CHEMISTRY

Standard IX

Part-2

Government of Kerala
Department of Education

State Council of Educational Research and Training (SCERT) Kerala

2016

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The National Anthem

Jana-gana-mana adhinayaka jaya he
Bharatha-bhagya-vidhata,
Punjab-Sindh-Gujarat-Maratha
Dravida-Utkala-Banga
Vindhya-Himachala-Yamuna-Ganga
Uchchala-Jaladhi-taranga
Tava subha name jage,
Tava subha asisa mage,
Gahe tava jaya gatha.
Jana-gana-mangala-dayaka jaya he
Bharatha-bhagya-vidhata,
Jaya he, jaya he, jaya he,
Jaya jaya jaya jaya he!

Pledge

India is my country. All Indians are my brothers and sisters.

I love my country, and I am proud of its rich and varied heritage. I shall always strive to be worthy of it.

I shall give my parents, teachers and all elders respect, and treat everyone with courtesy.

To my country and my people, I pledge my devotion. In their well-being and prosperity alone lies my happiness.

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Dear Students,

Science is the knowledge that man has gained through the process of experimentation, observation and analysis. Science is nothing but truth. Man is continuously marching towards progress by observing and analysing the changes happening around him and by making new discoveries as he moves on. Much of our material gains owe to the development happening in the field of science. Study of science is a pre-requisite for all those who aim at better growth and success. Science text books are instruments for this.

Chemistry has played a significant role in giving new dimensions to human civilization and also in improving the living standards of individuals. It can be said without doubt that there is no branch of science other than chemistry that has influenced mankind to such a great extent. The contributions of chemistry to the field of agriculture, industry, medicine and daily life is incomparable. Hence it can be said that the study of chemistry is the study of the progress of man.

Study of science should be made a pleasant experience by giving emphasis to the basic methods of science like experimentation, observation, analysis and elucidating inferences. While familiarising ourselves with new concepts and areas of knowledge, we should also be keen on acquiring and developing certain values and attitudes. It is indeed needed to scale greater heights by ensuring the continuation and development of knowledge and capabilities gained in lower classes. These aims have been kept in mind while preparing the new chemistry text book.

Study of science should be made a joyous experience by making the maximum use of, the learning activities, experiences and discussions provided in the Textbooks as well as the facilities available in the school premises and laboratories. Let this book help you in cultivating a scientific temper along with values while acquiring knowledge.

Wishing you the best...

Dr. P.A. Fathima
Director, SCERT

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(Need not be assessed)

ICT Possibilities for Concept Clarity

Significant Learning Outcomes

Let Us Assess

Extended Activities

5 ACIDS, ALKALIES AND SALTS

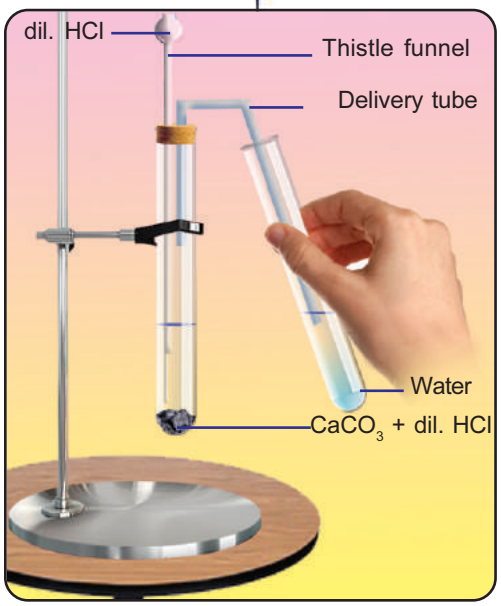


Figure 5.1

There are a variety of chemicals in your school laboratory. You might have conducted many experiments, using these chemicals, to prepare new substances. Can you identify the chemicals having similar chemical properties from among them? Let us perform an experiment.

Take some calcium carbonate in a boiling tube as shown in Figure 5.1. Add 5 mL dilute hydrochloric acid to it using a thistle funnel. Pass the emerging gas through water in a test tube.

- Which is the gas that comes out through the delivery tube? Add blue litmus solution to the water in the test tube.
- What do you observe? What is your inference?

The solution obtained by dissolving carbon dioxide in water is called carbonic acid. Let's find the formula of carbonic acid.

$$CO_2 + H_2O \rightarrow H_2CO_3$$

Soda water is the solution obtained by dissolving carbon dioxide in water under high pressure.

You have learnt that during lightning, the nitrogen gas present in the atmosphere combines with oxygen to form nitric oxide (NO) and then nitrogen dioxide (NO_2). When nitrogen dioxide dissolves in water in the presence of oxygen, nitric acid (HNO_3) is formed.

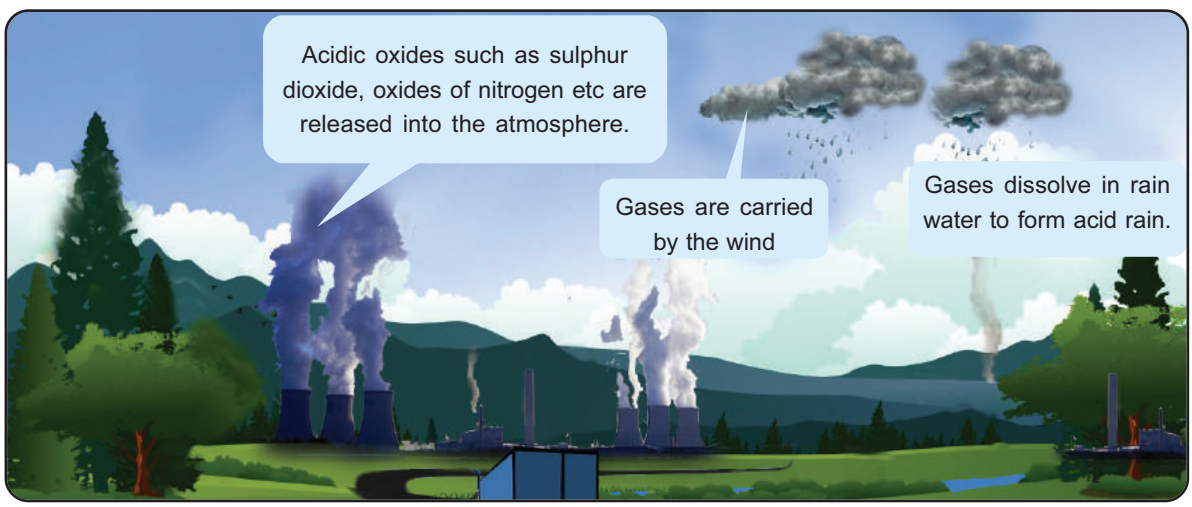


Figure 5.2

In addition to this, in industrial areas, where Chemical factories, motor vehicles and thermal power stations are more the chances of air pollution is very high. In such regions, gases like SO_2 and NO_2 reach the atmosphere in greater amounts. These gases dissolve in rain water and reach the earth as acids. This is known as 'acid rain' (Fig.5.2).

Write the chemical equation of the reaction in which SO_2 dissolves in water to form sulphurous acid (H_2SO_3).

CO_2, SO_2 and NO_2 are non-metallic oxides. In general, compounds formed by the reaction of non-metallic oxides with water are acidic.

What are the environmental problems caused by acid rain? Discuss.

- Plants lose their ability to produce carbohydrates through photosynthesis as their leaves are destroyed.
- Severe acid rain destroys the greenery of a region.
- The acidic nature of water causes the death and destruction of fish and corals.
-

It is found that the original beauty of Taj Mahal that is made of marble ($CaCO_3$) is gradually fading. Can you guess why? Think about this relating it to acid rain.

What precautionary measures can be taken against the environmental issues caused by acid rain? Discuss.

- Reduce the excessive use of fossil fuels.
- Before using remove sulphur compounds from the fossil fuels as far as possible.
-

Let's do an experiment.

Add quick lime (calcium oxide) in water taken in a beaker and stir well. Take some clear supernatant solution from the beaker in a test tube and add a drop of red litmus solution to it.

What do you observe?_ _

Is calcium oxide a metallic or a non-metallic oxide?

_ _

What is the compound formed by the reaction of calcium oxide with water? Find out by completing the chemical equation of the reaction.

$CaO + H_2O \rightarrow$ ....

What can be inferred about the nature of this substance from the litmus test?

_ _

The compounds formed by the reaction of metallic oxides with water are usually alkaline.

Classify the compounds given below into acidic and basic oxides and complete Table 5.1

SO_3, NO_2, CaO, K_2O, P_2O_5, Na_2O, CO_2, MgO

Acidic oxides	Basic oxides
• SO_3 • • •	• CaO • • •

Table 5.1

You have learnt some of the characteristics of acids and alkalies in earlier classes. Now, from the statements given below, select the statements suitable for acids and those for alkalies and complete Table 5.2.

- Have alkaline taste.
- Turn blue litmus red.
- React with carbonates to form carbon dioxide gas.
- Soapy to touch.
- Liberate hydrogen gas on reaction with reactive metals like Mg and Fe.
- Have sour taste
- Turn red litmus blue

Acids	Alkalies
• Have sour taste • • •	• Have alkaline taste • • •

Table 5.2

The citric acid present in lime and the tartaric acid present in tamarind are weak acids. Such organic acids present in naturally occuring sour substances are usually weak acids.

All acids should not be tasted. Mineral acids like hydrochloric acid, sulphuric acid and nitric acid are strong acids.

Some simple experiments can be done to find out the properties of acids and alkalies listed in Table 5.2.

Conduct these experiments and record your observations.

Common component in Acids

Complete Table 5.3 by writing the chemical formulae of the acids used in the experiments you have already conducted.

Name of Acid	Chemical formula
Hydrochloric acid	HCl
Nitric acid	.....
Acetic acid	CH_3COOH
Carbonic acid	.....
Sulphuric acid	.....

Table 5.3

Which component if present, is responsible for the common properties of acids? Study the table carefully and identify the component.

You have understood that metals like Mg and Fe react with acids to form hydrogen gas.

Now, try to write the chemical equation for the reaction of Fe with dilute hydrochloric acid.

Do all acids contain hydrogen atom?

Analyse the chemical equations for the reactions taking place when hydrochloric acid dissolves in water.

$$HCl \rightarrow H^+ + Cl^-$$

$$H^+ + H_2O \rightarrow H_3O^+ \text{ (Hydronium ion)}$$

What happens to the HCl molecule when it dissolves in water?

Which are the ions formed in the HCl solution?

What happened to the H^+ ions formed by the dissociation of HCl?

Since the H^+ ions released in the solution have no independent existence they combine with H_2O molecules to form hydronium ions (H_3O^+).

The H_3O^+ ions formed during the dissolution of acids in water is the basis of the properties of acids.

Like hydrochloric acid, other acids also can release hydronium ions in aqueous solution.

Acids are substances which can increase the concentration of hydronium ions (H_3O^+) in an aqueous solution.

Acids can be classified into monobasic, dibasic, tribasic etc. based on the number of H^+ ions released by molecule of the acid in its aqueous solution (the number of H^+ and H_3O^+ ions are equal in an aqueous solution).

HCl is a monobasic acid.

Observe how the dibasic acid H_2SO_4 changes into ions.

Figure 5.3

$$H_2SO_4 \rightarrow H^+ + HSO_4^-$$

(bisulphate ion)

$$HSO_4^- \rightarrow H^+ + SO_4^{2-}$$

(sulphate ion)

The chemical formulae of some acids are given below. Classify them into monobasic, dibasic and tribasic.

H_2CO_3, HNO_3, H_3PO_4, H_2SO_4, HCl, H_2SO_3

The Common component in Alkalies

During rainy season slaked lime is sprinkled over agricultural fields.

Why is this done?

Is it necessary to add slaked lime to all types of soils?

What is the chemical formula of slaked lime?

Is the substance formed by the reaction of slaked lime with water acidic or alkaline in nature?

You might have seen many chemicals stored in bottles in your laboratory. Write the chemical formulae of these chemicals by checking the labels of these bottles.

Find out more examples for alkalies from the chemicals you have listed.

Now, complete Table 5.4 and identify the common component in alkalies.

Chemical name of Alkalies	Chemical formulae
Sodium hydroxide	NaOH
Calcium hydroxide	.....
Ammonium hydroxide	.....
Magnesium hydroxide	.....
Potassium hydroxide	.....

Table 5.4

Bases and Alkalies

All bases are not alkalies. Water soluble bases are called alkalies.

NaOH and KOH are alkalies while, $Al(OH)_3$, and $Cu(OH)_2$ are bases. They are not treated as alkalies as they are insoluble in water.

Metallic oxides are generally basic in nature. But a few of them have both acidic as well as basic character. Such metallic oxides are called amphoteric oxides.

Eg: Al_2O_3, ZnO

They can react with acids as well as bases.

By analysing the chemical formulae of the alkalies listed in the table, you might have understood the common factor in alkalies. Most of the alkalies are also known by common names in addition to their chemical names.

Caustic Soda, Milk of Lime, Milk of Magnesia and Caustic Potash are the common names of some alkalies. Identify the chemical formulae of these with the help of Table 5.4 and record them.

Observe the chemical equation for the dissolution of sodium hydroxide in water.

$NaOH \rightarrow Na^+ + OH^-$ (Hydroxide ion)

Now, complete the given chemical equation for the ionization of calcium hydroxide.

$Ca(OH)_2 \rightarrow$ ..... (Ca^{2+}) + ...

Which is the common ion released when alkalies dissolve in water?

Alkalies are substances which can increase the concentration of hydroxide (OH^-) ions in an aqueous solution.

The chemical equations representing the ionization of some acids and alkalies are given below. Fill in the blanks.

$HCl \rightarrow H^+ + Cl^-$

$KOH \rightarrow K^+ + OH^-$

$H_2CO_3 \rightarrow$ .....$+ CO_3^{2-}$

$NH_4OH \rightarrow NH_4^+ +$ .....

$HNO_3 \rightarrow$ ..... $+ NO_3^-$

Svante Arrhenius
(1859 – 1927)

In 1887, the Swedish scientist Svante Arrhenius put forward a scientific theory regarding acids and alkalies. He proposed that any acid or alkali, when dissolved in water, dissociates into ions.

As per his theory, acids are substances which liberate H^+ ions in aqueous solution and alkalies are substances which liberate OH^- ions.

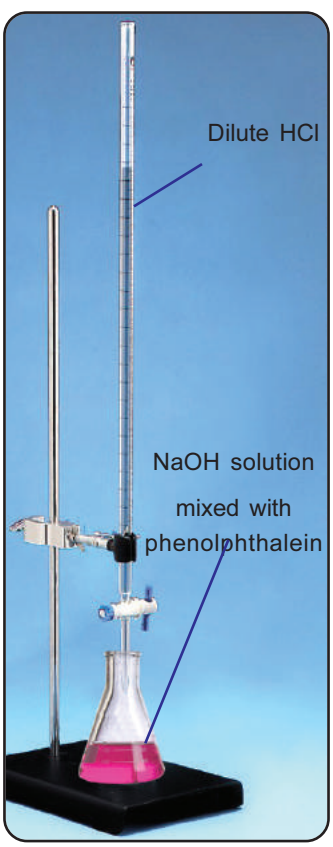


Figure 5.4

Neutralisation reaction

What happens when acids and alkalies react with each other? Let's find out.

Take 50 mL dilute hydrochloric acid (HCl) in a burette. Take 20 mL dilute sodium hydroxide (NaOH) solution in a conical flask. Add one or two drops of phenolphthalein to the sodium hydroxide solution. Note down the colour of the solution. Hold the conical flask below the burette and add dilute HCl gradually. Mix the solution well by shaking the conical flask continuously. Observe the change in colour taking place in the NaOH solution. As you near the stage of colour change, add HCl drop by drop and shake well. Stop adding HCl when the colour disappears completely with just one drop of HCl solution. Record the volume of HCl consumed by noting the level of acid in the burette.

- What do you infer from the decrease in the intensity of colour of the NaOH solution on adding HCl?

  -

- When does the colour disappear completely?

- -

- Is there any NaOH left in the conical flask at this stage?
- Add some NaOH solution to the colourless solution in the conical flask
- What do you observe? What is the reason for this?

- -

Add dilute HCl again to this, drop by drop and stir.

- What is your observation?

- -

Acid and alkali react with each other and mutually nullify their individual properties. Such chemical reactions are called neutralisation reactions.

Write the chemical equation for the neutralisation reaction between sodium hydroxide and dilute hydrochloric acid.

$NaOH + HCl \rightarrow NaCl + H_2O$

You have already recorded the volume of HCl used for neutralising 20mL NaOH in the earlier experiment.

Do you think that there will be a change in the volume of HCl used if the concentration of the acid is changed? Let's find out.

Add a few drops of concentrated HCl to the already prepared solution of dilute HCl. Take this in a burette and repeat the neutralisation reaction of NaOH solution. Now, what change do you notice in the volume of HCl required for the neutralisation of 20 mL NaOH?

What is your inference?

- -

Antacid

Hydrochloric acid produced in the stomach helps the digestion process. But, an increase in the acid level results in acidity which may lead to peptic ulcer and cancer. Antacids are medicines used to reduce acidity in the stomach. Chemicals like calcium carbonate, aluminium hydroxide, sodium bicarbonate and magnesium hydroxide are the main components of antacids.

Now you understand that concentration is an important factor in neutralisation reactions.

You have also learnt in the biology class that hydrochloric acid helps the process of digestion in the stomach.

What happens when the acid level in the stomach is high?

What do we do in such situations?

The medicines used for reducing acidity in the stomach are known as **antacids**. What types of substances are present in antacids? How do they work?

Isn't it the same process that takes place when slaked lime is sprinkled over farm lands?

There are instances of increased acidity level in soil. Similarly, there are instances of increased alkali level also. What types of substances are added in such situations?

Don't you think this is possible only after ascertaining the property of the soil?

Hence isn't it necessary to test the soil?

Let's see how we can express the strength of the acidic and alkaline nature.

pH Value

Take100 mL each of pure water (eg. distilled water) in two beakers. Add a drop of phenolphthalein to one and a drop of methyl orange to the other.

Do you notice a colour change in the water?

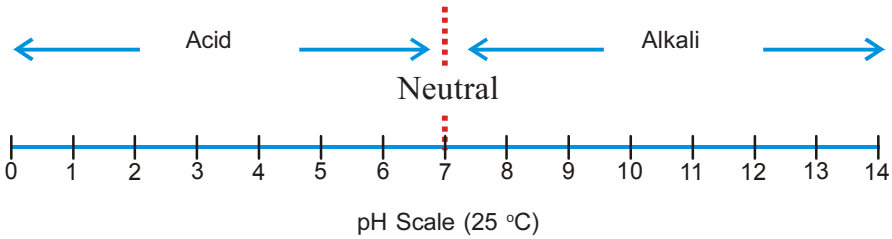
What property of water is revealed here?

As a result of weak ionisation, equal amounts of H^+ ions and OH^- ions are formed in the neutral solvent, water.

What happens to the amount of H^+ ions when a little acid is added to water.

What change occurs when alkali is added?

Determination of pH value is the scientific method for finding the acidic/alkaline nature of substances. For this purpose, the pH scale was devised based on the H^+ ion concentration. Observe the diagrammatic representation of the pH scale given below.



What are the numbers seen in the pH scale?

Which are the lowest and the highest pH values?

What is the pH value of a neutral solution?

pH Value

The acidic and alkaline nature of a substance is measured in terms of the H^+ ion concentration in it. The Danish scientist Sorensen devised the pH scale for this.


Sorensen
(1868 – 1939)

The chemical equation for the dissociation of water is given below

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

At room temperature, pure water dissociates only to a small extent. When one litre of water dissociates at 25 °C, 10^{-7} mol H^+ ions and 10^{-7} mol OH^- ions are formed. That is, the concentration of H^+ ions in water is 10^{-7} mol/litre. (1 mol ion = 6.022×10^{23} H^+ions). This is represented as $\left[H^+\right] = 10^{-7}$mol/litre.

pH is the reciprocal of the logarithm of H^+ ion concentration.

$$pH = \log \frac{1}{\left[H^+\right]} = -\log\left[H^+\right]$$

$\because \log 10 = 1$

For water $\left[H^+\right] = 10^{-7}$ mol/litre

$\therefore$ The pH of water $= \log\left[\frac{1}{10^{-7}}\right] = \log\left[10^7\right] = 7\log 10 = 7$

The pH scale is the method used to express the acidic and alkaline nature of a substance based on the amount of H^+ ions present in the aqueous solution. On the basis of the pH scale the pH value of a neutral solution is 7. The pH value of acids is less than 7 and that of alkalies is greater than 7.

The pH value of different substances can be identified and compared. A pH paper, pH solution or a pH meter can be employed for this purpose.

Add a drop of pH solution to the solution whose pH is to be determined or dip the pH paper into it. The pH value of the solution can be determined by matching the colour change observed with the pH colour chart (Fig. 5.5)

For further clarification open the application 'pH Scale' in the software PhET in Edubuntu of IT@School

pH values and the corresponding colours

Figure 5.5

Complete Table 5.5 after finding the pH value of the following substances using the pH paper.

Name of substance	Colour of paper	pH value	Acid/Alkali
Vinegar	……..	……..	……..
Lime water	……..	……..	……..
Dilute hydrochloric acid	……..	……..	……..
Water	Colourless	7	Neutral
Washing soda solution	……..	……..	……..
Ammonia solution	……..	……..	……..
Ammonium chloride solution	……..	……..	……..
Sodium chloride solution	Colourless	……..	Neutral

Table 5.5

pH Meter

The pH meter is a device used for the determination of the pH of aqueous solutions. A pH meter measures the voltage between two electrodes and convert them into their equivalent pH value. A probe is the most important part of this equipment. It is a sensor attached to the end of a rod-like portion made of glass. The pH is measured by dipping the probe in the solution.

Crops and pH value

The nature of soil is not the same everywhere on the earth's surface. There exists a relation between the nature of soil and the crops. This is the reason for the diversity of crops in different parts of the world. The weather at a particular place, the availability of water and the nature of the soil are the factors which influence the growth of crops. Usually, soil having the pH in the range 6.5 to 7.2 is suitable for majority of crops. A pH of 7 to 8 is suitable for crops like carrot, cabbage etc.

Is it the acidic nature or alkaline nature that increases with an increase in the pH value?

Does the amount of H^+ ions increase or decrease with an increase in the pH value?

The pH of soil is an important factor for crops. It is important to identify whether the soil of a region is suitable for a particular crop. For some crops soil with acidic nature is suitable while for some others, soil with alkaline nature is suitable.

Is it now clear that it is necessary to ascertain the pH of soil before farming?

Salts

What are the products of the reaction between dilute hydrochloric acid and sodium hydroxide solution?

$$Na^+ \boxed{OH^- + H^+} Cl^- \rightarrow Na^+Cl^- + H_2O$$

Name the product formed when the common component of an acid and the common component of an alkali combine with each other.

Which is the positive ion in sodium hydroxide?

Which is the negative ion in hydrochloric acid?

Write the chemical formula of the compound formed by the combination of these two ions. Identify this substance.

Sodium chloride, formed by the reaction between the acid HCl and the alkali NaOH is a salt.

Neutralisation is the process in which acid and alkali react with each other to form salt and water.

Salts are usually ionic compounds.

Salts dissociate into positive and negative ions when dissolved in water or on fusion. The positively charged ion is called **cation** and the negatively charged ion is called **anion.**

The name and symbol of some cations and anions are given in Table 5.6

Name of cation	Symbol	Name of anion	Symbol
Potassium ion	K^+	Hydroxide ion	OH^-
Zinc ion	Zn^{2+}	Carbonate ion	CO_3^{2-}
Ferrous ion	Fe^{2+}	Bicarbonate ion	HCO_3^-
Ferric ion	Fe^{3+}	Nitrate ion	NO_3^-
Cuprous ion	Cu^{1+}	Sulphate ion	SO_4^{2-}
Cupric ion	Cu^{2+}	Bisulphate ion	HSO_4^-
Ammonium ion	NH_4^+	Phosphate ion	PO_4^{3-}
Manganous ion	Mn^{2+}	Dihydrogen phosphate ion	$H_2PO_4^-$

Table 5.6

The names of a few salts and their chemical formula are given in Table 5.7. Complete the table adding names of more salts identifying their cations and anions.

Name of salt	Chemical formula	Cation	Anion
Sodium chloride	NaCl	Na^+	Cl^-
Magnesium sulphate	$MgSO_4$	Mg^{2+}	SO_4^2
Calcium carbonate	$CaCO_3$	.....	.....
.....	.....	.....	.....
.....	.....	.....	.....

Table 5.7

Can you find out the acid and alkali responsible for the formation of the salts given in the table from their chemical formulae?

Prepare a table by writing the chemical formulae of more salts that you are familiar with and also the names of the acids and alkalies from which they are formed.

Salts are electrically neutral.

For salts to be neutral the total charge of cations in them should be equal to the total charge of the anions.

The magnitude of charge on individual cation and an anion need not be equal.

So, shouldn't their salts also be neutral?

What is the number of anions in NaCl? _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

What is the number of anions in $MgCl_2$? _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Is the number of cations and anions equal in all salts? How is this number related to the charge carried by the ions?

Find out how the chemical formulae of salts are written analysing Table 5.8 given below.

Cation		Anion		Chemical formula of the salt
Symbol	Charge	Symbol	Charge	
Na^+	1+	Cl^-	1-	NaCl
Mg^{2+}	2+	Cl^-	1-	$MgCl_2$
Ca^{2+}	2+	SO_4^{2-}	2-	$CaSO_4$

Table 5.8

Examine the chemical formulae of the salts given in the table. Which symbol is written first while writing the formulae of a salt?

Is it the symbol of cation or anion?

How can we arrive at the chemical formulae from the symbols?

⇒ Write the numbers indicating the charge of each ion as subscripts after interchanging them.

⇒ Simplify the subscripts and write them in the smallest ratio.

Some cations and anions are given in Table 5.9. Write the chemical formulae of all the salts possible by combining them.

Cation	Anion
Ca^{2+} (Calcium ion)	Cl^- (Chloride ion)
NH_4^+ (Ammonium ion)	SO_4^{2-} (Sulphate ion)
	PO_4^{3-} (Phosphate ion)

Table 5.9

Uses of Salts

You have learnt that various elements are required for the growth of plants. Isn't it from the soil that plants get these elements?

Do all these elements exist in all types of soils?

What measures can be adopted to compensate the deficiency of these elements in the soil?

Some salts that are used as fertilisers are given below.

- Ammonium sulphate - $(NH_4)_2SO_4$
- Potassium chloride - KCl
- Sodium nitrate - $NaNO_3$

We use various salts in our daily life. A list of some of these salts and their chemical formulae are given in Table 5.10. Analyse the table.

Name of the salt	Chemical name	Chemical formula	Use
Table salt	Sodium chloride	NaCl	• Making of freezing mixture •
Sylvine/ Muriate of potash	Potassium chloride	KCl	• •
Blue vitriol	Copper sulphate	$CuSO_4.5H_2O$	• Fungicide •
Baking soda	Sodium bicarbonate	$NaHCO_3$	• •
Washing soda	Sodium carbonate	$Na_2CO_3.10H_2O$	• Manufacture of glass •
Gypsum	Calcium sulphate	$CaSO_4.2H_2O$	• •

Table 5.10

Find the uses of the salts given above and complete the table. Find the names of more salts and their uses and add them to this list.

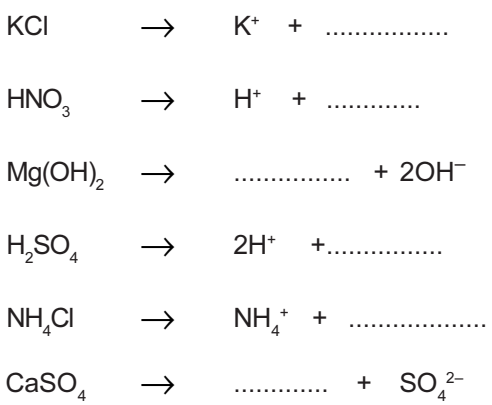
Significant Learning Outcomes

The Learner

- identifies through experiments the chemical nature of the substances formed by the reaction of metallic and non-metallic oxides with water.
- classifies different oxides into those acidic in nature and those basic in nature.
- classifies substances into acids and alkalies after identifying their characteristics.
- explains the basis for the chemical nature of acids and alkalies on the basis of Arrhenius theory.
- defines neutralisation reaction and applies it in daily life.
- identifies the pH scale and categorises substances into those having acidic properties and alkaline properties on the basis of pH value.
- explains the importance of determining the pH value in agriculture and applies them in daily life.
- explains how salts are formed by the reaction between acids and alkalies and writes their chemical formulae.
- identifies and lists some salts used in our daily life along with their uses.

Let us assess

1. Complete the chemical equations for the following ionisation reactions.



2. Identify the symbols of ions from the box and write against their names.

SO_3^{2-} , NO_3^- , HCO_3^- , OH^-, CO_3^{2-} , HSO_4^-

Carbonate -

Bisulphate -

Sulphite -

Nitrate -

Hydroxide -

Bicarbonate -

3. Name the salt formed by the reaction between magnesium hydroxide [$Mg(OH)_2$] and dilute hydrochloric acid [HCl].

Write the chemical equation for the reaction.

Which acid is used for preparing Magnesium sulphate?

4. List the cations and anions of the substances given in the table.

Substance	Chemical formula	Cation	Anion
Potassium chloride	KCl	K^+	Cl^-
Magnesium chloride	$MgCl_2$	.....	.....
Sodium nitrate	$NaNO_3$	.....	.....
Ammonium chloride	NH_4Cl	.....	.....
Aluminium sulphate	$Al_2(SO_4)_3$	.....	.....
Calcium phosphate	$Ca_3(PO_4)_2$	.....	.....

5. A little distilled water is taken in a beaker.

   A. What is the pH value of distilled water?

   B. What happens to the pH value when the following substances are added to the water in the beaker? Justify your answer.

   a) Caustic soda

   b) Vinegar

6. Some salts are given in column A. Their chemical formulae and uses are given in column B and column C irregularly. Match the columns by identifying the correct chemical formulae and the uses of the salts.

A	**B**	**C**
Salt	**Chemical formula**	**Use**
Washing soda	$CuSO_4.5H_2O$	Fire extinguisher
Gypsum	$NaHCO_3$	Fungicide
Blue vitriol	$Na_2CO_3.10H_2O$	Cement manufacture
Baking soda	$CaSO_4.2H_2O$	Glass manufacture

7. The pH values of some substances are given in the table. Analyse the table and answer the questions that follow.

Substance	pH value
Vinegar	4.2
Lime water	10.5
Milk	6.4
Water	7
Tooth paste	8.7
Blood	7.36

a. Is blood acidic or alkaline in nature?

b. The pH value of pure milk is 6.4. Does the pH value increase or decrease when milk changes to curd? Justify your answer.

c. Among the substances given in the table,

i) Which one is strongly alkaline?

ii) Which one has weak acidic nature?

Extended Activities

1. Organic acids are present in a number of substances we use.

(e.g. Tomato, orange, apple, grapes, curd etc.)

Identify the organic acids in each of them and prepare a list.

2. Haven't you identified the pH value of the soil in relation with different crops? Identify the pH value of soil samples collected from different places.

Identify the crop that is suitable for the soil of each area on the basis of its pH value.

3. a) Complete the chemical equations for the ionisation of phosphoric acid.

$H_3PO_4 \rightarrow \quad H^+ + H_2PO_4^-$

(Dihydrogen phosphate ion)

$H_2PO_4^- \rightarrow \quad H^+ +$ .....

(Hydrogen phosphate ion)

..... $\rightarrow \quad H^+ + PO_4^{3-}$

(Phosphate ion)

b) How many types salts can be formed by phosphoric acid? Why?

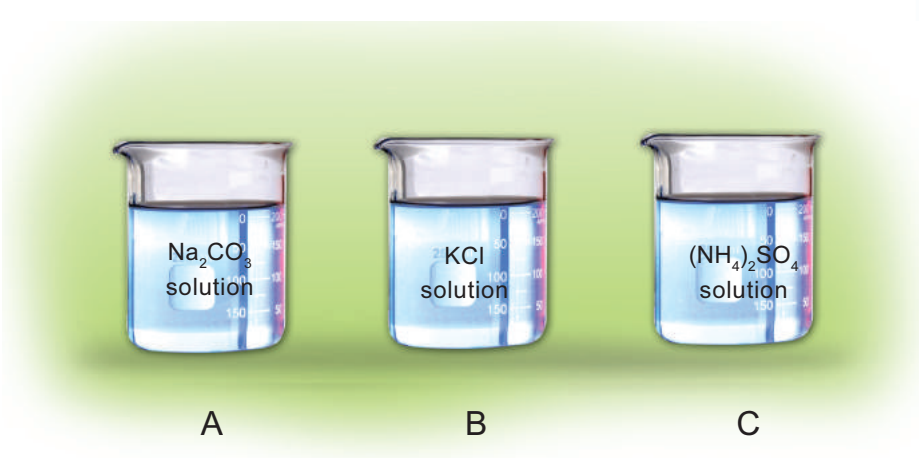
c) Write the chemical name of the following salts.

$Mg(H_2PO_4)_2$

$MgHPO_4$

$Mg_3(PO_4)_2$

4. Solutions of sodium carbonate, potassium chloride and ammonium sulphate are taken in separate beakers.



Dip litmus paper (red, blue) in each beaker

i. Observe the colour change of litmus paper and tabulate.

Salt	Colour of litmus paper	Nature of the substance
A		
B		
C		

ii. Name the acids and alkalies that react with each other to form each of the salts given above?

iii. Can you explain the colour change of the litmus paper on the basis of the nature of the acid and alkali that react with each other to form the salt?

(Hint: potassium chloride is a salt formed by the reaction between strong acid and strong alkali)

6 COMPOUNDS OF NON-METALS

Are you familiar with the chemicals shown in the picture?

These chemicals are of utmost importance in the agricultural and industrial sectors. Hence they are produced in large quantities. We shall familiarise ourselves with the methods of production and properties of some chemicals of industrial importance.

Ammonia (NH_3)

Ammonia is an important raw material in the production of nitrogenous fertilizers which are essential for the growth of plants.

How can we prepare ammonia in the classroom? Let's do an experiment.

Take some ammonium chloride (NH_4Cl) in a watch glass and add some calcium hydroxide ($Ca(OH)_2$) to it. Stir well.

Do you sense any smell?

Show blue and red wet litmus papers over the watch glass one by one. Which litmus paper changed its colour?

Is the gas acidic or basic?

Look at the picture showing the preparation of ammonia in the laboratory (Figure 6.1).

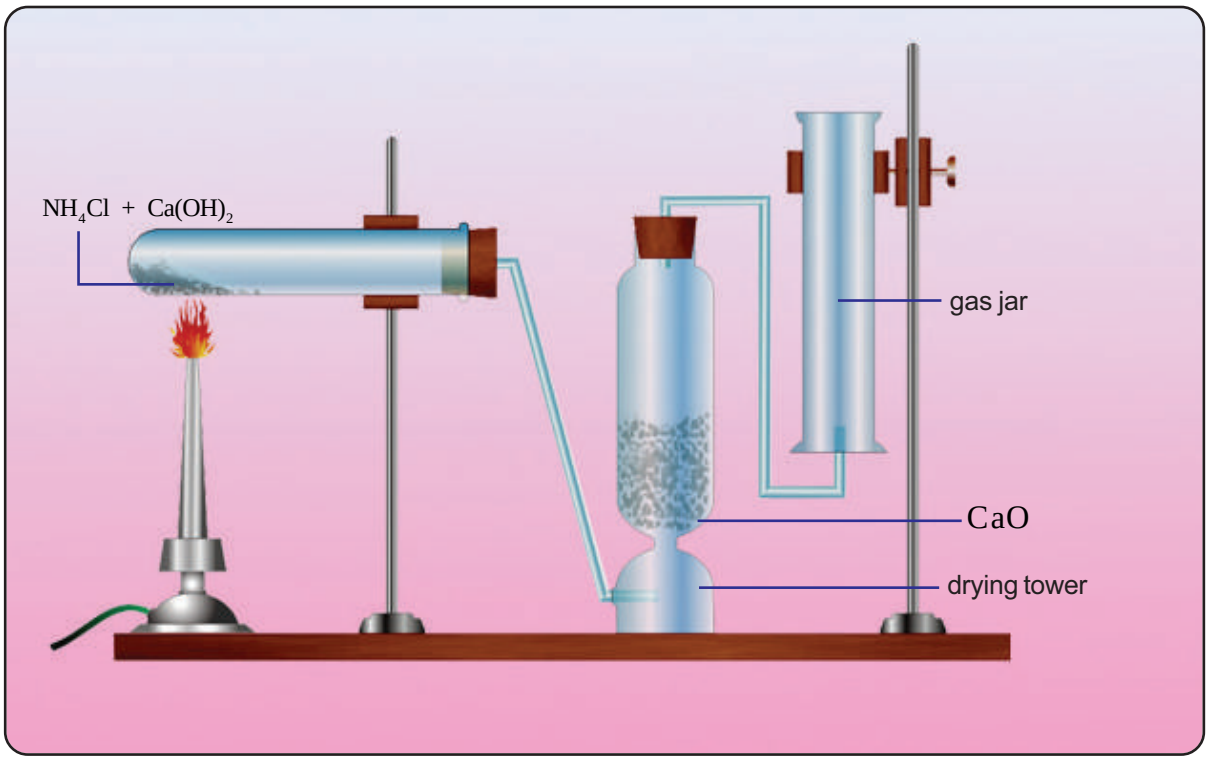


Figure 6.1

Open Chemistry for Class X in School resources of IT@School Edubuntu and see the video "Ammonia Nirmanam' from the page "Chila Aloha Samyiktangal'.

$$2NH_4Cl + Ca(OH)_2 \rightarrow CaCl_2 + 2H_2O + 2NH_3$$

Why is ammonia gas passed through quicklime (CaO)?

Ammonia is passed through a drying tower containing quicklime (CaO) to remove the moisture present in it.

You see that the gas jar used for collecting ammonia is kept in an inverted position.

- Why is ammonia collected in this manner?
- What is the inference about the density of ammonia from this?

Let's do an experiment using ammonia gas.

Collect dry ammonia in a round bottomed flask.

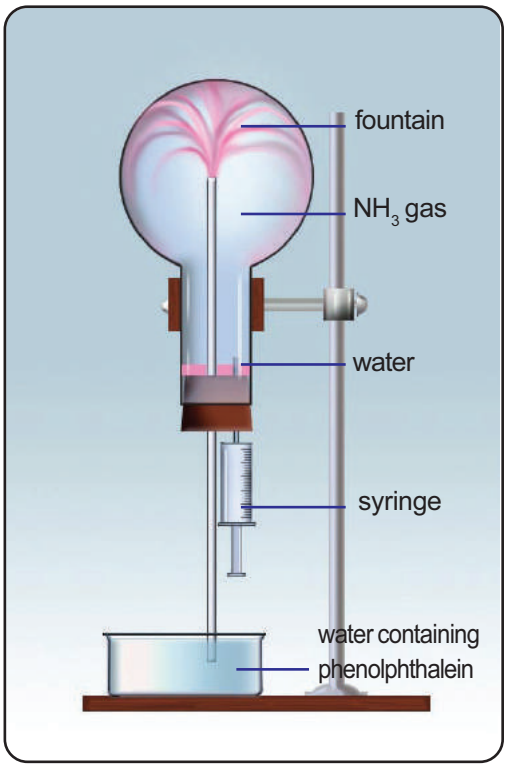


Figure 6.2

Arrange the apparatus as shown in the figure (Figure 6.2). Dip the jet tube in the beaker containing water, to which some phenolphthalein is already added. Using a syringe, add few drops of water into the flask in which ammonia is collected.

What do you observe?

What inference can be made about the solubility of ammonia in water? Why does water rush into the flask?

Why does water entering the flask change its colour?

- -

Which property of ammonia is responsible for this change in colour?

Complete the chemical equation given below and find the product obtained when ammonia is dissolved in water.

$NH_3 + H_2O \rightarrow$ .....

Open Chemistry for Class X in School Resource of IT@School Edubuntu & see the video

A highly concentrated solution of ammonia in water is called **liquor ammonia**. Ammonia gas can be liquefied easily by applying pressure. Liquefied ammonia is known as **liquid ammonia.**

Put a tick mark (✓) to those which are applicable to ammonia in Table 6.1 given below.

Colour	Yes/No
Odour	Pungent smell/ No smell
Nature	Acidic/ Basic
Solubility in water	Less/ Very high
Density of ammonia	Less than that of air/More than air

Table 6.1

Introduce a glass rod dipped in concentrated hydrochloric acid into a glass jar filled with ammonia.

What do you observe? -

Complete the chemical equation and find the product.

$NH_3 + HCl \rightarrow$ .....

Ammonia reacts with acids yielding ammonium salts which are used as chemical fertilizers.

Let's look at some of the uses of ammonia. Ammonia is used

- for the manufacture of chemical fertilizers like ammonium sulphate, ammonium phosphate, urea etc.
- as a refrigerant in ice plants.
- to clean tiles and window panes.
- ----------

Open chemistry for class X in school resources of IT@school Edubuntu and see 'nitrogenum hydrogenum upayogichu ammonia nirmanam'

Open Chemistry for class X in School resources of IT@School Edubuntu & see the video "Ammonia plant"

Industrial preparation of Ammonia

Ammonia is industrially prepared by combining nitrogen with hydrogen at high temperature and pressure and in the presence of a catalyst. This is known as the **Haber Process**. See the equation of this process.

$$N_2 + 3H_2 \rightarrow 2NH_3$$

Identification of ammonium salts

Prepare the solution of an ammonium salt.

Take 5 mL Nesslers reagent in a test tube. To this, add a few drops of the salt solution.

Write down your observations.

Repeat the experiment with other ammonium salts.

This can be used as a test for identifying ammonium salts.

Haber Process

Fritz Haber
(1868-1934)

The Haber process was invented by the German Scientist Fritz Haber in 1912, for preparing ammonia on an industrial basis. Nitrogen and hydrogen, taken in the ratio 1:3, are made to combine at a very high pressure (500 atm) and a temperature of 450 °C to produce ammonia. Spongy iron is used as the catalyst. Ammonia is an important compound used in large quantities to produce chemical fertilizers. It was through the green revolution that our country ensured food security and achieved self sufficiency in food production. One of the major principles of the green revolution was the use of chemical fertilizers.

Sulphuric Acid (H_2SO_4)

Sulphuric acid is a chemical of utmost importance in industry. Let us get an idea of the various uses of sulphuric acid by analysing the concept map given below.

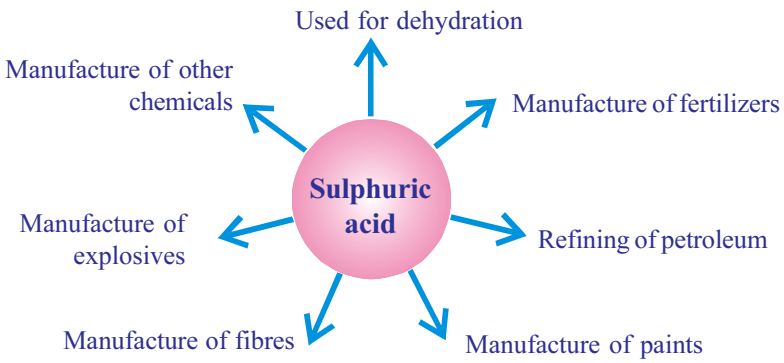


Figure 6.3

Now you might have understood why sulphuric acid is called the King of Chemicals.

Industrial Preparation of Sulphuric acid

Sulphuric acid is industrially prepared by the '**Contact Process**'. Let us examine the different stages in the Contact process.

Open chemistry for class X in school resources of IT@school Edubuntu and see the video 'Sulphuric acid'

Sulphur is burnt in oxygen to produce sulphur dioxide.

$$S + O_2 \rightarrow SO_2$$

The SO_2 thus formed is allowed to combine with oxygen at a high temperature in the presence of vanadium pentoxide (V_2O_5) as catalyst to produce sulphur trioxide.

$$2SO_2 + O_2 \xrightarrow[450°C]{V_2O_5} 2SO_3$$

SO_3 is now dissolved in concentrated sulphuric acid.

$$SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$$

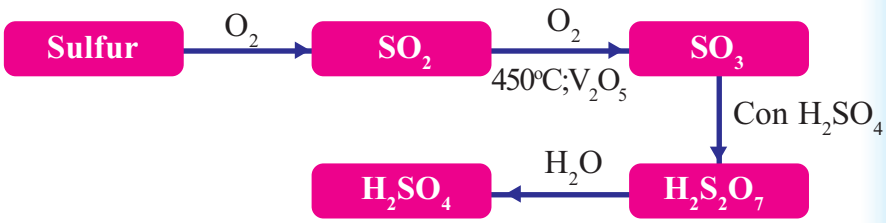
The product thus formed is known as oleum. Sulphuric acid is produced by mixing oleum with water.

$$H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$$

Sulphuric acid is formed also by the direct dissolution of sulphur trioxide in water. Still, sulphur trioxide is not directly dissolved in water. Why?

The dissolution of sulphur trioxide in water is an exothermic process. It may turn sulphuric acid initially formed into fine smog-like particles which will hinder further dissolution.

That is why sulphur trioxide is dissolved in concentrated sulphuric acid to make oleum.



Properties of Sulphuric acid

- Colourless
- Viscous in nature
- Highly corrosive
- Denser than water
- Water soluble

Let's familiarise ourselves with some of the chemical properties of sulphuric acid.

Affinity towards water

Take 5 mL water in a test tube and slowly add concentrated sulphuric acid to it. Touch the bottom of the test tube. What do you feel?

Is the reaction exothermic or endothermic?_ _ _ _ _ _ _ _ _ _ _ _

While diluting sulphuric acid, the acid should be added to water in very small quantities, stirring it. If water is added to the acid, it will result in spurting and may cause burns to our body, as the reaction is highly exothermic

Take some sugar in a watch glass and add a few drops of concentrated sulphuric acid to it. What do you observe?

_ _

Drying agent

Drying agents are substances capable of absorbing the moisture present in substances. Quicklime (CaO) is a drying agent. Being basic, it can remove the moisture from ammonia without reacting with it.

P_2O_5, concentrated sulphuric acid etc. are examples of acidic drying agents.

What is the substance that remains in the watch glass? _

What may be the reason?

Assess the chemical equation given below and find out.

$$C_{12}H_{22}O_{11} \xrightarrow{\text{Conc } H_2SO_4} 12C + 11H_2O$$

Now you have understood the reason for the conversion of sugar to a black residue.

Concentrated sulphuric acid has the ability to remove chemically combined hydrogen and oxygen from substances in the ratio corresponding to that of water. This process is known as dehydration. Concentrated sulphuric acid is a **dehydrating agent**.

Drying agents are substances capable of absorbing the moisture present in a substance.

Concentrated sulphuric acid is used as a drying agent in the manufacture of Cl_2, SO_2 and HCl.

Why is concentrated sulphuric acid not used as a drying agent in the manufacture of ammonia?

_ _

Reaction with Salts

Concentrated sulphuric acid forms hydrogen chloride on reaction with chlorides and nitric acid on reaction with nitrates. See the chemical equations given below.

$$NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$$

$$KNO_3 + H_2SO_4 \rightarrow KHSO_4 + HNO_3$$

Concentrated sulphuric acid can displace volatile acids from their salts.

This method is employed in the manufacture of hydrochloric acid, nitric acid etc.

Oxidising nature

Concentrated sulphuric acid reacts with metals and non metals and oxidises them.

Add concentrated sulphuric acid to a small quantity of carbon taken in a test tube. Heat it. What do you observe?

Analyse the chemical equation and find the reason for your observation.

$$C + 2H_2SO_4 \rightarrow CO_2 + 2H_2O + 2SO_2$$

What is the oxidation state of elemental carbon? What about the carbon in carbon dioxide?

Was carbon oxidised or reduced in this reaction? Which is the oxidising agent?

See the reaction between concentrated sulphuric acid and copper.

$$Cu + 2H_2SO_4 \rightarrow CuSO_4 + 2SO_2 + 2H_2O$$

Is copper oxidised or reduced in this case?

Think about it relating the oxidation states of elemental copper and the copper in copper sulphate.

Find the oxidising agent in this reaction. Which is the reducing agent?

Identification of sulphate salts

Sulphates are produced when dilute sulphuric acid reacts with some metals, alkalies and carbonates.

$$H_2SO_4 + Zn \rightarrow ZnSO_4 + H_2$$

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

$$H_2SO_4 + CaCO_3 \rightarrow CaSO_4 + H_2O + CO_2$$

We know that sulphates are the salts of sulphuric acid.

Let's see how sulphate salts can be identified.

Prepare an aqueous solution of a sulphate salt. Add some barium chloride solution to it.

What change do you observe? _

The chemical equation of the reaction is given below.

$$Na_2SO_4 + BaCl_2 \rightarrow BaSO_4 + 2NaCl$$

What could be the white precipitate that is formed?

Add a little concentrated hydrochloric acid to this precipitate.

Does the precipitate disappear?

The given salt is a sulphate, if the precipitate remains insoluble in concentrated hydrochloric acid.

Is this method useful for identifying sulphuric acid also? Verify and find out.

A white precipitate of barium carbonate will be formed when barium chloride is added to the solution of a carbonate salt. This precipitate gets dissolved in hydrochloric acid. Check this by conducting an experiment by adding barium chloride to sodium carbonate solution.

Hydrogen chloride (HCl)

Hydrogen chloride is an important compound of hydrogen and chlorine.

The apparatus used to prepare hydrogen chloride in the laboratory is given in Fig. 6.4.

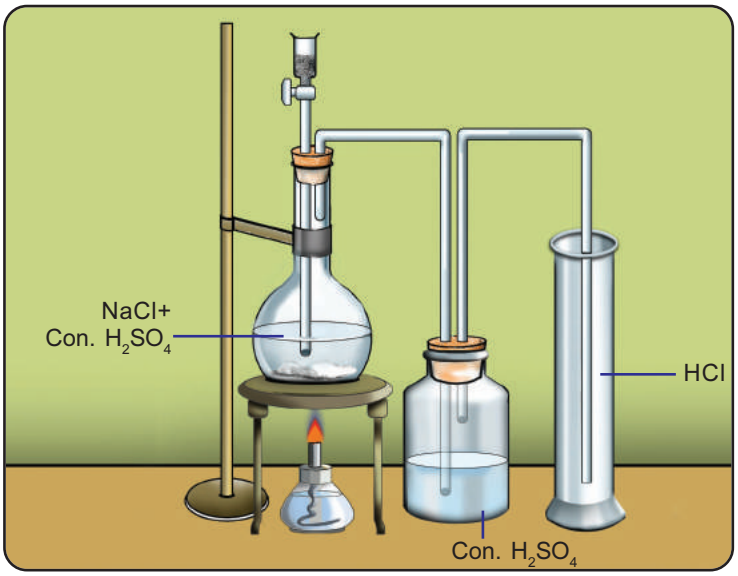


Figure 6.4

What are the reactants used?

Complete the chemical equation of the reaction.

$NaCl + H_2SO_4 \rightarrow$ ..... + ...

Why is the HCl gas thus formed passed through concentrated sulphuric acid?

Conduct an experiment by introducing blue and red wet litmus papers to the mouth of the gas jar in which HCl gas is collected.

Which litmus paper changes its colour?

What inference about HCl can be drawn?

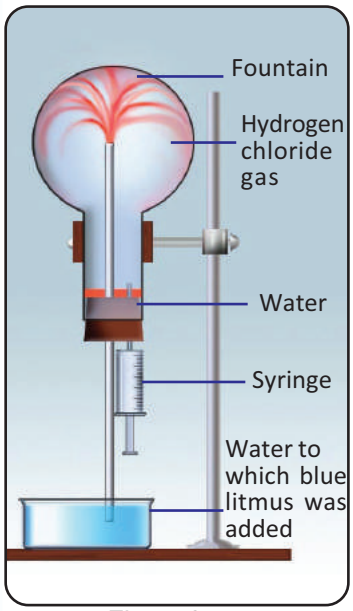


Figure 6.5

Don't you remember the fountain experiment conducted using ammonia? Repeat the fountain experiment using HCl gas (Fig. 6.5). Which property of HCl gas is revealed here?

Complete Table 6.2 listing the properties of hydrogen chloride.

Colour	.....
Odour	Pungent smell
Density	Denser than air
Solubility in water	.....
Acidic/basic nature	.....

Table 6.2

Introduce a glass rod dipped in ammonia at the mouth of a gas jar containing hydrogen chloride.

Note down your observation and find out the reason.

You know that hydrogen chloride readily dissolves in water. Hydrochloric acid is prepared by dissolving HCl gas in water.

Hydrochloric acid reacts with most of the metals and their compounds.

You are already familiar with the reaction of hydrochloric acid with zinc, sodium hydroxide and calcium carbonate.

Complete the equations of the reactions

$2HCl + Zn \rightarrow$ ..... +.....

$HCl + NaOH \rightarrow$ ..... +.....

$2HCl + CaCO_3 \rightarrow$ ..... +.....+.....

Chlorides are the salts of hydrochloric acid.

Identification of chloride salts

Add a little silver nitrate solution to an aqueous solution of the given salt. What do you observe? See the chemical equation of the reaction.

$NaCl + AgNO_3 \rightarrow AgCl + NaNO_3$

Add ammonium hydroxide solution to the white curdy precipitate. What is the change that occurs?

If the precipitate dissolves, the given salt is a chloride.

Can this experiment be used to verify whether a given liquid is hydrochloric acid? Conduct the experiment and find out.

Nitric Acid – HNO_3

Nitric acid is another industrially important compound. It has many uses including the production of chemical fertilizers.

Nitric acid is produced in the laboratory by heating potassium nitrate and concentrated sulphuric acid in a retort. See the picture (Fig. 6.6) of this arrangement.

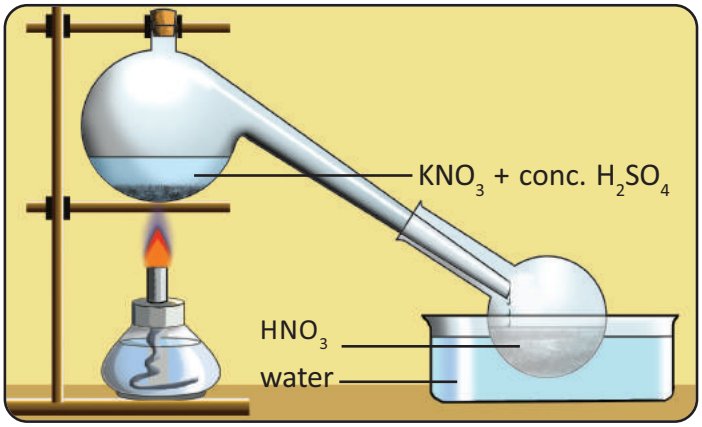


Figure 6.6

$$KNO_3 + H_2SO_4 \rightarrow KHSO_4 + HNO_3$$

Nitric acid is a volatile acid. Hence the acid vapours that come out are cooled and condensed using cold water.

Pure nitric acid is a colourless liquid. But the nitric acid obtained in the laboratory is pale yellow in colour.

What could be the reason for this?

Nitric acid dissociates to produce reddish brown nitrogen dioxide (NO_2) gas. It dissolves in the acid giving the pale yellow colour.

$$4HNO_3 \rightarrow 2H_2O + 4\ NO_2 + O_2$$

Large scale industrial production of nitric acid is possible through **Ostwald process**.

Ostwald Process


Wilhem Ostwald (1853-1932)

Ostwald process is the process desig ned by the German scientist Wilhem Ostwald in 1932 for the industrial production of nitric acid. In the first stage, nitric oxide is produced by the reaction of ammonia with oxygen in the presence of platinum as the catalyst. This is followed by the conversion of nitric oxide to nitrogen dioxide in the presence of oxygen. The nitrogen dioxide thus obtained is dissolved in water again in the presence of oxygen to produce nitric acid.

$$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$$
$$2NO + O_2 \rightarrow 2NO_2$$
$$4NO_2 + 2H_2O + O_2 \rightarrow 4HNO_3$$

Reaction with metals

The reaction of nitric acid with different metals depends on the nature of the metal as well as the concentration of the acid. Analyse the chemical equations given below and try to find out the gases formed in each case.

i) Concentrated nitric acid

$Zn + 4HNO_3 \rightarrow Zn(NO_3)_2 + 2H_2O + 2NO_2$ (nitrogen dioxide)

ii) Dilute nitric acid

$3\ Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 4H_2O + 2NO$ (nitric oxide)

$4\ Zn + 10HNO_3 \rightarrow 4Zn(NO_3)_2 + 5H_2O + N_2O$ (nitrous oxide)

iii) Very dilute nitric acid

$Mn + 2HNO_3 \rightarrow Mn(NO_3)_2 + H_2$

$Mg + 2HNO_3 \rightarrow Mg(NO_3)_2 + H_2$

Nitrates are salts of nitric acid

Identification of nitrate salts

Take the given salt solution in a test tube and add an equal amount of freshly prepared ferrous sulphate ($FeSO_4$) solution and shake well. The test tube containing the solution is held in a slanting position and concentrated sulphuric acid is poured into it along the sides. If a brown ring is formed at the junction of the two liquids, the salt can be confirmed as a nitrate.

Aqua regia

Aqua regia (Royal liquid) is a mixture of concentrated nitric acid and concentrated hydrochloric acid taken in the ratio 1:3. Aqua regia can dissolve noble metals like gold and platinum. How is this possible?

$HNO_3 + 3\ HCl \rightarrow 2H_2O + NOCl + 2[Cl]$

The [Cl] thus formed reacts with gold, platinum etc. forming their chlorides and thereby dissolving them.

Uses of nitric acid

Nitric acid is used

- in the manufacture of fertilizers.
- as an oxidising agent in rocket fuels.
- in the purification of gold.
- For etching alphabets and pictures on metals.
- to prepare aqua regia used for dissolving noble metals.

Significant Learning Outcomes

The Learner

- prepares ammonia and collects it in the laboratory.
- explains the properties and uses of ammonia.
- identifies ammonium salts by experimentation.
- explains the importance of sulphuric acid
- explains the industrial production as well as the physical and chemical properties of sulphuric acid.
- identifies sulphates by experimentation.
- prepares hydrogen chloride gas in the laboratory.
- explains the physical and chemical properties of hydrogen chloride.
- identifies chloride salts by experimentation.
- prepares nitric acid in the laboratory and explains the properties and uses of nitric acid.
- identifies nitrate salts by experimentation.

Let us assess

1. Given below are the names of some chemicals.

   Sodium chloride, ammonium hydroxide, nitric acid, concentrated sulphuric acid, sodium hydroxide.

   a) Select and write down the substances required to prepare hydrogen chloride.

   b) Suggest a method to identify hydrogen chloride gas.

2. CaO is used as the drying agent while preparing ammonia in the laboratory. Can concentrated sulphuric acid be used as the drying agent in the place of CaO. Substantiate your answer.

3. Write down the property of sulphuric acid made use of, in the following situations?

   a) During the preparation of chlorine gas, the gas is passed through concentrated sulphuric acid.

b) Wooden shelves get charred when they happen to come into contact with concentrated sulphuric acid.

4. Some salts, the chemicals used to identify them and the results of the experiments are arranged in an incorrect way in the table below. Match them and write in the correct order.

Salt	Chemicals	Result/Observation
Sulphate	Silver nitrate	Orange precipitate
Ammonium	Barium chloride	White curdy precipitate
Chloride	Nesslers Reagent	Brown ring
Nitrate	Sulphuric acid and ferrous sulphate	White precipitate

5. Two suggestions were made when there was a leak of ammonia gas.

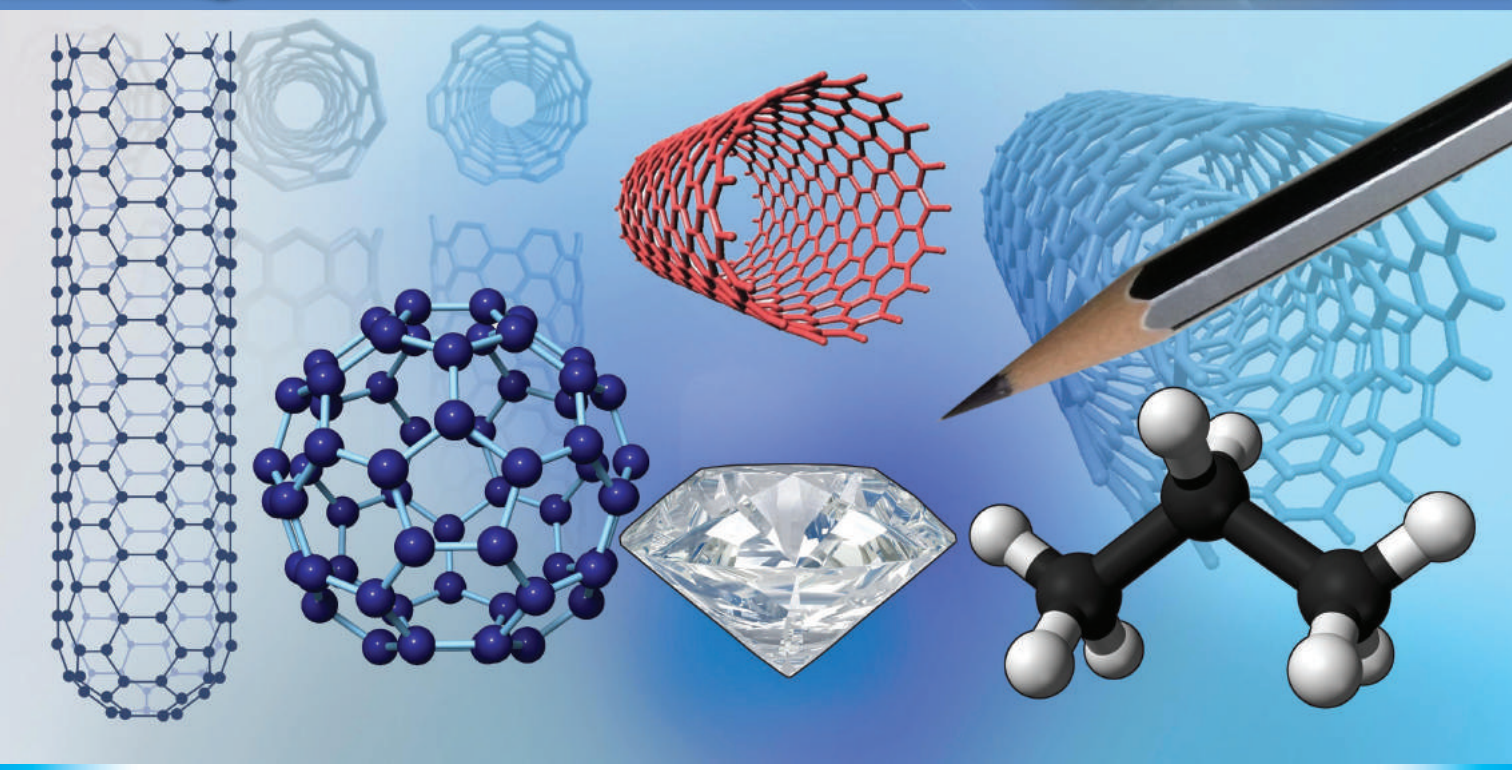
   1. Spray water
   2. Spray HCl

   Which among this would you choose? Substantiate your answer.

Extended Activities

1. It is often said that the production of sulphuric acid is a bench mark of the industrial development of a country. Prepare a note based on the various uses of sulphuric acid.
2. Collect more information about the industrial production and uses of strong acids like H_2SO_4, HCl, and HNO_3. Prepare a note and present it in the class.
3. Fill half of a beaker of capacity 50 mL with sugar. Add concentrated sulphuric acid so that the sugar is immersed in it. Observe the changes. What are the products formed? Which property of sulphuric acid is revealed here?

7 CARBON AND ITS COMPOUNDS



You know that matter on earth is made up of elements and their compounds.

The compounds containing carbon are much larger in number than those containing other elements.

Carbon is present in almost all substances that we come across in our daily life. Food items, clothes, oils, soap, cosmetics, fuels, medicines, plant and animal body, paints, rubber, paper etc., are primarily made up of compounds of carbon. New compounds of carbon are being discovered or created almost everyday.

Presence of carbon in nature

Carbon is seen both in the elemental state and combined state in nature. Wood charcoal, charcoal made from coconut shell, lamp black, sugar charcoal etc., are all carbon.

The charcoal residue left behind when substances undergo combustion is due to the presence of carbon in them. The black smoke formed when substances burn is also due to the presence of carbon.

Allotropes of carbon

Allotropy is the phenomenon by which the same element exists in different physical forms. Diamond, graphite, fullerene and graphene are the crystalline allotropes of carbon.

Thermal conductivity of diamond

Diamond, the hardest allotrope of carbon is also an excellent conductor of heat. The strong covalent chemical bonding in diamond is responsible for this property. The thermal conductivity of diamond is about five times that of copper. The thermal conductivity of diamond is made use of in identifying fake diamonds.

Coloured diamonds

Chemically and structurally pure diamonds are colourless. The presence of certain elements impart colour to diamonds. For example, the presence of boron imparts blue colour and the presence of nitrogen imparts yellow colour to diamonds. The refractive index of diamond is very high. If diamond is cut into certain shapes, the light entering the diamond will undergo total internal reflection and get separated into its component colours. This makes diamond attractive.

Diamond

Diamond is the hardest allotrope of carbon.

Look at the characteristics of diamond. It

- is very hard
- is transparent
- is not a conductor of electricity
- has high thermal conductivity
- has high refractive index

Look at some of the uses of diamond. Diamonds are

- used to make ornaments
- used for cutting glass.

Which are the properties of diamond that make it useful for these purposes? Find out.

What could be the reason for the peculiar properties of diamond? See the crystal structure of diamond given in Fig. 7.1. Here each carbon atom is linked by covalent bonds with four other carbon atoms surrounding it.

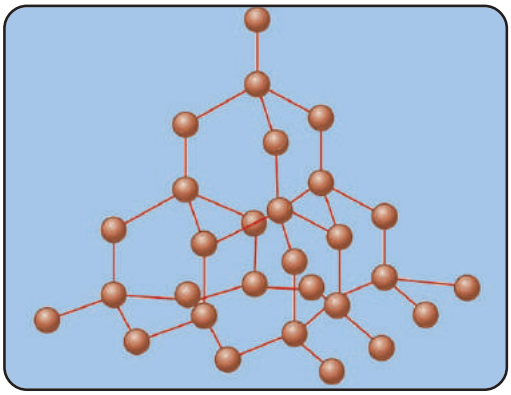


Figure 7.1

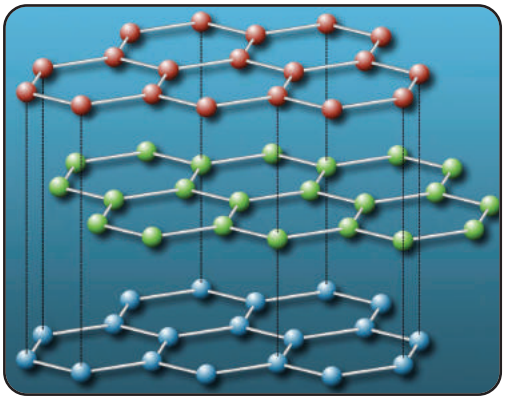


Figure 7.2

This strong bonding is responsible for the hardness of diamond. Due to the absence of free electrons in this crystal structure, diamond does not conduct electricity.

Graphite

Graphite is the most stable crystalline allotrope of carbon.

Let's list out the characteristics of graphite.

- Lustrous
- Grey in colour
- Conductor of electricity
- Non volatile

Given below are some uses of graphite.

- Used to make pencil lead
- Used to make electrodes of dry cells.
- Used as a solid state lubricant.

Find the properties of graphite that make it useful for these purposes?

Look at the crystal structure of graphite given in Figure 7.2

The origin of the name

Graphite got its name from the Latin word 'Graphien', which means 'capable of writing'. Since graphite was grey in colour and smooth and could make marks in a paper, it was eventually used for writing. In the initial stages, graphite was mistaken for lead. It was due to this reason that graphite pencils got the name lead pencils.

In graphite, each carbon atom is covalently bonded with three surrounding carbon atoms and forms a sheet like structure. These sheets or layers are stacked one above the other to form the three dimensional structure.

Each layer is made up of hexagons. There is no covalent bonding between these layers. These layers are held together by weak van der Waals physical forces. Hence the layers can slide over one another.

The presence of free electrons not involved in strong covalent bonding make graphite a conductor of electricity.

Fullerenes

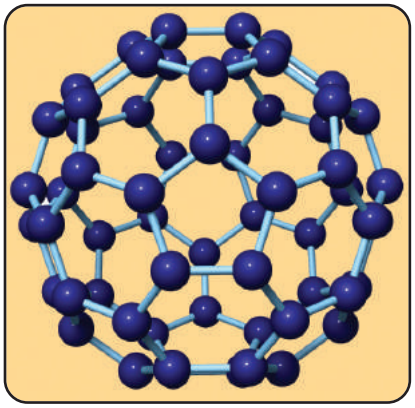


Figure 7.3

Look at the structure of yet another allotrope of carbon (Figure 7.3). Fullerenes have a hollow structure consisting of pentagons and hexagons. They are known as Bucky balls. Fullerenes with cylindrical structure are called carbon nano tubes and they are known as Bucky tubes.

They have revolutionised information technology.

Graphene

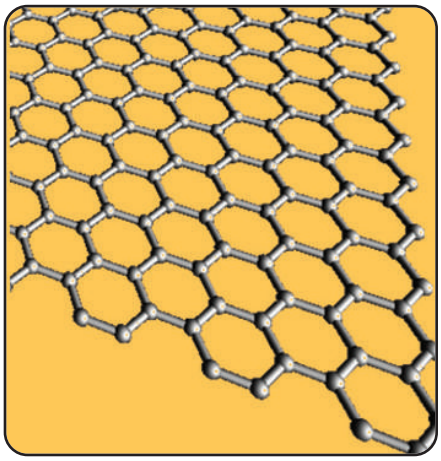


Figure 7.4

Graphenes are two dimensional sheets of hexagonal rings formed by carbon. Graphenes resemble a single layer of graphite. It can be said that graphenes are the basic units of the allotropes of carbon like graphite and fullerene.

Let's list some of the properties of graphene.

- Two hundred times stronger than steel
- Conductor of heat and electricity

Graphene has already emerged as a material that has revolutionized the field of nanotechnology.

Isotopes of Carbon

You already know about isotopes. Isotopes are atoms of the same element having the same atomic number but different mass numbers. Carbon–12, carbon–13 and carbon–14 are the different isotopes of carbon. 99% of the carbon in nature is in the form of carbon–12. The mass of carbon–12 is taken as the reference for expressing the atomic masses of other elements. Carbon–14 is the radioactive isotope of carbon. The presence of this isotope in materials is measured by scientists to determine the age of prehistoric materials and fossils (carbon dating).

Compounds of carbon
Carbon dioxide (CO_2)

Which compound of carbon is present in the atmosphere?

Which compound of carbon is formed as a result of the combustion of of fuels? ---

You know that carbon dioxide is formed when carbon and its compounds are burnt in the air.

$C + O_2 \rightarrow CO_2$

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

What are the properties of carbon dioxide known to you? Tick the correct ones given below.

- Coloured/colourless
- Supports combustion/ does not support combustion
- Denser than air/ lighter than air
- Has a characteristic odour/ odourless

You know how carbon dioxide is prepared.

Describe any one method.

Figure 7.5 shows the ways in which carbon dioxide is recycled over the earth. This is known as carbon dioxide cycle.

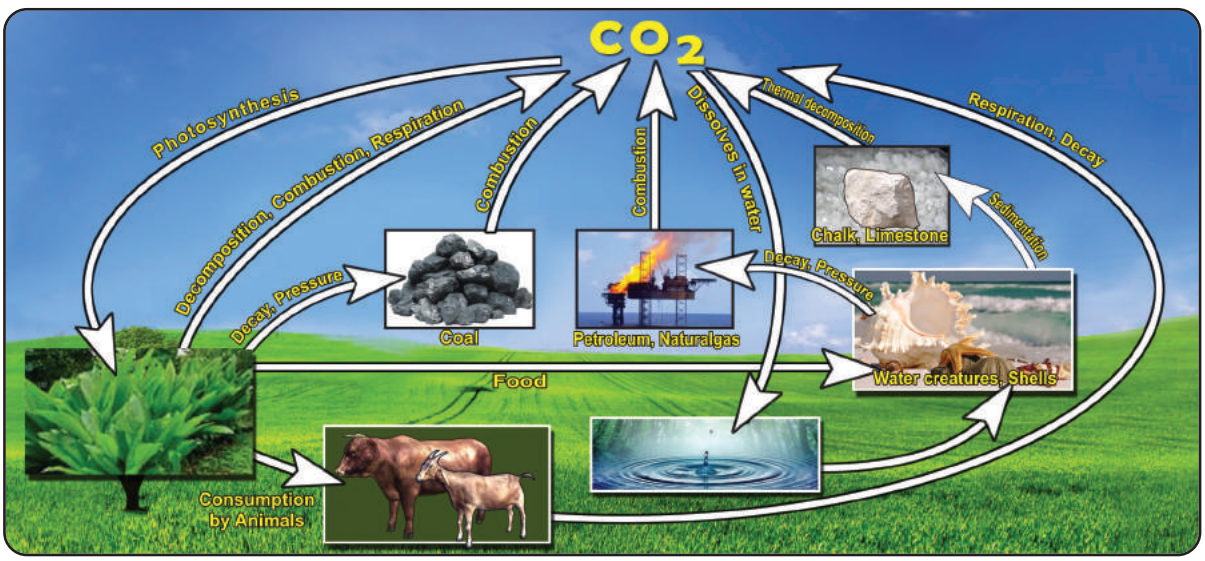


Figure 7.5

- Name the process by which carbon dioxide is utilised by plant? _____
- What are the activities that increase the amount of carbon dioxide in air? _____
- What will be the consequences if its amount increase?

Prepare a note including the details you have studied in your lower classes also.

Uses of carbon dioxide

- Used in fire extinguishers.
- Used to make soda water and soft drinks.
- Used in the manufacture of washing soda and baking soda.
- Used in the manufacture of chemical fertilisers like urea.
- Used in carbogen (95% oxygen and 5% carbon dioxide) used for artificial respiration.
- The solid form of carbon dioxide (dry ice) is used as a refrigerant and also to create stage effects resembling clouds.

Green house effect and Global warming

You have learnt that ultraviolet and infrared rays also reach the earth's surface along with sunrays. Infrared rays are thermal radiations. Carbon dioxide present in the atmosphere traps a part of the infrared radiation that is reflected and radiated from the earth. This is responsible for the present temperature of the earth and its atmosphere. This phenomenon is known as green house effect. When the amount of carbon dioxide increases, more heat gets trapped. As a result of the green house effect, the average temperature of the earth and its atmosphere increases. This is known as global warming.

Carbon monoxide (CO)

Carbon dioxide is the gas formed when carbon reacts with oxygen.

However, if the relative amount of carbon increases or that of oxygen decreases, the reaction takes place as given below.

$2C + O_2 \rightarrow 2\,CO$

The gas thus formed is carbon monoxide. It is a poisonous gas.

Carbon monoxide is formed by the incomplete combustion of carbon in a limited supply of oxygen.

When carbon monoxide is inhaled, it reacts with the haemoglobin in the blood and forms carboxy haemoglobin. As a result, the oxygen carrying capacity of blood decreases leading even to death.

What measures can be taken to avoid situations that produce carbon monoxide? Discuss.

Carbon monoxide is a gas with several uses even though it is poisonous. The following are some of the uses of carbon monoxide.

- Used as a gaseous fuel.
- Used to produce industrial gases like water gas ($CO + H_2$) and producer gas ($CO + N_2$).
- Used as a reducing agent in metallurgy.

Carbonates and Bicarbonates

Carbonates and bicarbonates are another set of compounds containing carbon.

Washing soda ($Na_2CO_3.10H_2O$), Baking soda ($NaHCO_3$) and Marble ($CaCO_3$) are certain compounds of this category.

You have already learnt what happens when acids react with carbonates and bicarbonates.

This method is used to identify carbonates and bicarbonates.

Let's do another experiment to verify whether a given water soluble salt is a carbonate.

To an aqueous solution of the carbonate salt, add a few drops of barium chloride solution. Don't you observe a white precipitate? What is this precipitate? Find it from the chemical equation.

$$Na_2CO_3 + BaCl_2 \rightarrow BaCO_3 + 2\ NaCl$$

To this precipitate, add a little concentrated hydrochloric acid. You see that the precipitate gets dissolved and disappears.

Can this be used as a test for identifying water soluble carbonate salts?

Carbon dioxide, carbon monoxide, carbonates and bicarbonates are carbon compounds obtained from inorganic materials like minerals and salts.

Let us familiarise some other carbon compounds.

Organic Compounds

You know that the number of carbon compounds is very high. Why is carbon able to form such a large number of compounds? Let's examine.

Examine the position of carbon in the periodic table and find out the following (Table 7.1)

Symbol	.....
Atomic number	.....
Mass number	.....
Electronic configuration	.....
Valency	.....

Table 7.1

The valency of carbon is four. Carbon has four electrons in the outermost shell. Carbon can form covalent bonds in three different ways. Analyse the representation (Figure 7.6) given below.

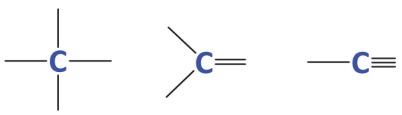


Figure 7.6

The structure of the compound formed by a carbon atom combining with four hydrogen atoms can be represented as given below (Figure 7.7).

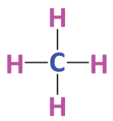


Figure 7.7

Write the molecular formula of this compound. _ _ _ _ _ _ _ _ _ _ _

Atoms and molecules are three dimensional forms. See the three dimensional representation of the molecule given (Figure 7.8).

Ball and stick model of CH_4 molecule

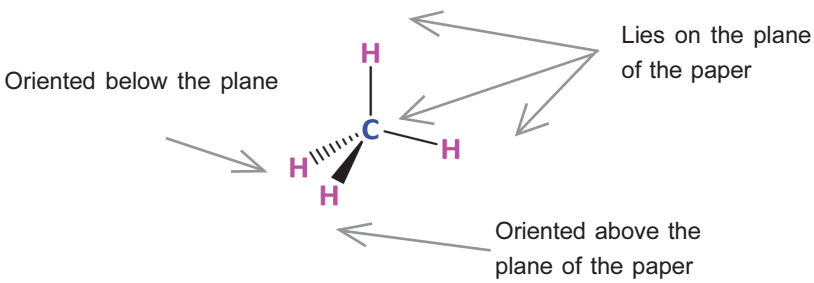


Figure 7.8

Catenation

Catenation is the ability of the atoms of an element to combine among them selves and form chains. In comparism to other elements, the ability of carbon to catenate is very high. Catenation is one of the important reasons for the existence of a large number of carbon compounds.

The structure of the compound formed by two carbon atoms and maximum number of hydrogen atoms needed to complete their valency is represented here (Figure 7.9). Write the molecular formula.

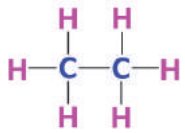


Figure 7.9

The structural formula of this compound can also be written in a condensed way as $CH_3–CH_3$. This method of representation is known as condensed formula.

See the three dimensional structure of the molecule

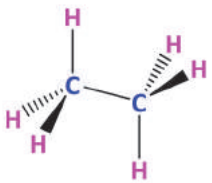
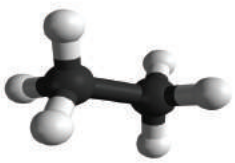


Figure 7.10



Ball and stick model of C_2H_6 molecule.

Now what will be the situation if there are three carbon atoms (Figure 7.11) ?

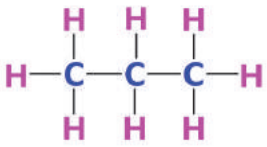
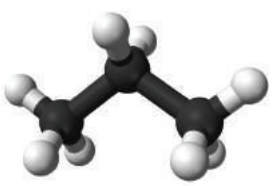


Figure 7.11

What is the molecular formula of this compound?

Write its condensed formula.

See the three dimensional structure of the molecule (Figure 7.12).



Ball and stick model of C_3H_8 molecule.

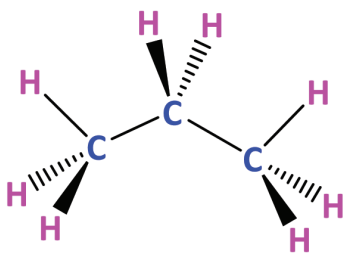


Figure 7.12

Represent the structure of more such molecules by including more number of carbon atoms.

Complete Table 7.2

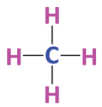
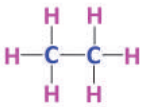
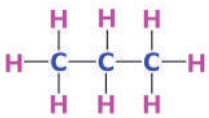
Number atoms of carbon	Structure of the alkane	Condensed formula	Molecular formula
1		CH_4	CH_4
2		CH_3 - CH_3	C_2H_6
3		CH_3 - CH_2 - CH_3	C_3H_8
4	.....	CH_3 - CH_2 - CH_2 - CH_3	.....
5	.....	.....	C_5H_{12}
6	.....	.....	.....
7	.....	.....	.....

Table 7.2

IUPAC

IUPAC (International Union of Pure and Applied Chemistry) is an international organisation that strives to carry forward the new trends in the field of chemical sciences happening worldwide and thereby contribute to the application of chemistry for the service of mankind. This organisation, founded in 1919, has its headquarters at Zurich in Switzerland. IUPAC takes the lead role in the naming of elements and compounds, standardisation of atomic weights and physical constants, recognising new terms in chemistry etc.

What are the characteristics of the compounds in Table 7.2?

- Only carbon and hydrogen are present in these compounds.
- Single bonds exist between the carbon atoms.

Compounds containing only carbon and hydrogen are called **hydrocarbons**.

The compounds shown above contain only single bonds.

IUPAC has named the hydrocarbons having only single bonds between the carbon atoms as **alkanes**.

Alkanes are known as saturated hydrocarbons.

This is because, each carbon atom in alkanes satisfies its valancies by single bonds.

Homologous series

- What is the relation between the number of carbon and hydrogen atoms in alkanes?
- How many hydrogen atoms will be present in an alkane having 'n' carbon atoms?
- In that case, can a general formula be deduced for alkanes?

Analyse the molecular formulae of CH_4 and C_2H_6.

- What is the difference in the number of carbon and hydrogen atoms between CH_4 and C_2H_6?
- Is the difference same in the case of C_2H_6 and C_3H_8?

What is the difference between the molecular formulae of any two successive alkanes?

A series of such compounds is called a **homologous series.**

See the characteristics of a homologous series.

- The members can be represented by a general formula.
- Successive members differ by a CH_2 group.
- Members show similarity in chemical properties.
- There is a regular gradation in their physical properties.

Are organic compounds biocompounds?

Once it was believed that organic compounds could be produced only from plant or animal based substances. But in 1828, the German Scientist Friedrich Wohler prepared the organic compound urea from an inorganic compound named ammonium cyanate. This paved the way for the preparation of a large number of organic compounds from inorganic substances.

$$NH_4CNO \xrightarrow{heat} NH_2\text{-}CO\text{-}NH_2$$

Unsaturated hydrocarbons

Given in Figure 7.13 is the representation of a double bond between two carbon atoms (Figure 7.13)

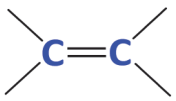


Figure 7.13

Complete the valencies of the carbon atoms using hydrogen atoms.

Draw the structures of hydrocarbon with more number of carbon atoms containing a double bond between any two carbon atoms in the chains.

Complete the table given below (Table 7.3).

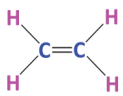
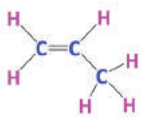
Number of carbon atoms	Structure of the alkene	Condensed formula	Molecular formula
2		$CH_2 = CH_2$	C_2H_4
3		$CH_2 = CH - CH_3$	C_3H_6
4	.....	.....	.....
5	.....	$CH_2 = CH - CH_2 - CH_2 - CH_3$	.....
6	.....	.....	C_6H_{12}
7	.....	.....	.....

Table 7.3

Hydrocarbons having a double bond between any two carbon atoms are named as **alkenes**.

- Analyse Table 7.3 and find the number of hydrogen atoms in an alkene with 'n' carbon atoms.
- If so, can a general formula of alkenes be deduced? Try to write it.

Check whether the alkenes given in the above table are members of a homologous series.

Look at the structure of a hydrocarbon carrying a triple bond between two carbon atoms (Figure 7.14).

Figure 7.14

Complete Table 7.4.

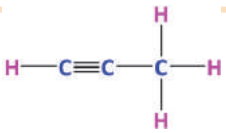
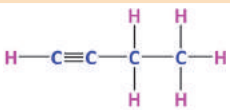
Number of carbon atoms	Structure of the alkyne	Condensed formula	Molecular formula
2		CH ≡ CH	C_2H_2
3		CH ≡ C – CH_3	C_3H_4
4		.....	.....
5	.....	.....	.....
6	.....	.....	.....

Table 7.4

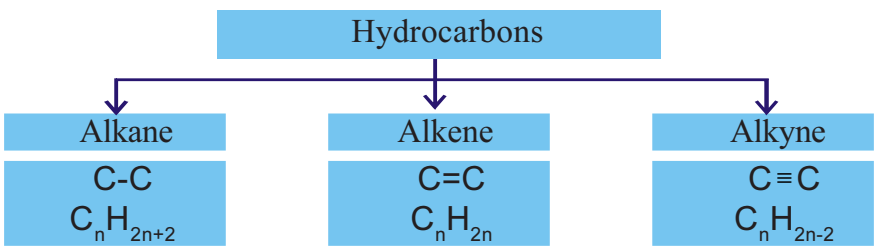
Hydrocarbons having a triple bond between any two carbon atoms are named as **alkynes**.

- Analyse Table 7.4 and find how many hydrogen atoms would be present in an alkyne with 'n' carbon atoms.
- If so, can a general formula of alkynes be deduced?

Try to write the general formula of alkynes.

Are alkynes an example of a homologous series? Examine.

Look at the classification of the hydrocarbons that we have discussed so far.



Nomenclature of hydrocarbons

Naming of organic compounds is a difficult task as they are found in large numbers and have complex structures.

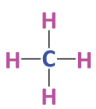
IUPAC has put forward some rules for the naming of hydrocarbons. Let's familiarise ourselves with some of them. What are the main points to be considered while naming hydrocarbons?

- Number of carbon atoms
- Nature of the chemical bond between the carbon atoms.

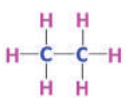
Word roots are selected based on the number of carbon atoms.

C_1	=	Meth
C_2	=	Eth
C_3	=	Prop
C_4	=	But
C_5	=	Pent
C_6	=	Hex
C_7	=	Hept
C_8	=	Oct
C_9	=	Non
C_{10}	=	Dec

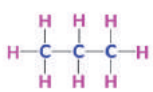
Let us see how certain hydrocarbons with single bonds are named on the basis of this.



CH_4 Methane



C_2H_6 Ethane



C_3H_8 Propane

Do you notice any peculiarity in their names?

Now you might have understood how the names were derived from the word roots.

Naming of alkanes

Alkanes are named by adding the suffix 'ane' along with the word root that denotes the number of carbon atoms.

Meth + ane → Methane

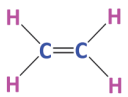
Eth + ane → Ethane

Word root + ane → Alkane

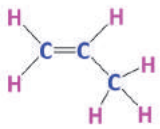
Write the IUPAC names of all the alkanes in Table 7.2.

Naming of alkenes

Look at the IUPAC names given to certain alkenes.



C_2H_4 Ethene



C_3H_6 Propene

Which is the suffix added here?

We can certainly find out the way the names were given?

Eth + ene → Ethene

Prop + ene → Propene

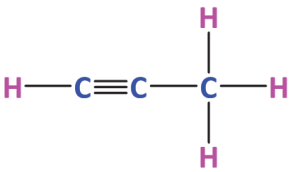
Word root + ene → Alkene

Write the IUPAC names of all the alkenes in Table 7.3.

Naming of alkynes

Analyse how certain alkynes have been named.

C_2H_2 Ethyne



C_3H_4 Propyne

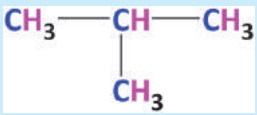
How are alkynes named?

Word root + yne → Alkyne

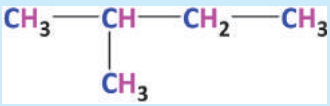
Find the IUPAC names of more alkynes.

Branched Chain Compounds

We are now familiar with the structure of open chain hydrocarbons. Other than this, there are compounds with branches. See some examples.



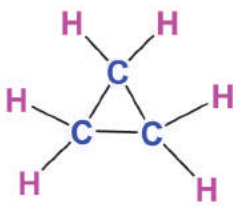
2-Methylpropane



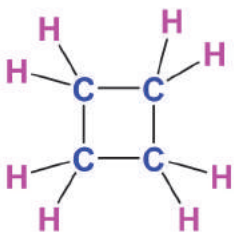
2-Methylbutane

Cyclic or Ring Compounds

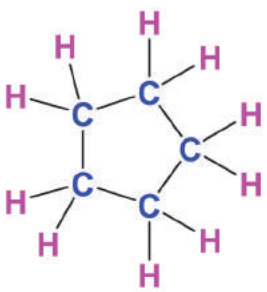
There are numerous organic compounds with a cyclic structure. The structures of some of them are represented here.



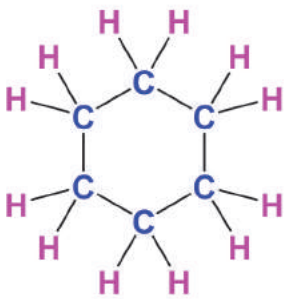
Cyclopropane



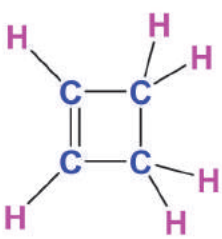
Cyclobutane



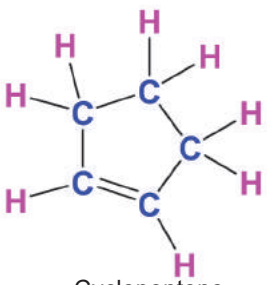
Cyclopentane



Cyclohexane



Cyclobutene



Cyclopentene

Uses of Hydrocarbons

Fuels like petrol, diesel, kerosene, LPG, LNG, CNG etc., are all mixtures of hydrocarbons. Methane is the main component of biogas. Butane is the main component of LPG. Ethene (ethylene) is a hydrocarbon that helps in the ripening of fruits. Ethyne, popularly known as acetylene is the important component of the oxy-acetylene flame used in gas welding. Benzene, hexane, heptane, cyclohexane etc., are used as solvents.

Try to find how these hydrocarbons are named.

What is the minimum number of carbon atoms required to form a cyclic hydrocarbon ? _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Carbon - the Magician

What are the conclusions that you draw from the structure of the compounds that we have seen so far?

Compare your assumptions with those given below. Think whether they explain the presence of large number of carbon compounds.

- The valency of carbon is four.
- A carbon atom can combine with four different atoms or groups at the same time.
- The ability for catenation is very high for carbon atom.
- Single, double and triple bonds are possible between carbon atoms.
- Carbon atoms combine with each other to form numerous straight chain, ring and branched chain compounds.
- Depending on the different atoms or groups that combine with carbon, a wide variety of compounds are formed.

Till now, we have been discussing only hydrocarbons. When carbon atoms combine with atoms or groups other than hydrogen, other different organic compounds are formed. Carbon compounds have diverse properties and complex structures. There is a branch of chemistry dedicated to the exclusive study of carbon compounds, which is known as **Organic Chemistry**. You can learn more about carbon compounds and their properties in higher classes.

Significant Learning Outcomes

The learner;

- explains the importance of the element carbon and its presence in nature.
- understands the properties and uses of the different allotropes of carbon.
- grasps the properties and the importance of the allotropes of carbon like diamond, graphite, fullerene and graphene.
- understands the properties and the importance of carbon dioxide.
- explains the way in which the exchange of carbon dioxide happens in nature.
- understands the situations in which carbon monoxide is formed and also environmental and health hazards posed by the gas.
- distinguishes the different carbonates and bicarbonates and explains their uses.
- draws the structure of hydrocarbons belonging to different categories like alkanes, alkenes and alkynes.
- explains the properties of a homologous series and classifies different compounds into homologous series.
- explains the IUPAC rules in naming hydrocarbons and gives IUPAC names.

Let us assess

1. The names of some allotropes of carbon, their properties and uses are given in the table, but not in the correct order. Match them suitably.

Diamond	Two dimensional hexagonal structure	Bucky balls	Manufacture of ornaments
Graphite	Transparent	Smooth	Nano technology
Fullerene	Not volatile	High refractive index	Information technology
Graphene	Spherical shape	High strength	Lubricant

2. Some statements related to carbon monoxide and carbon dioxide are given. Classify them correctly

   a) formed as a result of the incomplete combustion of carbon containing substances

   b) aqueous solution shows acidic nature

   c) poisonous gas

   d) used in fire extinguishers

   e) can be used as a fuel

   f) formed as a result of the complete combustion of substances

   g) can be prepared from carbonates and bicarbonates

   h) is a component of producer gas and water gas.

3. a) Write the chemical formula of calcium carbonate.

   b) Which gas is produced when calcium carbonate reacts with acids?

   c) What is the name of an aqueous solution of this gas?

   d) Write any two substances that contain calcium carbonate.

4. Write the chemical formula of the compounds that are missing in the homologues series given below.

A	CH_4	.....	C_3H_8	C_4H_{10}	.....	C_6H_{14}
B	C_2H_4	C_3H_6	.....	.....	C_6H_{12}	.....
C	.....	C_3H_4	C_4H_6	.....	.....	C_7H_{12}

5. Given below are the chemical formulae of some hydrocarbons

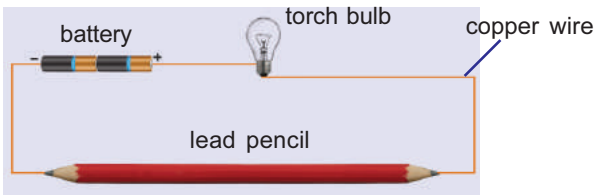
   C_3H_6, C_2H_6, C_3H_4

   a) Represent their structure

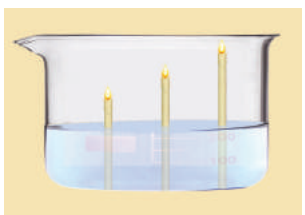
   b) Based on their structure, classify them into alkane, alkene and alkyne.

Extended Activities

1. Arrange the objects as shown in the figure and conduct the experiment. Based on your observations, what is the conclusion that you reach at?

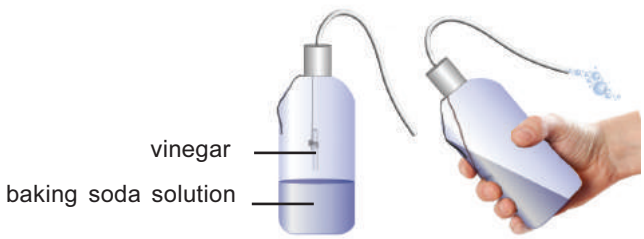


2. Lighted candles of different heights are arranged in a trough as shown in the figure. Pour a saturated solution of sodium bicarbonate (baking soda) into the trough. Add a little vinegar to the solution. What do you observe? Give reasons for the observation.



3. Making a fire extinguisher.

   Arrange the apparatus as shown in Figure (a). Add the vinegar contained in the test tube to the sodium bicarbonate (baking soda) solution (Figure (b)) by tilting the wash bottle. Introduce the resultant gas to a candle flame. Record your observation. What is your inference?



4. Construct and display the ball and stick models of some hydrocarbons.

5. Prepare a write up on the topic 'Importance of organic chemistry' and present it in your class.

NOTES

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