotation of screw head the distance its screw tip covers is called pitch or thread internal of screw gauge. It is the distance between two threads of screw.

Least count- Suppose in one complete rotation of screw head distance travelled by screw tip is S. So pitch or thread-interval to screw gauge is S. If there are n number of division on circular scale of screw head then-

$$\text{Least count} = \frac{\text{Pitch or thread interval}}{\text{Number of divisions on circular scale of screw head}}$$

Normally thread interval in screw gauge is 1 mm and total number of divisions on circular scale is 100.

Least count of

Screw Gauge = 1/100 mm = 0.01 mm = 0.001 cm.

Construction of Screw Gauge

Screw gauge has mainly three parts-

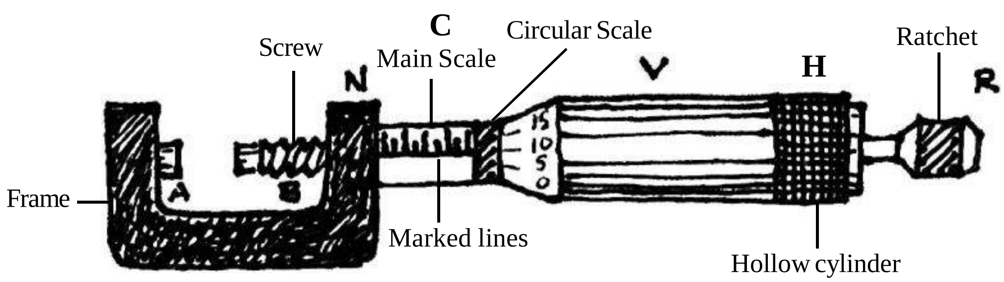
(i) U-shaped metal frame.

(ii) Screw and Main scale

(iii) Head Scale or circular scale.

i) U-shaped metal frame- In U- shaped metal frame, inside the extreme arm a fixed small metal block 'A' called stud. In other arm of the frame a threaded hole is present though which screw 'B' slides forward and backward.

(ii) Screw and Main scale- It is major part of this instrument. It is tubular hub denoted by 'C' in the fig. It is extends from the right side of the frame and has small division a of an mm or half millimeter.



(iii) Head Scale or circular scale- Screw can be moved forward and backward using a long screw head. It is like a circular head which is divided in 100 divisions in circular manner so it is called circular scale.

Modern screw gauges are provided with a ratchet 'R' to keep the scale tight.

Possible Errors- While using Screw Gauge following errors are possible-

(i) Backlash error (ii) Zero error

Backlash Error

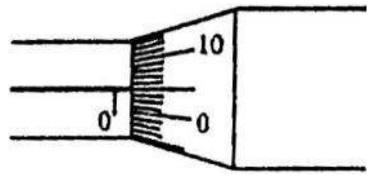
We know the principle of screw that the linear distance travelled by a screw, on moving forward and backward, is directly proportional to the rotation of the head. But due to continuous use of screw gauge, its threads are worn out due to friction and screw becomes loose in the nut and in such case if we move the screw forward suddenly, it goes backward and head scale rotates and screw tip does not move forward or backward. This error is called backlash error.

For removing this error screw should be moved in one direction only. If it is needed to move backward then it should be rotated backward more and again rotated forward.

Zero Error

When screw tip is moved up to stud and is touching it, and in this condition base line of the main scale does not match with Zero (O) of head scale then there is Zero error in the intrument. It is of two types-

(i) **Positive Zero error-** If zero of head scale is below the reference of main scale after touching the screw tip to stud then this error is known as positive zero error.



Positive Zero error

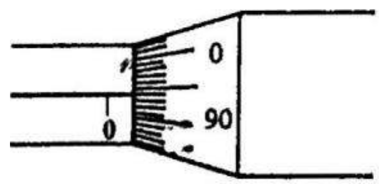
To determine the magnitude of zero error we check which division of head scale is exactly in front of reference line of main scale and number of this division is then multiplied with least count, the value so obtained is positive Zero error. This value is subtracted from observed reading. Positive zero error is shown in the fig. 4.8.

Suppose in front of reference line of main scale a higher division of circular scale comes then,

Positive zero error = n × least count

Where n = No. of divisions above zero.

(ii) **Negative Zero error-** When after touching the screw tip with stud. reference line of main scale is below the Zero of head scale then there is negative zero error in the screw gauge.



Negative Zero error

For determining value of this error we check how many number of divisions of head scale are below zero which matches the reference line of main scale. Then these number of divisions is multiplied with least count. The value so obtained is added to observed reading.

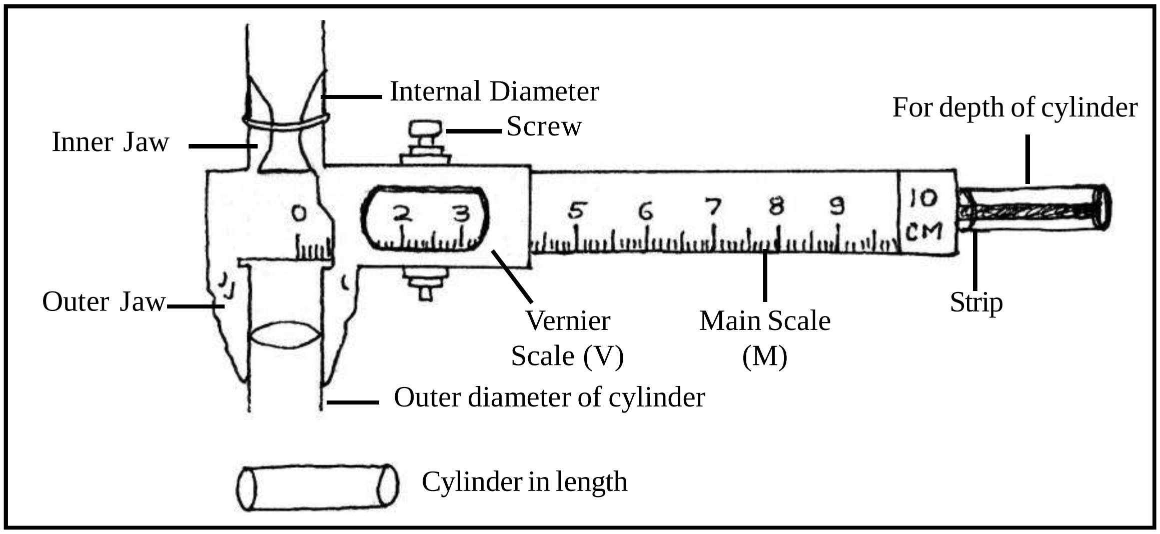
Physics

Practical Work (Measurement)

Objective : Measurement of length/internal or external diameter/depth of a hollow cylinder with the help of vernier callipers.

Materials Required : Vernier callipers, hollow cyliner.

labelled Diagram :



The oretical formula : Least count of vernier callipers (L.C.)

$$\text{Least Count} = \frac{\text{Magnitude of 1 division Main Scale}}{\text{Total no.of divisions in Vernier scale}}$$

Procedure : Procedure for measuring length/diameter/depth with the help of vernier callipers is same for all.

If cylinder is hollow then for its internal and external diameter measurement we take reading by fixing the cylinder as per fig. 3 and for measuring depth of cylinder it is kept as per fig. and correct reading is noted.

Observation tables for length/diameter/depth are similar. Here measurement of length of cylinder by vernier callipers is explained.

(i) First of all least count of vernier is calculated.

(ii) If apparatus has any zero error then its type and magnitude is measured.

(iii) Now given cylinder is put between jaws in such manner that its length should be parallel to main scale.

(iv) In this condition by tightening the scale, cylinder is taken out from both the jaws.

(v) Now take the reading on main scale which is ahead of the zero of vernier. This is main scale reading.

(vi) Them check which division of vernier matches with some division of main scale. This division of vernier is then multiplied with least count.

(vii) Sum of main scale reading and vernier scale reading will be the length of cylinder.

(viii) This exercise is done for few times and their average is taken.

(ix) From this average value zero error is subtracted along with sign. This is actual length of cylinder.

Observation Table :

Least count of apparatus = ... cm.

S.No.	**Reading of main scale (in cm.)**	**Reading of vernier scale**		**Total reading (in cm.)**
		No. of divisions	**No. of division × least count**	
1.	....	....	...............×.............=..........	....
2.	....	....	...............×.............=..........	....
3.	....	....	...............×.............=..........	....
4.	....	....	...............×.............=..........	....
5.	....	....	...............×.............=..........	....

Average Zero Error = ... cm.

Observation Table for Length of Cylinder

S.No.	Main Scale Reading	Vernier Scale Reading		Total Reading
	(in cm.)	No. of divisions	No. of division × least count	(in cm.)
1.	....	....	............×............=............	....
2.	....	....	............×............=............	....
3.	....	....	............×............=............	....
4.	....	....	............×............=............	....
5.	....	....	............×............=............	....

Actual length = observed length – (Zero error with actual sign)

Result : Actual length of cylinder .... cm. (similarly value of diameter or depth is also measured).

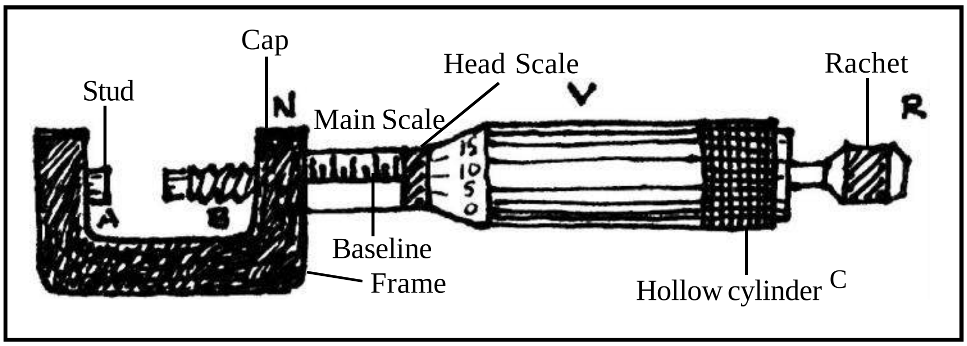
Precautions :
1. Cylinder must be properly tightened between jaws.
2. Reading should be taken from different positions of cylinder.
3. While taking a reading, eye should be perpendicular to the scale.
4. After calculating zero error it should be adjusted with main scale reading.

Practical Work (Measurement)

Objective : To measure diameter of wire with the help of screwgauge.

Materials Required : Screw gauge, wire etc.

labelled Diagram :



Theoretical Formula : $$\text{Least count} = \frac{\text{Thread Interval of screw gauge}}{\text{Total no. of divisions on circular scale}}$$

$$= \frac{0.1}{100}$$

$$= 0.001 \text{ cm.}$$

Procedure : Before using screw gauge for measuring diameter of wire we first calculate zero error. After this we find least count which is generally 0.001 cm.

Now experimental wire is tightened between screw and stud by rotating the cap and main scale reading is noted.

Reading on circular scale is also noted. (Here we observe which division of circular scale is in front of main scale)

By putting the values in observation chart diameter of wire is calculated and actual diameter is calculated by deducting zero error value.

Observation table for zero error

S.No.	Main Scale Reading	Reading on Circular Scale		Total Reading
		No. of divisions above/below baseline	No. of division × least count	(in cm.)
1.	....	....	..............×..............=............	....
2.	....	....	..............×..............=............	....
3.	....	....	..............×..............=............	....

Average Zero error = ± ....

Observation Table of Diameter of Wire

S.No.	Main Scale Reading	Reading on Circular Scale		Total Reading
		No. of divisions matching baseline	No. of division × least count	(in cm.)
1.	....	....	..............×..............=............	....
2.	....	....	..............×..............=............	....
3.	....	....	..............×..............=............	....

Average diameter of wire = ... cm.

Calculation : 1. Actual diameter of wire = Observed diameter – (Zero error along with sign)

2. Radius of wire = $\frac{\text{Diameter of wire}}{2}$ = ... cm.

Result : Thus diameter of given wire is .... cm. and Radius is .... cm.

Precautions :

1. Wire should not be over tightened.
2. Reading should be taken at different places of wire.
3. Rachet must be used.
4. Screw should be rotated in one direction only.

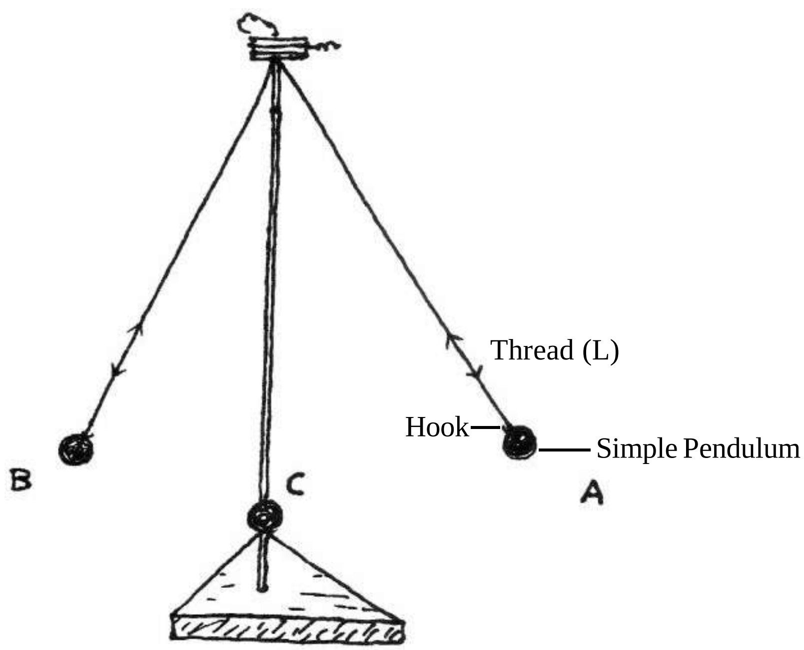
Practical Work (Sound)

Objective : To study the change in time period with respect to length of simple Pendulum and draw a graph of length (Time period)^2

Materials Required : Simple pendulum, thread, Vernier-Callipers, stop watch etc.

Principle : Acceleration due to gravity is different at different places. If acceleration due to gravity at any place is g. time period of simple pendulum at that place is T, length of simple pendulum also known as effective length is L then according to law of simple pendulum Time period is directly proportional to its length.

labelled Diagram :



Procedure :

1. First of all, with the help of Vernier Callipers, radius of pendulum is measured or pendulum of known radius is used.
2. Length of hook is measured with the help of scale.
3. Length of thread is taken as such that the sum of radius of ball, length of hook and thread length should come to the simple multiple of 10.

   Ex.- Radius of ball + hook length + thread length

   = 1.2 + 1.4 + 77.4

   = 80 cm.

   This length is known as total length or effective length.
4. In this way length is changed to 80, 90, 100 ...... cm.

5. By taking different length and giving 15 to 20 oscillations time taken is noted by stop watch.
6. Lastly a graph is plotted between length and square of time period.

Observation Table

1. To measure radius of ball with the help of vernier callipers.

Table-1

S.No.	Reading of Main Scale (x)	Reading of Vernier Scale		Diameter
		No. of division	No. of div. × Least count (y)	Total reading ($x + y$)
1. 2. 3.				

Zero is deducted from diameter

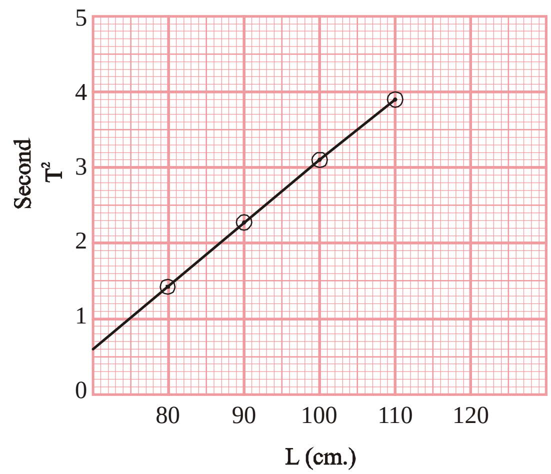
$$\text{Radius} = \frac{\text{Diameter of wire}}{2}$$

Radius = ... cm.

Table-2

S.No.	Hook length (a)	Radius (b)	Thread Length (l)	Effective Length (a+b+1)	Oscillation Period (T)	T^3
1. **2.** **3.**						

Result : Straight line obtained in the graph verifies that $T \propto \sqrt{L}$ or $T^2 \propto L$ which means square of time period is directly proportional to effective length.



Precautions :
1. Least count of Vernier Callipers and stop watch should be calculated and simultaneously zero error corrections is also necessary.
2. Motion of simple pendulum should be simple harmonic motion.
3. Displacement of pendulum should be 4°-5°.
4. Effect of fraction should be least on the motion of simple pendulum.

Practical Work (Motion)

Objective : To draw position-time graph using the figures of motion and to understand the type of motion.

Materials Required : Figures of position and time, graph paper, pencil, scale etc.

Principle : When an object moves non uniform distance in uniform time, then its motion is called as non-uniform motion. When a body moves uniform motion in uniform time then its motion is called as uniform motion. The position time graph of a uniform motion is straight line.

Procedure :
1. According to the given figures, choose a suitable scale for position and time.
2. Now place time on x axis, and position on y axis and draw a graph.

Observation Table :

Time	0	1	2	3	4	5	6	7
Position	2	6	12	12	12	18	22	29

Result : The line AB and CB in the graph show uniform motion while BC shows non-uniform motion.

Precaution :
1. Choose the scales carefully so that it is appropriate.
2. Take time on x axis and position on y axis only.

Project Work

Important instructions related to project work–

1. Projects can be done in small groups of students.
2. It is compulsory for each student to do a minimum of 3 projects, one each in physics, chemistry and biology.
3. Project writing should follow a sequence. You can include pictures, paper cuttings, graphs, collections, photographs and other exhibits to elaborate.
4. During practical examinations, it is compulsory to conduct oral assessment of project work and experiments.
5. Project work may also be done on local issues.

Biology

1. Understand the process of classification.
2. Understand the different ways of treatment/testing/identifying symptoms of diseases.
3. Study the habitat of a plant.
4. Identify biodegradable and non-biodegradable wastes.

Chemistry

1. Collecting and making a list of different mixtures used in daily life and categorization into solutions, colloids and suspensions.
2. Making a list of elements, compounds and mixtures found around you and writing two uses of each one of them.
3. Understand the role of plastic codes in the recycling of objects made of plastics.
4. Ask 5 persons involved in different occupations in the locality of your school, whether their consumption of fossil fuels (coal, L.P.G. petrol, kerosene) has increased or decreased over time. Discuss in detail. Also find out the steps taken by them to reduce fossil fuel consumption.

Physics

1. Making a comparative study of examples from daily life related to acceleration, velocity and retardation.
2. Calculating the amount of electrical energy consumed daily at home/school.

Biology

Project work (Biodiversity and classification)

Objective : Understand the process of Classification

Materials required : Plastic scale, wooden scale, pencil, wooden block, alpin, rubber ball, cricket bat, key, rope, chalk, book, rubber, cycle tube, a piece of glass, plane mirror

Process: Write down the names of all these objects on the blackboard. Form two groups to start playing this game. The number of members of a team should not exceed 15. Choose a leader for each team. As you start playing, the leader of one of the teams must discuss with the team members and write the name of an object from the list on a piece of paper and hand it over to the teacher. The members of the other team should not get any idea of the chosen object. They have to find out the name of the object by asking appropriate questions the answer to which should be in 'yes' or 'no' only like is the object used for playing games? The questions must be asked by proper discussion within group members. Both groups should get a turn each in deciding the name of object. The group that asks a minimum number of questions to find out the object wins.

Question :

1. What were the characters that were made basis for asking the questions?
2. Make a flow chart of classification of the objects by taking the help of Figure1 of the chapter(Biodiversity and Classification).

Project Work (Our Health)

Objective : to conduct a survey to find out the number of people whogofor confirmation of disease before treatment (raise awareness towards need of tests and proper line of treatment).

- Contact any five people who are sick. Collect information from them on the basis of the following table and answer the questions given in this section.

Name of the sick person	Symptoms of the disease	Did the patient undergo test for confirmation? (Yes/No)	Name of the disease	Treatment

- How many patients resorted to confirmatory tests for the disease?
- How many patients underwent treatment?
- What were the different ways adopted for treatment?

Project Work (Habitat)

Objective : To study the habitat of a plant

Materials required : copy, pencil, rubber, sharpener, rope, hand lens, matchbox, bottle, paper bag etc.

Method : Divide into groups of 3-5 members. Let half of the group study Parthenium sp.(gajarghas)/grass and the other half study railway creeper(besharam)/Dhatura. Include the following points essentially to collect information-

- What were the plants found around an area of one square meter of the plant under study? Note their number. Animals feeding on these plants, try to collect some evidences in the form of the insect itself(be careful not to hold the insect rather collect the whole leaf on which the insect may be found to feed in a paper bag) or a leaf eaten by insect. Note the names of animals if you know, take the help of your teacher as well.
- Describe the kind of soil that you find in which the plant grows(like dry/wet, redsoil/blacksoil/etc.,sandy/clayey/etc.)
- Use of the plant if any.
- Collect any other information you find notable and worth observing.
- Try to make a sketch of the plant that was studied.

Get back to the class and share the informations collected with your friends.

Questions :

1. What were the similarities and differences found while comparing your observations?
2. There can be some difference in the habitat of the same species. Discuss this aspect on the basis of your findings.

Project Work (Waste and its Management)

Objective : Identify biodegradable and non- biodegradable wastes

Materials required : 8-10 earthen pots, soil, plain paper, gum, water, natural and human generated waste like vegetable or fruit peels, toffee papers, nails, glass pieces(be careful while handling them) or glass balls, covers of bottles etc.

Method : Follow the following method to find out about biodegradable and non-biodegradable wastes.

Fill soil upto a certain level in all the earthen pots. Add water to retain moisture. Separate out the waste materials and add them to the soil in the pots like add fruit and vegetable peels in one, a bottle cover in another, a nail in the third one etc. now cover up the materials with soil and add water over the same. Label the pots by writing the date and thetype of waste in it. Keep the pots in a shaded area for 3 to 4 weeks and leave them aside(remember to sprinkle water on them to keep the soil moist).

Dig out the waste material of all the pots after four weeks, observe the condition of the waste materials and write a report of your observation(use rubber gloves to carry out your work with soil). You could take the help of the following table for this.

S.No. of Pot	Name of object(waste)	Fully degraded	Partially degraded	No change
1.				
2.				
3.				
4.				

- What was the nature of objects that were fully degraded?
- What kind of waste is it?

Chemistry

Project work (Matter : Nature and Behaviour)

Objective : Classify the mixtures used in daily life into solutions, colloids or suspensions.

Theory : Solution is a homogenous mixture. The particles of a solution are so small that they cannot be seen through naked eye and we cannot seperate the particles of a solute from a solution by the process of filtration. As the particles are very small they do not disperse light rays. Therefore, we cannot observe the path of light rays in a solution.

Suspension is a heterogeneous mixture. We can see its particles through naked eye. These disperse light rays and hence we can see the path of light rays. We can seperate its particles through the process of filtration.

A colloid is a heterogenous mixture. Its particles are so small that we cannot see then by naked eyes. But they are large enough to disperse light rays. We cannot seperate its particles through filteration.

Procedure : Make a list of all the mixture that you use in your daily life.

S.No.	Substance	Solution/Colloid/Suspension	Basis of classification
1.	Lemonade	Solution	Cannot see the particles and cannot seperate them by filtration.
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

Discuss your observation in the classroom and on this basis write down point wise conclusions in your project report.

Note : Take examples of solution/colloids/suspension from your surroundings and items such as medicines etc.

While writing down the project report, include the difficulties faced by you and their solutions. If you had to make any changes in the procedure, do mention it. Also mention the things you learnt during this project.

Project work (Matter : Nature and Behaviour)

Objective : Classify the items in your surroundings into elements/compounds and mixture and write down 2 uses of each.

Theory : An element is a fundamental form of matter and cannot be divided into other simpler substances through chemical reactions. Elements can be classified as metals and non-metals. Metals have lustre, are good conductors of heat and electricity, ductile, malleable and produce metallic sounds. Non-metals do not show these properties. Non-metals are of different colour, are bad conductors of electricity and are brittle. Compounds are made from chemical combination of 2 or more elements in a specific ratio. Properties of a compound are different from its constituent elements. Mixtures are made from two or more elements or compounds mixed in any ratio. Chemical reactions do not take place during the formation of mixtures. They possess the properties of constituent elements.

Procedure : Form your surroundings, classify items into elements/compounds/mixtures based on their properties and note your observations in the following table–

S.No.	Example	Element/ Compound/ Mixture	Constituents	Basis of classification	Uses
1.	Iron nail	Element	Iron	Cannot be divided into simpler susbstances.	
2.	Water	Compound	Hydrogen & Oxygen	Formed by chemical combination	
3.	Brass	Mixture	Copper and Zinc	Chemical reaction does not take place during formation.	
4.					
5.					
6.					
7.					
8.					
9.					

Project work (Coal, Petroleum and Petrochemicals)

Objective : To understand the role of plastic codes in the recycling of plastic items used in daily life.

Theory : In recent times, the plastic industry has rapidly grown as has the petrochemicals industry.We use a vast number of plastic objects in our daily life. On the basis of its property, plastic is coded and the code is mentioned on the item. We can easily see the code on plastic objects. Recycling of plastic is done on the basis of these codes.

Procedure :

- Formation of groups of students should take place under the supervision of teachers.
- Each group should visit at least 5 houses in their surrounding and gather information about the plastic items used by them and their plastic codes. Note down the plastic codes in your notebook. Discuss about the recycling of plastic.
- Students can do this survey in their locality.
- After the survey, discuss your observations and form a table of all the items under plastic codes 1 to 7 respectively.
- Make a report on the recycling process of all these tabulated items.
- Talk with the person of your neerby junkyard and collect information about the importance of plastic codes for them.
- The growing use of plastics is hazardous for our health. With the help of your head teacher arrange a discussion on this topic and include the points in your report.

Project work (Coal, Petroleum and Petrochemicals)

Objective : To know about the work done for conservation and use of fossil fuels. To encourage ourselves and society for the conservation of fossil fuels.

Theory : Fossil fuels are a source of energy which takes millions of years to form but our current stores will last only another 100 years. Therefore, we should try to stop misuse of fossil fuels. It will be available for future generations only if we use it wisely. We may face energy crisis in future therefore it is necessary to motivate society and community to use fossil fuels wisely.

Procedure :

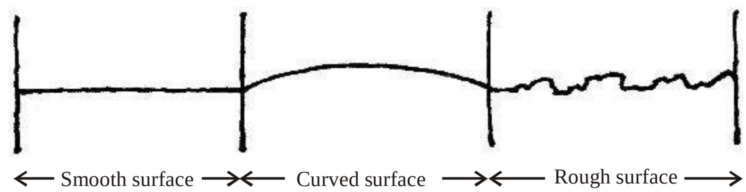
- Formation of groups should be done by the teacher.
- Each group must visit 5 houses near there school and have a discussion with 5 persons occuped in 5 different occupations. Gather information about their fossil fuel (coal, LPG, petrol, Kerosene) utilization. Ask whether their consumption has increased or decreased in last 5 years. Ask whether they take any steps for the conservation of fossil fuels and write down about it after a through discussion. Suggest them your own ideas about fossil fuel conservation. Note down your discussion in your project report.

Project Work (Physics)

Motion

Objective : To study velocity, acceleration and deceleration using daily life examples.

Materials required : Stop watch, different types of vehicles (cycles, motor-bike, car, auto), paper, pen, pencil, tape etc.



Theory : Distance covered in a given direction in a unit time by an object in motor is called velocity.

velocity = displacement / time

Acceleration : Rate of change of velocity in a non-uniform motion is called acceleration.

acceleration = change in velocity/time interval

Procedure :

1. Form a group of 4-5 members to study daily life examples of velocity, acceleration and deceleration.
2. Choose a path which has some part as plane surface, some part as curved surface and some rough patches.
3. Mark a point at some fixed distance. Ask one of the members to stand at that point.
4. Note down the distance and time of travel taken by various vehicles and fill in the table. Measure the distance using metre scale or tape and measure the time using a stopwatch.

Observe the figures carefully and study them.

S.No.	Description	Walking	Cycle	Auto	Bike	Car
1.	Time taken to cover 20 m. of plane surface.					
2.	Time taken to cover 20 m. of .... surface.					
3.	Time taken to cover 20 m. of rough surface.					

Result : By doing a comparative study of the velocity, acceleration and deceleration of various vehicles we conclude that acceleration takes place on plane surface while deceleration takes place on rough surface.

Safety measure :

1. Use a common scale while marking distances so that we find regular distances and error free results.
2. Stand at a safer place on the roadside. to calculate the time. Be alert to avoid any mishappenings.

   On the same basis you can take another example of walking on plane surface, climbing on stairs and climbing down from stairs.

Project work (work and energy)

Objective : Calculate the energy spent daily in your house/school.

Materials required : Watch, various electrical equipments, multi-meter etc.

Theory : We calculate the daily expenditure of energy using the following formula.

Total energy expended daily = No. of equipments × power of equipments (watts) × time (in hours) / 1000

Procedure : Calculate the energy spent daily at your house or school using the above formula.

Observation table

S.No.	Name of equipment	No. of equipment	Power of equipment	Time spent when the equipment was on	Energy spent	Total energy spent

Calculation :

1. Daily energy =
2. Monthly energy = daily energy × no. of days
3. Energy expenditure = total energy spent in month / rate.

Result : Energy spent daily in your house/school is ....

Safety measures :

1. Take proper safety measures for electricity use.
2. Don't touch any electrical equipment when it is on.
3. Stay away from equipments when they are in running condition.

Future scope : What measures can you take to avoid electrical energy wastage?