CHEMISTRY
PART - II

Standard
IX

Government of Kerala
Department of General Education

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2024

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.

Chemistry

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Dear students,

You are familiar with the fact that the study of science is possible only through various activities like experiment, observation, data collection, data analysis and consolidation of inferences. You might have been inspired by the research done by eminent scientists to prove universal facts. With the developments in scientific concepts, diverse branches of science are emerging day by day. Chemistry is one such branch which is evolving tremendously. Almost every object that we use not only in the fields of agriculture, industry and health but also in our daily life is a gift of chemistry. Emphasis should be given to the comprehension of basic ideas and acquisition of problem solving skills, which are essentially needed for the study of chemistry.

Chemical kinetics, solutions, non metals and organic chemistry are the units included in this textbook. Due importance is given to the planning of various activities like experiments, seminars, quiz, projects and analysis. The text lays emphasis on the potential of continuous evaluation in order to enhance self assessment and helps in the completion of assessment through learning activities. The extended activities in each unit stresses the realisation of the practicability of learning concepts and the development of creativity.

Chemistry should be learnt with interest and enjoyment. Concepts which appear to be complicated can be easily acquired through group discussions and activities among teachers and students.

Let the study of chemistry be a delightful experience through team work and collaboration.

With love and regards.

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Certain icons are used in this textbook for convenience

For further reading (Not considered for evaluation)

Continuous assessment questions

Let us assess

Extended activities

THE CONSTITUTION OF INDIA

PREAMBLE

WE, THE PEOPLE OF INDIA, having solemnly resolved to constitute India into a [1]**[SOVEREIGN SOCIALIST SECULAR DEMOCRATIC REPUBLIC]** and to secure to all its citizens :

JUSTICE, social, economic and political;

LIBERTY of thought, expression, belief, faith and worship;

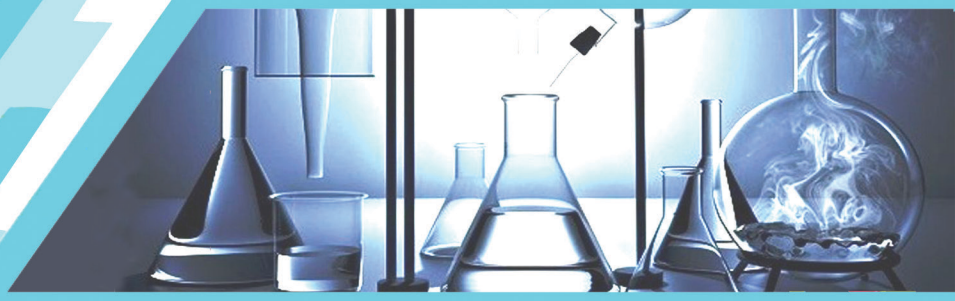
EQUALITY of status and of opportunity; and to promote among them all

FRATERNITY assuring the dignity of the individual and the [2][unity and integrity of the Nation];

IN OUR CONSTITUENT ASSEMBLY this twenty-sixth day of November, 1949 do **HEREBY ADOPT, ENACT AND GIVE TO OURSELVES THIS CONSTITUTION.**

---

1. Subs. by the Constitution (Forty-second Amendment) Act, 1976, Sec.2, for "Sovereign Democratic Republic" (w.e.f. 3.1.1977)
2. Subs. by the Constitution (Forty-second Amendment) Act, 1976, Sec.2, for "Unity of the Nation" (w.e.f. 3.1.1977)



5 Chemical Kinetics

Do you know that the kitchen in our homes is a chemical laboratory? Several physical and chemical changes take place there.

Classify the processes given below into physical changes and chemical changes.

Process	Physical change / Chemical change
Melting of ice	.....
Burning of wood	.....
Curdling of milk	.....
Dissolution of sugar in water	.....
Boiling of water	.....

Table 5.1

Chemical reactions are an integral part of technology, culture and everyday life. Chemical reactions such as burning fuels, smelting iron, making glass and pottery, preparing wine and cheese have been known for thousands of years. Numerous chemical reactions take place in the complex processes that occur in the earth's surface, atmosphere, oceans and in living organisms.

You have learned that chemical change is a change that takes place in matter as a result of which one or more new substances are formed. Moreover, chemical changes are accompanied by a change in energy. Let us examine the changes happening during chemical reactions, through some experiments.

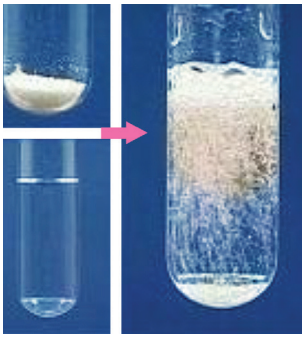


Figure 5.1

1. Take some sugar ($C_{12}H_{22}O_{11}$) in a spatula and heat it on a bunsen burner.

   What is the colour of the product obtained?

   .....

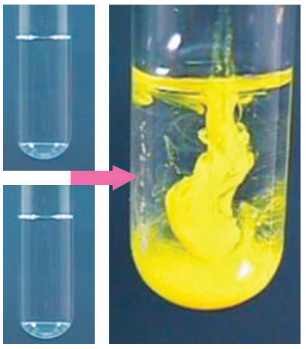


Figure 5.2

2. Take some sodium carbonate (Na_2CO_3) in a test tube. Add 2-3 mL of dilute hydrochloric acid to it (Figure 5.1).

   What is your observation?

   .....

3. Add 2-3 mL of potassium iodide solution to 2-3 mL of lead acetate ($Pb(CH_3COO)_2$) solution in a test tube (Figure 5.2).

In which part of the test tube is the product found?

.....

What is its colour?

.....

4. Take some iron sulphide in a test tube. Add 2-3 mL of dilute hydrochloric acid to it and heat.

   Is the smell familiar?

Complete the table based on the activities given above.

Experiment	How the chemical change is identified?
1	The colour of sugar changed.
2	.....
3	.....
4	.....

Table 5.2

Different types of chemical reactions

It can be understood that the chemical change resulting from chemical reactions can be identified by the colour change, the gas liberated, the smell experienced or the products precipitated. Let us see how chemical reactions can be classified based on the products formed.

Take some quick lime (CaO) in a beaker. Pour some water into it. Touch the beaker. What do you observe? Here, calcium oxide reacts with water to form calcium hydroxide ($Ca(OH)_2$). It is an exothermic reaction as well.

Write the chemical equation of the reaction.

.....

Examine the equation of another chemical reaction given below.

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

Which are the substances combined in this reaction?

.....

What is the product obtained as a result of this reaction?

.....

Let us examine another reaction.

$$2SO_2 + O_2 \rightarrow 2SO_3$$

The reaction in which two or more simple substances (elements/compounds) combine to form a compound is called combination reaction.

Can you find out more examples of combination reaction?

Take 3 g of ammonium dichromate ($(NH_4)_2Cr_2O_7$) in a conical flask, cover the mouth of the flask with cotton and heat it.

What change is observed?

.....

When ammonium dichromate undergoes thermal decomposition, chromium trioxide (Cr_2O_3), water vapour and nitrogen are formed (Figure 5.3).

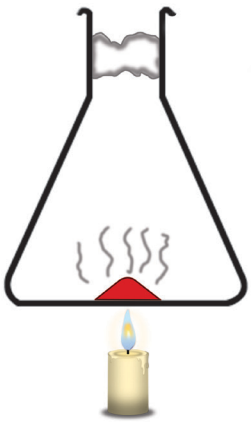


Figure 5.3

$$(NH_4)_2Cr_2O_7 \rightarrow Cr_2O_3 + 4H_2O + N_2\uparrow$$

Examine the following chemical reactions.

$$2Pb(NO_3)_2 \rightarrow 2PbO + 4NO_2\uparrow + O_2\uparrow$$

$$CaCO_3 \rightarrow CaO + CO_2\uparrow$$

Which substances underwent decomposition?

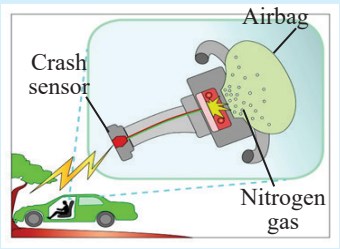
What are the products obtained?

Decomposition reaction is the process by which a compound breaks down into two or more substances.

Can you find out more examples of decomposition reactions?

? Heat a small amount of copper carbonate ($CuCO_3$) in a boiling tube. What change is observed? What are the products obtained? Write the balanced chemical equation of the chemical reaction.

The chemistry of airbag activation in vehicles



You know that airbags are used for safety in vehicles. When an accident occurs, the airbags come out suddenly and protect the driver and passengers from the impact to some extent. This occurs when the bag gets filled with the nitrogen gas, produced by the decomposition of sodium azide.

$$2NaN_3 \rightarrow 2Na + 3N_2\uparrow$$

There are collision detection sensors in the vehicle. During collision, these sensors detonate a small amount of an igniter compound using an electrical sensor. The heat from this combustion decomposes the sodium azide, producing sufficient amounts of nitrogen gas to fill the airbag. This requires only 0.03 seconds.

Take 2-3 mL solution of sodium chloride (NaCl) in a test tube. Add 2-3 mL solution of silver nitrate ($AgNO_3$) into it. What do you observe?

Figure 5.4

Examine the chemical equation of this reaction given below.

$$NaCl + AgNO_3 \rightarrow AgCl\downarrow + NaNO_3$$

Can you identify the product precipitated as a result of this reaction? (Figure 5.4)

.....

In one of the reactants, sodium chloride, which ion is bonded to the sodium ion?

.....

Among the products formed, with which metal ion does the chloride ion combine?

.....

Consider the nitrate ion in the second reactant silver nitrate. With which metal ion does the nitrate ion combine to form the product?

.....

In the reaction between sodium chloride and silver nitrate, ions are exchanged.

Double decomposition reaction is a reaction in which two compounds, reacting with each other, interchange their ions to form two new compounds.

Double decomposition reactions can be classified into three types.

1. Precipitation reactions - Precipitates are insoluble solid compounds which can be separated from the solution.

$$MgCl_2 + H_2SO_4 \rightarrow MgSO_4\downarrow + 2HCl$$

2. Reactions that involve formation of gas.

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2\uparrow$$

3. Reactions that involve formation of products among which at least one compound does not dissociate into ions.
The neutralisation reaction between an acid and a metal hydroxide base to give water and salt is an example of such a chemical reaction.

$$HCl + NaOH \rightarrow NaCl + H_2O$$

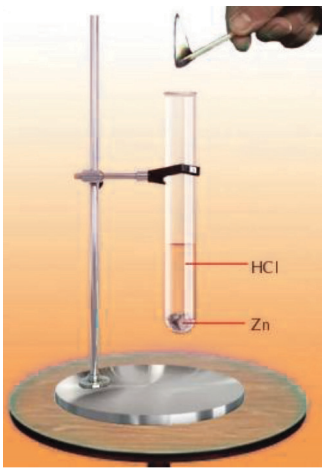


Figure 5.5

Examine the chemical equation given below and identify the ions which are exchanged by the compounds.

$$BaCl_2 + H_2SO_4 \rightarrow BaSO_4\downarrow + 2HCl$$

Can you find out more examples of double decomposition reaction?

Take 5 mL of dilute hydrochloric acid in a test tube, put some zinc granules in it and insert a lighted matchstick to the mouth of the test tube. What do you observe? (Figure 5.5)

.....

Which gas burns with a 'pop' sound?

.....

Notice the balanced chemical equation of this chemical reaction, given below.

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2\uparrow$$

During this chemical reaction, which atom replaces hydrogen in the reactant, HCl, to form the product?

.....

The zinc atom replaces the hydrogen atom in hydrochloric acid.

Reactions in which an element in a compound is displaced by another element are called displacement reactions.

Can you find out more examples of displacement reactions?

You are now familiar with four different types of chemical reactions. List their characteristics.

Reaction	Characteristics
Combination reaction	
Decomposition reaction	
Double decomposition reaction	
Displacement reaction	

Table 5.3

? Classify the following chemical reactions into combination reaction, decomposition reaction, double decomposition reaction and displacement reaction. Expand table 5.4 by including more examples.

1. $Zn + 2AgNO_3 \rightarrow Zn(NO_3)_2 + 2Ag$
2. $CaCO_3 \rightarrow CaO + CO_2$
3. $2HI \rightarrow H_2 + I_2$
4. $Cu(NO_3)_2 + Na_2S \rightarrow CuS + 2NaNO_3$
5. $SO_2 + H_2O \rightarrow H_2SO_3$

Thermite

Thermite is a pyrotechnic mixture of a metal powder and another metal oxide. Iron thermite is the most common thermite mixture. It is a mixture of iron oxide and aluminium powder. When the thermite mixture is heated, aluminum displaces iron from iron oxide. The iron obtained is in a molten state due to the release of high amount of heat in this process. Minor cracks in railway tracks can be fixed by thermite process.

$$Fe_2O_3 + 2Al \rightarrow 2Fe + Al_2O_3$$

Combination reaction	Decomposition reaction	Double decomposition reaction	Displacement reaction

Table 5.4

Rate of chemical reaction

Figure 5.6

The above pictures depict some chemical processes. Identify them.

- Explosion
- Rusting of iron
- Changes in rocks due to chemical weathering
- Filling of dental cavity

Do all these chemical reactions occur at the same rate?

You can imagine how difficult it would be to eat food if the chemical mixture used to fill dental cavity sticks to the tooth very slowly.

Similarly, if the rusting of iron is too fast, what will be its harmful effects?

What measures do we take to prevent spoilage of food ?

- Preserve using salt.
- Use of preservatives.
- Keep refrigerated.
- .....
- .....

All chemical reactions do not take place at the same speed. There are several factors that affect the speed of a chemical reaction. Let us examine some of them.

Collision theory

According to collision theory, a chemical reaction occurs when the particles of the reactant collide with each other. Not all collisions between reactant particles lead to product formation. Collisions leading to product formation are called effective collisions. Effective collisions require a certain excess amount of energy for the reactant particles. An increase in the number of particles per unit volume and energy of particles results in more effective collisions which in turn increase the rate of chemical reaction.

1. Nature of reactants

How does the nature of reactants affect the rate of a chemical reaction? Let us do an experiment.

Take equal volume of dilute hydrochloric acid in three test tubes. Place pieces of copper (Cu), zinc (Zn), and magnesium (Mg) of the same size in each of the three test tubes.

Record the observation.

Test tube 1 .....

Test tube 2 .....

Test tube 3 .....

Which test tube shows the highest rate of chemical reaction?

Here, since the metals are of the same size and the volume of hydrochloric acid is equal, it can be understood that the rate of chemical reaction is different due to the characteristic properties of metals like copper, zinc and magnesium.

? Why does magnesium react very slowly with water while sodium reacts vigorously with water at room temperature?

Allotropes of phosphorus

White phosphorus and red phosphorus are two allotropic forms of elemental phosphorus. White phosphorus ignites when exposed to oxygen in the air, but red phosphorus can remain exposed to air for a long period of time.


White phosphorus


Red phosphorus

2. Concentration of reactants

Take equal volume of concentrated hydrochloric acid and dilute hydrochloric acid in two test tubes.

Concentration is the number of molecules per unit volume.

If so, which test tube contains more number of HCl molecules per unit volume?

.....

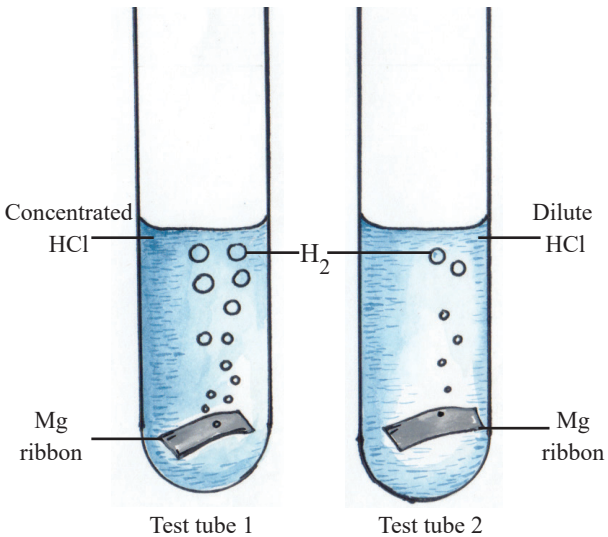


Figure 5.7

Place magnesium ribbons of equal mass in both the test tubes.

Record the observation of the chemical reaction taking place in each test tube.

Test tube 1

.....

Test tube 2

.....

Which test tube shows the higher rate of chemical reaction?

You must have understood that the rate of chemical reaction in the test tube containing concentrated hydrochloric acid is higher because the number of molecules per unit volume is higher.

As the concentration of reactants increases, the number of particles per unit volume increases and consequently the number of effective collisions increases. This increases the speed of the chemical reaction.

?

If a steel wool is heated in air, it will become red hot and gets oxidised slowly (Figure A). But, if the heated steel wool is exposed to an oxygen rich environment, it will burn strongly (Figure B) and produce products at a faster rate. What is the reason for this?

Figure A

Figure B

3. Surface area of reactants

Analyse the given picture.

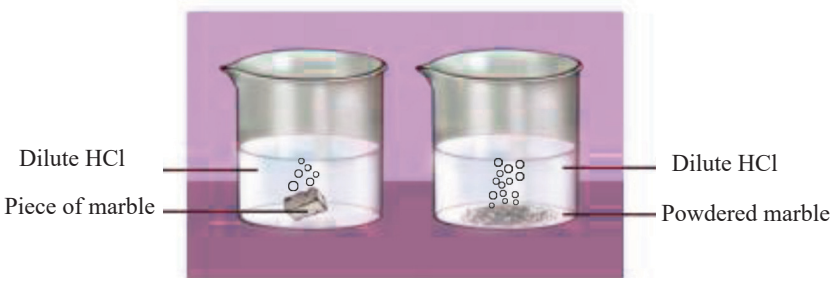


Figure 5.8

Which are the reactants in this chemical reaction?

What are their physical states?

Let us write the chemical equation of this reaction.

$$CaCO_3(s) + 2HCl(l) \rightarrow CaCl_2(s) + H_2O(l) + CO_2(g)$$

Now, take a piece of marble and powdered marble of equal mass. Treat them with dilute hydrochloric acid of equal volume and same concentration. Record the observations.

- Is the rate of the reaction the same in both the beakers?
- Is the surface area of the marble equal?
- What change occurs in the rate of collision between the reactant molecules as the surface area increases?
- What is the change in the rate of reaction if the marble pieces are ground to fine powder?

Surface area is the main factor influencing the rate of chemical reactions involving solids.

When substances are broken down into smaller pieces or powdered, the surface area increases, resulting in an increase in the number of molecules involved in the effective collisions thereby increasing the rate of chemical reaction.

Now you must have understood why wood burns quickly when it is cut into small pieces.

Find out more examples from everyday life to show that the rate of chemical reactions increases with an increase in surface area.

Physical state of reactants and rate of reaction

Rate of chemical reaction is related to the physical state of the reactants. When zinc sulphate and barium nitrate in solid state are mixed, no noticeable reaction takes place between them. But when their aqueous solutions are mixed together, a white precipitate of barium sulphate is immediately formed. This chemical reaction occurs due to the effective collision between the molecules. That is, the physical state of the reactants plays an important role in determining the rate of reaction. This also explains why gasoline vapour ignites more explosively than liquid gasoline.

?

1. Take dilute hydrochloric acid in two test tubes. Put a large piece of egg shell in the first test tube. In the second test tube, add an equal amount of powdered egg shell.

- In which test tube is the rate of chemical reaction found to be higher?
- What is the reason for this?
- Write the chemical equation of the chemical reaction taking place here.

2. Fire crackers used to enrich celebrations contain magnesium. Magnesium gives off a rich glow when it burns. Magnesium powder is used here. What could be the reason?

4. Temperature

Let us examine the reaction between ammonium chloride (NH_4Cl) and sodium hydroxide (NaOH).

What are the products obtained when these compounds react?

Notice the chemical equation of this reaction given below.

$$NH_4Cl + NaOH \rightarrow NaCl + H_2O + NH_3\uparrow$$

Let us try out this experiment.

Figure 5.9

Take 2 mL of ammonium chloride solution in a test tube and pour into it 2 mL of sodium hydroxide solution taken in another test tube.

Did you observe the formation of any product?

Wave your hand so that air from the mouth of the test tube moves towards your nose, as shown in figure 5.9.

Do you experience any smell?

Heat the test tube and check the smell again.

The pungent smell of ammonia is obtained when the test tube is heated. That is, the increase in the rate of reaction is due to the increase in temperature.

Reactants undergoing a chemical reaction require a certain amount of kinetic energy to get converted into products. This energy is called threshold energy.

When the reactants are heated, the kinetic energy of the particles increases. That is, as the temperature increases, the number of particles that attain the threshold energy increases, and as a result, the number of effective collisions increases leading to an increase in the rate of reaction.

?

The procedure for the chemical reaction between sodium thiosulphate ($Na_2S_2O_3$) and hydrochloric acid (HCl) is given below. Identify the factor that affects the rate of a chemical reaction by doing the experiment.

Prepare a dilute solution of sodium thiosulphate in a beaker. Take equal amount of this solution in two test tubes. Heat one of the test tubes for a short while. Pour an equal volume of dilute hydrochloric acid into both the test tubes.

Record your observations.

.....

In which test tube did the precipitate form quickly?

Which factor influenced the rate of the chemical reaction here?

5. Effect of catalyst

Have you heard of the compound hydrogen peroxide (H_2O_2)? An aqueous solution of hydrogen peroxide is used as a disinfectant in

our homes and hospitals. We have used sanitisers containing hydrogen peroxide during the covid outbreak. Hydrogen peroxide can liberate oxygen when it undergoes decomposition.

Notice the chemical equation of this reaction, which is given below.

$$2H_2O_2 \rightarrow 2H_2O + O_2\uparrow$$

Take some hydrogen peroxide solution in a boiling tube. Insert a burning incense stick in the boiling tube.

Is there any difference in the burning of the incense stick?

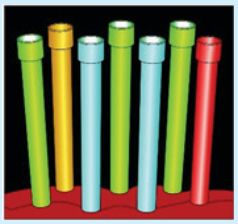
Now, add a little manganese dioxide (MnO_2) into the boiling tube and insert the burning incense stick in the tube again.

What is observed now?

It can be seen that the speed of combustion of the incense stick has increased. This is because the rate of decomposition of hydrogen peroxide increases and more oxygen is released.

Let us recognise the effect of temperature on some of the reactions around us.

- The dough that we grind to make dosa and idli can be seen to ferment quickly at normal temperature but if the dough is kept in the refrigerator, it will rise slowly.
- You know that light worms can emit light by the chemiluminescence effect. Light sticks mixed with certain chemicals can also emit light. Such light sticks can emit intense light at high temperatures.



Here, the decomposition of hydrogen peroxide is accelerated by the substance, manganese dioxide.

Once the process is complete, filter the solution using a filter paper.

What is the residue on the filter paper?

We can see that it is manganese dioxide itself. And on closer examination, it can be seen that there has been no change in its quantity and quality.

Substances that increase the rate of chemical reaction without themselves undergoing any permanent chemical change are called catalysts.

Manganese dioxide is used as a catalyst in the decomposition of hydrogen peroxide.

Similarly, can you identify the catalysts in the following chemical reactions?

1. Manufacture of ammonia by Haber process.

$$N_2(g) + 3H_2(g) \xrightleftharpoons[200atm,\ 700K]{Fe} 2NH_3(g)$$

2. Manufacture of sulphuric acid by Contact process.

$$2SO_2(g) + O_2(g) \xrightleftharpoons[2atm,\ 720K]{V_2O_5} 2SO_3(g)$$

'⇌' indicates reversible reactions.

In addition to the nature, concentration, and surface area of the reactants, temperature and the presence of catalysts also influence the rate of a chemical reaction.

Catalysis in nature

Many catalytic processes occur in nature.

In every living cell, thousands of chemical reactions occur at normal temperature and pressure. These chemical reactions are accelerated by protein molecules known as enzymes, and hence they are catalysts. For example, amylase, found in saliva, is an enzyme that converts starch into maltose.

Catalyst and magic

When a sugar candy is heated, it melts, but does not burn. But if it is melted after a little ash is coated on it, the sugar candy burns. Here, certain metal compounds in the ash act as catalyst in the combustion of the sugar candy.

Bombardier beetle uses catalytic decomposition of hydrogen peroxide for self defence. The enzymes produced by the beetle catalyse a rapid exothermic reaction. As a result, steam and other irritating chemicals are released.

Let us assess

1. Classify the following chemical reactions into combination reaction, decomposition reaction, double decomposition reaction and displacement reaction.

   $Zn + FeSO_4 \rightarrow ZnSO_4 + Fe$

   $NaCl + AgNO_3 \rightarrow NaNO_3 + AgCl$

   $2Pb(NO_3)_2 \rightarrow 2PbO + 4NO_2 + O_2$

   $H_2 + I_2 \rightarrow 2HI$

   $Pb(NO_3)_2 + 2KI \rightarrow PbI_2 + 2KNO_3$

   $NH_4NO_2 \rightarrow 2H_2O + N_2$

Combination reaction	Decomposition reaction	Double decomposition reaction	Displacement reaction

2. Write the balanced chemical equations of the chemical reactions given below and classify them into combination reaction, decomposition reaction and displacement reaction.
   a. Magnesium + Nitrogen $\rightarrow$ Magnesium nitride
   b. Zinc carbonate $\xrightarrow{\text{Heat}}$ Zinc oxide + Carbon dioxide
   c. Aluminum + Lead nitrate $\rightarrow$ Aluminum nitrate + Lead

3. Identify the types of chemical reactions given below.
   i. Formation of black copper oxide on heating copper powder in a china dish
   ii. Silver nitrate solution reacts with sodium chloride solution to form silver chloride and sodium nitrate solution.
   iii. Formation of ferric oxide, sulphur dioxide and sulphur trioxide on heating ferrous sulphate granules in a test tube.

4. What are displacement reactions? Write an example.

5. Write two examples each of chemical reactions that take days or months to complete, and those, that take just a few seconds or minutes.

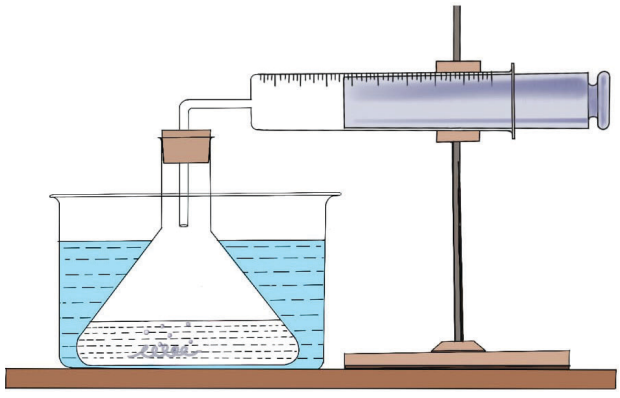
6. How does the rate of a chemical reaction vary when a gas reacts with large pieces of a solid substance and its fine powder? Explain the reason.
7. The rate of a chemical reaction for a fixed amount of a reactant is slow at room temperature. Is it possible to increase the rate of the chemical reaction without changing the temperature? Explain.
8. Zinc reacts with hydrochloric acid to produce hydrogen gas.
   a. Write the chemical equation of this reaction.
   b. What type of chemical reaction is this?
   c. Suggest any two methods for increasing the amount of hydrogen.
9. The chemical equation of the conversion of hydrogen peroxide to water and oxygen is given.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

   a. What type of chemical reaction is this?
   b. Which substance is used to accelerate the decomposition of H_2O_2? By what name is it commonly known?
10. Solutions of ammonium chloride and sodium hydroxide are taken in a test tube and heated.
   a. Which gas is produced?
   b. Which factor helps to increase the rate of the chemical reaction?
   c. What is threshold energy?
   d. Why does the rate of a chemical reaction increase as temperature increases?

Extended activities

1. Carry out the reaction between dilute hydrochloric acid and magnesium, following the experimental procedure given below.



Take 25 mL of dilute HCl in a conical flask. Place a 15 cm long Mg ribbon in the flask and start a stopwatch. Record the volume of hydrogen gas produced every 30 seconds. Swirl the flask slowly at regular intervals to ensure continuous reaction of the reactants. After the experiment, plot a graph between volume of hydrogen on 'Y' axis and time on 'X' axis.

i. When is the rate of the chemical reaction highest in this experiment?

ii. How can the variation in the rate of the chemical reaction be explained?

iii. Repeat the above experiment using 25 mL of concentrated HCl instead of dilute HCl. Draw the graph. What change is noticed in the rate of the chemical reaction?

iv. Repeat the experiment by placing a 5 cm long Mg ribbon in 25 mL of hydrochloric acid. Then, repeat the experiment by replacing the Mg ribbon with magnesium powder of equal mass. Compare the rates of chemical reactions using the graph.

v. Heat the system to 50°C. Then, put a 5 cm long Mg ribbon and record the volume of hydrogen every 30 seconds. Explain how the change in temperature affects the rate of chemical reaction by plotting the graph.

2. Take equal volume of potassium persulphate ($K_2S_2O_8$) solution in two test tubes. Heat one of the test tubes. Pour an equal amount of potassium iodide solution into both the test tubes. In which test tube does iodine get precipitated rapidly and form a brown colour? Write the chemical equation of this reaction. What is the effect on the rate of reaction by adding a little manganese dioxide to the unheated test tube? What is the role of manganese dioxide here?

3. Observe the rate of formation of hydrogen iodide by passing a fixed amount of hydrogen gas at room temperature into the iodine crystals taken in a closed container. Repeat this experiment by heating it upto 130°C. What change occurs in the rate of the chemical reaction? Explain.

6 Solutions

A student prepared a metal box for exhibition in the science fair and painted it with black enamel paint. When the brush was washed using water, the paint did not come off from the brush. What could be the reason?

Later, when the brush was dipped in turpentine as instructed by the teacher, the student was able to wash the paint off. This is because enamel paint is insoluble in water and soluble in turpentine.

You are familiar with many substances which are soluble in water. Can you list them?

Common salt, sugar, ..., ...

Now, can you name some substances which are insoluble?

Enamel paint, sand, ..., ...

The substance that dissolves is called solute and the substance in which the solute dissolves is called solvent. When a solute dissolves in a solvent, a solution is formed.

We have learned that sugar solution is a homogeneous mixture. Solutions are homogeneous mixtures of two or more substances.

A mixture which shows the same property throughout is a homogeneous mixture.

Another important fact is that the components in the mixture do not react chemically.

Different types of solutions

You are familiar with many solutions in daily life.

They are often liquid solutions. There are solid solutions and gaseous solutions also.

Some solutions are given in the table. Find out the solute and the solvent, identify their physical states and complete the table (6.1).

Solution	Solute and its state	Solvent and its state	State of solution
Table salt solution	Table salt Solid	Water Liquid	Liquid
Brass	Zinc	Copper	.....
Soda water	CO_2	Water	.....
Mixture of alcohol and water	Alcohol	....	.....
Blue vitriol ($CuSO_4$) solution	..... Solid	Water	.....

Table 6.1

You have understood that solutions are seen in different states of matter. Is there any relation between the state of the solution and that of the solvent? Examine the table. In most of the cases, the physical state of the solvent itself is the state of the solution.

Why is pure air a gaseous solution? Notice the diagram showing the components of atmospheric air.

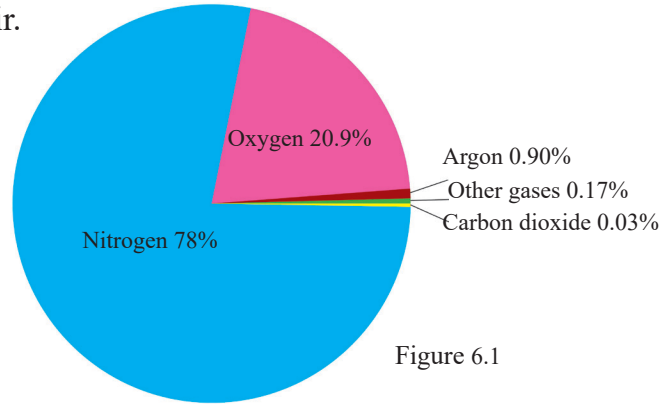


Figure 6.1

We have seen that pure air is a homogeneous mixture of various gases.

How do we find out the solute and solvent in a solution?

Brass, which is an alloy, contains 34% zinc (Zn) and 66% copper (Cu). Find out the solute and the solvent in brass from the table 6.1 and record it.

Solute ..... Solvent .....

The component present in lesser quantity is the solute and the component present in greater quantity is the solvent.

Which component in atmospheric air is the solvent? Why?

.....

In aqueous solutions, water is always the solvent, irrespective of its quantity.

In the beginning of this lesson, we saw that there are substances which are insoluble in water and soluble in some other solvents. Which is the solvent that dissolved the enamel paint?

.....

Certain solvents like turpentine, kerosene, petrol etc., are mixtures of various hydrocarbons.

Alcohol, carbon disulphide (CS_2), benzene (C_6H_6), carbon tetrachloride (CCl_4) etc., are some organic solvents.

All liquids may not mix together to form solutions. Try to dissolve kerosene, petrol etc., separately in water. Do they dissolve? What may be the reason?

916 gold

You may have noticed the advertisements of jewelleries. What do they mean when they claim that theirs is 916 gold? 1000 g of jewellery contains 916 g of pure gold and the rest is alloyed with silver and copper. This is essential to impart strength to the jewellery. Thus the gold jewellery is a solid solution.

Water is a polar compound while kerosene, petrol etc., are non polar compounds.

A solute dissolves in a solvent based on the general principle 'Like dissolves like.' That is why table salt which is an ionic compound dissolves in water, whereas others like kerosene and petrol do not. You have understood that covalent compounds generally do not dissolve in water.

How does table salt dissolve in water?

Table salt or sodium chloride (NaCl) is an ionic compound formed by the combination of the elements sodium and chlorine. In the solid state, it consists of sodium ions (Na^+)and chloride ions (Cl^-) in an ordered structure. It is the force of attraction between oppositely charged ions that holds them together. When NaCl crystals are added to water, water molecules (H_2O) enter the crystal and surround the Na^+ ion and Cl^- ion. The hydrogen atoms in water molecules have a partial positive charge (δ^+) and the oxygen atoms have a partial negative charge (δ^-). Each Na^+/Cl^- ion is surrounded by water molecules on their oppositely charged sides. Thus, the force of attraction between Na^+/Cl^- ions in water is highly reduced and the ions tend to become more free, resulting in the formation of more hydrated ions. Due to the decrease in the attractive force between the hydrated ions, the table salt crystals lose their crystalline structure and change into an ionic solution. That is, the Na^+/Cl^- ions in the table salt crystal break down into microscopic hydrated ions and dissolve in water. Here, it is generally observed that polar solutes dissolve in polar solvents. That is, a solute dissolves in a solvent on the basis of the principle that 'Like dissolves like.'

Use of solvents in daily life

The uses of water as a universal solvent in different situations are familiar to you.

Let us examine the uses of some other solvents. Solvent mixtures are also included here.

Solvents / Solvent mixtures	Uses
Petrol, kerosene, turpentine, ammonia solution	To remove grease, paint, stain etc., from clothes and for drycleaning.
Borax solution	To remove the stain of tea and coffee from clothes.
Alcohol	To dissolve aromatic oils for the preparation of perfume.
Tincture of Iodine (It is a solution of 2-3% iodine in alcohol and water. Small amount of potassium iodide is also present.)	To clean wounds and as an antiseptic.

Table 6.2

Let us examine some other properties of solution.

You have probably heard people complaining about food being too salty or not salty enough. We feel the difference in tastes according to the amount of table salt added to the food.

Let us do the experiment given below.

Take equal quantity of water in two beakers. Add one or two crystals of potassium permanganate ($KMnO_4$) to one beaker. Add five or six crystals to the second beaker.

Observe the difference in the colour of the solutions in the two beakers.

Beaker 1 : .....

Beaker 2 : .....

What is the reason for the difference in the colour of the two solutions?

.....

The solution containing greater amount of solute is said to be more concentrated. From this, we can understand that the concentration of a solution depends on the amount of solute.

The concentration of a solution refers to the amount of solute dissolved in a fixed amount of solvent. A solution containing a small amount of solute is known as a dilute solution and the one which contains a large amount of solute is known as a concentrated solution.

There are several units to express the concentration of a solution. Let us familiarise ourselves with one of these.

Mass percentage

It is the method of indicating the mass of the solute dissolved in a solution in percentage. It expresses the amount of solute in gram present in 100 g of the solution.

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

For example, if 10 g common salt is dissolved in 90 g water how is the concentration calculated in terms of mass percentage?

Mass of solute = ...g

Mass of solvent = ...g

Mass of solution = 10 g + 90 g = 100 g

Mass percentage of solution = $\frac{10}{100} \times 100 = 10\%$

Some other units that express the concentration of a solution

Parts per million (ppm)

Parts per million is a unit that indicates how many parts per million (10^6) of a given mass of solute are present in a solution. ppm is commonly used to indicate the presence of very small quantities of a solute. For example, the concentration of chlorine in drinking water is 4 ppm. The dissolved oxygen content of sea water is 5.8 ppm. The concentration of carbon dioxide (CO_2), one of the greenhouse gases was 270 ppm in the atmosphere in the pre industrialisation era, but today it has increased to 414 ppm. This is one of the factors responsible for global warming.

Some other units that express the concentration of a solution are volume percentage, molarity, molality etc.

What does it mean if the concentration of the common salt is 15%? It can be understood that 15 g of common salt is present in 100 g of the solution.

? • A solution is prepared by dissolving 2 g of substance A in 18 g water. Calculate the mass percentage of the solution.

Concentration of solvents in terms of mass percentage is important in the production of many products in the industry.

For example, the bleaching solution used for industrial purposes is the aqueous solution of 3.62 mass percentage of sodium hypochlorite. This shows the importance of accuracy in measurement.

Saturated solution

We are familiar with various types of solutes and solvents. How much solute can be dissolved in a solvent? Let us do the activity given below.

Activity 1

Take 100 mL water in a beaker. Dissolve ammonium chloride in small portions. We can see that the solute dissolves in it. Stir continuously adding more ammonium chloride crystals. You reach a particular point when you notice that excess solute does not dissolve any more. A solution thus obtained is called a saturated solution. Note that the temperature remains constant.

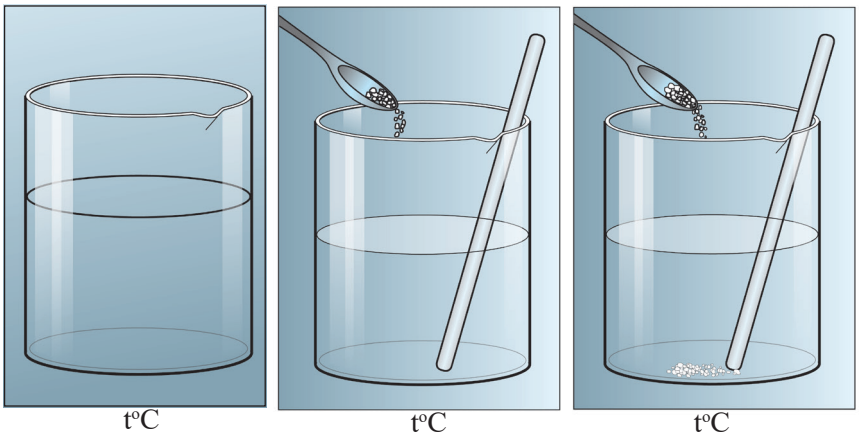


Figure 6.2

A solution obtained by dissolving the maximum amount of solute at a given temperature is called a saturated solution.

Unsaturated solution

Activity 2

You noticed that before the saturated solution is formed ammonium chloride crystals dissolved completely in water. This is called an unsaturated solution.

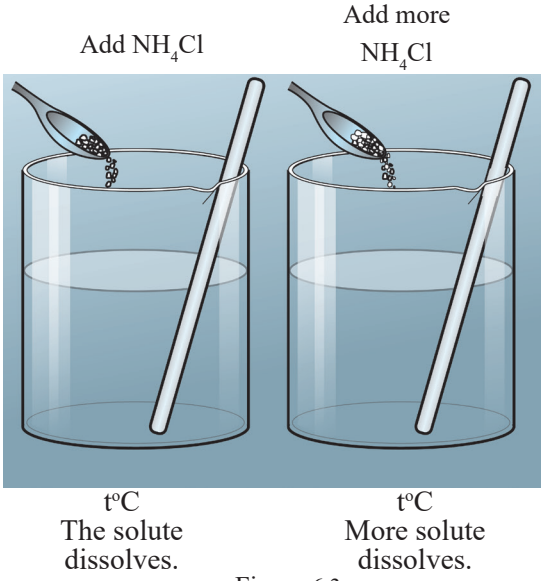


Figure 6.3

A solution obtained by dissolving less amount of solute than that required to make the solution saturated at a particular temperature is called an unsaturated solution.

You have noticed that more solute can be dissolved in an unsaturated solution.

Supersaturated solution

Activity 3

You saw that when a saturated solution of ammonium chloride was prepared, a little solute remained undissolved.

Is it possible to dissolve it?

Try heating it. Add some more ammonium chloride and continue heating. What happens? Does the solute dissolve?

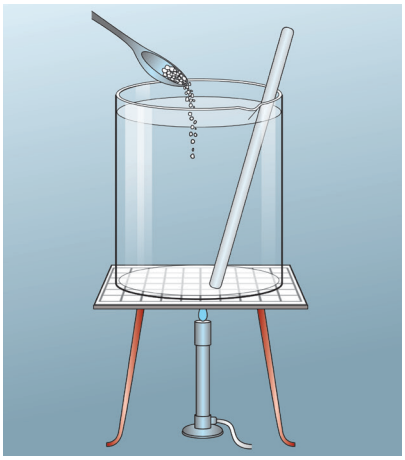
.....

Now, leave the solution undisturbed and allow it to cool gradually to room temperature.

Does the solute get precipitated? Record your observations.

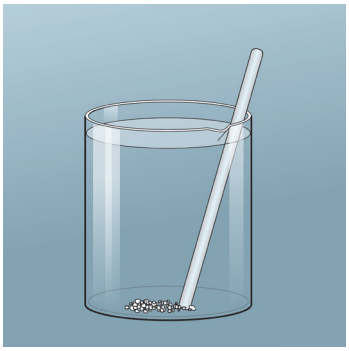
.....

.....



More solute dissolves at higher temperature.

Figure 6.4



On cooling the supersaturated solution, crystals of excess solute are formed.

A solution which contains more amount of solute than required to saturate it at a particular temperature is called supersaturated solution.

Does a supersaturated solution remain stable for a long period? What may be the reason? The excess solute can be precipitated and it can be changed into a saturated solution again.

But if it is carefully brought to room temperature, the dissolved solute often does not precipitate. Let us see how crystals are formed in the supersaturated solution thus prepared.

Growing crystals

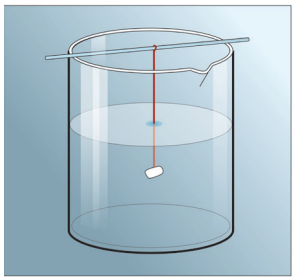


Figure 6.5

Prepare supersaturated solutions of copper sulphate ($CuSO_4$) and potassium nitrate (KNO_3) in separate beakers. Into these solutions, hang one small crystal each (seed crystal) of copper sulphate and potassium nitrate using a thread as shown in figure 6.5. What change do you observe after some time? Observe it again after a day. Record your observations.

.....

The process by which crystals of the solute are formed when a supersaturated solution is cooled slowly is called crystallisation.

Solubility

Do different substances dissolve in the same solvent to the same extent, at a specific temperature? Let us examine.

Take 50 mL water each in two beakers. Take 100 g each of powdered common salt (NaCl) and sodium bicarbonate ($NaHCO_3$) in separate dishes. Prepare saturated solutions by adding common salt to the first beaker and sodium bicarbonate to the second beaker in small portions, stirring slowly. By calculating the amounts of the two salts remaining in each dish from 100 g solute, we can find out the amount of solute required to prepare the saturated solution. Did the two solutes dissolve to the same extent?

Record your observations.

.....

.....

You have seen that the amounts are different. Why is it so?

> The amount of solute in grams required to saturate 100 g of a solvent at a given temperature is the solubility of the solute in that solvent.

Here, we can see that it is the nature of the substance that affects solubility.

You have learnt from the previous experiments that a change in temperature affects solubility.

Does solubility increase with an increase of temperature? Let us examine the graph given below. This is called a solubility curve.

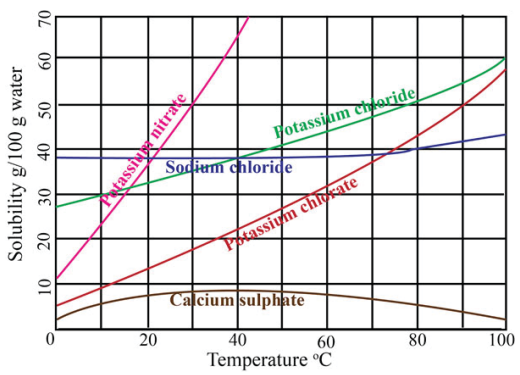


Figure 6.6

This is a graph that shows the solubility of certain salts in water, with respect to temperature.

- What is the change that generally occurs in solubility with a rise in temperature? Increases/Decreases
- Which is the substance whose solubility decreases with a rise in temperature?
- Which substance shows maximum solubility at 30°C?
- What is the peculiarity in the solubility of sodium chloride compared to other salts?

Prepare a note on the relation between temperature and solubility.

Are there any other factors which influence solubility?

We can see that sodium chloride is highly soluble in water. But it is only slightly soluble in alcohol, and insoluble in kerosene. This may be due to the difference in the nature of the solvents.

Normally carbon dioxide (CO_2) gas is only slightly soluble in water. You must have seen that when a bottle of soda is opened, CO_2 gas comes out from the bottle with a brisk effervescence. What may be the reason? Soda water is prepared by dissolving carbon dioxide in water under high pressure.

Which is the factor that affects solubility here?

.....

- On the basis of the observations you have made so far, try to list the factors which affect solubility.

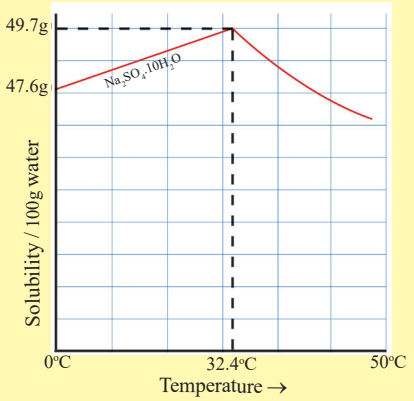
1. ..... 2. .....

3. ..... 4. .....

?

Note the given solubility curve of Glauber's salt ($Na_2SO_4.10H_2O$).

- Find out the characteristics of the solubility of Glauber's salt that differentiate it from other salts.



True solution, Suspension

Are solutions formed when substances are mixed together? Let us mix it up.

Beaker 1 : Water + sugar

Beaker 2 : Water + chalk powder

Stir the contents in both the beakers well, and observe.

In which of these beakers are the particles visible?

.....

Let us examine the beakers after keeping them undisturbed for some time.

In which of these beakers did the particles settle down?

.....

Stir the mixtures in both the beakers well, and pass an intense beam of light through the sides of the beakers.

In which of these beakers is the path of the light beam visible?

Glauber's salt
($Na_2SO_4.10H_2O$)

Glauber's salt is a salt that is added to medicines to relieve constipation (laxatives). It is hydrated sodium sulphate salt. Its solubility at 0°C is 47.6 g. On heating, the solubility increases to a certain point and reaches the maximum solubility of 49.7 g at 32.4°C. It can be seen that its solubility decreases on further heating above 32.4°C. Sodium sulphate exists in the molecular structure, $Na_2SO_4.10H_2O$, upto 32.4°C and absorbs heat and increases its solubility. Above 32.4°C, the kinetic energy of the solute molecules increases and the molecular structure Na_2SO_4 is attained. Due to this, heat is liberated and the solubility tends to decrease. Glauber's salt is cited as an example for anomalous solubility.

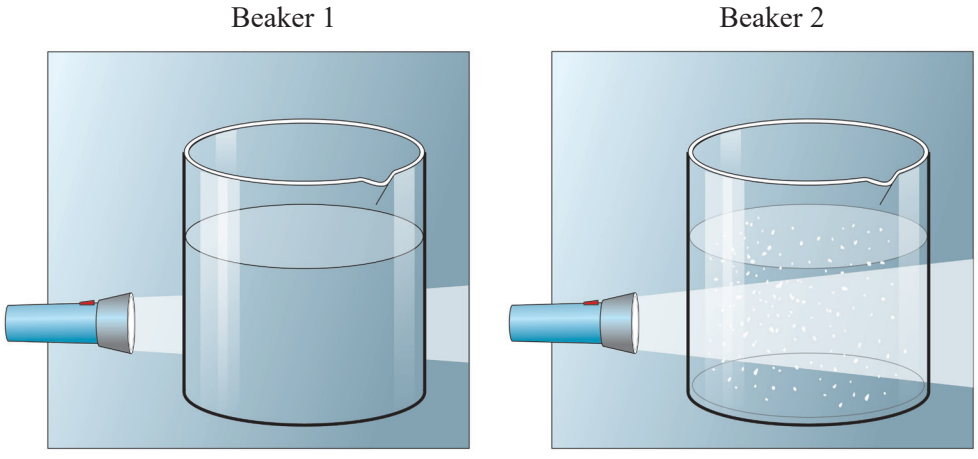


Figure 6.7

Filter each mixture using filter papers. Particles of which beaker could be separated?

.....

The mixture of sugar and water is a true solution. Since it is a homogeneous mixture, it has a uniform composition throughout the mixture. The mixture of chalk powder and water is known as a suspension.

Why is it a heterogeneous mixture? Does the mixture have a uniform composition throughout?

If the components in a mixture are not distributed uniformly, it is known as a heterogeneous mixture.

Find out more examples of heterogeneous mixtures?

Based on which aspects do we consider muddy water as a suspension?

Now, you can tabulate the characteristics of a true solution and a suspension, from what you have observed. Fill up the blank spaces.

Activity	True solution	Suspension
Filtering using a filter paper.	Particles cannot be separated by filtration.	.....
Passing an intense beam of light.	.....	Path of light beam is visible.
Keeping it undisturbed.	.....	.....

Table 6.3

Here, what may be the reason for the difference in observations? Is it due to the difference in the size of the solute particles?

The size of the solute particles is very small in a true solution. They cannot be seen with naked eye or even a microscope. As the particles are very minute, they cannot scatter a beam of light. Hence, the path of light beam is not visible. In the case of a suspension, the solute particles are large enough to be seen with the naked eye. They scatter light. They gradually settle down due to gravity. We can filter these out also.

Colloids

We have learned about solutions and suspensions. Are there any mixtures which are neither of these?

Does milk belong to this category? Let us check.

Take a mixture of water and milk in a beaker and repeat the previously done activity. Tick (✓) your observations.

	True	False
• Particles can be seen with the naked eye.	☐	☐
• Path of the light beam can be seen.	☐	☐
• Particles can be separated by filtration.	☐	☐

We cannot see the particles in it with naked eye as in a solution. They also do not settle down as in a suspension.

But on passing an intense beam of light, the path of the beam is visible.

Colloidal mixtures are intermediate between solutions and suspensions. Hence, we can understand that milk is a colloid.

In cinema theatres and smart classrooms where visuals are shown using a projector, have you noticed that the path of light beam can be clearly seen if there are dust particles in air? What is the reason for this?

The size of the dust particles is equal to the particle size of colloids.

By analysing the above activities, list the characteristics of true solution, suspension and colloid.

Particle size in nanometer

True solution - 0.01 to 1 nm
Colloid - 1 to 1000 nm
Suspension - more than 1000 nm

True solution	Suspension	Colloid

Table 6.4

Let us do an experiment.

Prepare a solution by adding 2 g sodium thiosulphate ($Na_2S_2O_3.5H_2O$) to a beaker containing 50 mL of water. Place the beaker in the path of a beam of light as shown in figure 6.8, add a few drops of dilute hydrochloric acid, and stir well. Observe for a while. Record your observation.

Result .....

As the result of the chemical reaction, sulphur gets precipitated in colloidal form. A path of the light beam is formed. With the passage of time, more and more sulphur particles get separated, and the size of the particles increase. Finally sulphur settles down in the form of suspension.

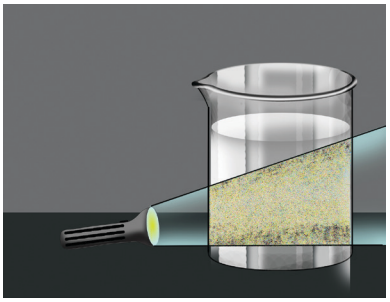


Figure 6.8

The phenomenon of scattering of a beam of light by colloidal particles is known as Tyndall effect.

Try to find out more examples of this phenomenon from daily life.

Colloids in daily life

Colloids have several applications in the modern world. Food production, treatment of waste water, production of cosmetics, medicines, oil/water emulsions, mayonnaise, gels, dairy products are all related to colloids.

Identify the ingredients used in these and prepare a note. Present it in the class.

Mayonnaise

It is a soft colloid commonly used in sandwiches and salads. Nowadays, mayonnaise is used along with alfaham and grilled chicken which are part of the changing food habits. The ingredients used to make mayonnaise are vinegar, vegetable oil and egg white (now milk is used as an alternative). It has been noticed that serious health problems including food poisoning occur if such substances are not kept clean or they turn stale. It is important to ensure food safety while adopting new food habits.

All colloids are made up of two important components. They are dispersion medium and dispersed phase. Dispersed phase will be dispersed in dispersion medium. There are eight major sub classes of colloids. They differ according to the physical state of the above two components.

Different types of colloids

Sl. no.	Type of colloid	Dispersed phase	Dispersion medium	Important examples
1	Solid sol	Solid	Solid	Gems/precious stones
2	Gel	Liquid	Solid	Butter, jam, cheese
3	Solid foam	Gas	Solid	Foam/rubber mattress
4	Sol	Solid	Liquid	Rice starch water
5	Emulsion	Liquid	Liquid	Milk, paint
6	Foam	Gas	Liquid	Soap lather
7	Aerosol	Solid	Gas	Smoke, dust storm
8	Liquid aerosol	Liquid	Gas	Mist, rain clouds

Soft drinks

Figure 6.9

Haven't you seen the preparation of 'kulukki sarbath' in cool drinks shop. What all ingredients are dissolved into it? Some of them are not soluble also.

Drinks are essential to quench our thirst in hot weather. Several juices that we consume are in the colloidal form.

Some stabilisers

- Brominated vegetable oil
- Sucrose acetate isobutyrate
- Glyceryl ester of rosin

Some of them are natural while others are artificial. We can find examples of natural drinks.

Pure water, butter milk, lemon juice, tender coconut water, ...

How long are they fit for consumption?

.....

In the juices and beverages, that are available in the market these days, several chemical substances are added for preserving them for a long period.

The chemicals added to beverages in order to prevent the settling of particles are called stabilisers.

The practice of using certain substances to prevent the spoilage of food has been existing since ancient times. Some of these are vinegar and salt.

They are commonly known as preservatives.

Chemicals that maintain the quality or enhance the taste of food are used for this purpose. Certain chemicals are also added to artificial drinks to give them attractive colours. Let us get acquainted with some of such chemicals.

Chemical substance	Juice / food substance to which it is added	Use
Tartrazine	Food substance, soft drinks	Colouring agent (yellow)
Erythrosine	Food substance, soft drinks	Colouring agent (red)
Indigo caramine	Food substance, soft drinks	Colouring agent (blue)
Vanillin	Food substance	Taste enhancer (flavouring agent)
Phosphoric acid	Soft drinks	To add sour taste
Allyl hexanoate	Food substance	To enhance aroma (pineapple)
Sodium benzoate	Sauce, salad, softdrinks	To prevent yeast, fungus
Sorbic acid	Cheese, cake, salad	To prevent fungus

Table 6.5

You can find such ingredients on the labels of soft drink bottles and packet food. Compare the data with those in this table.

Do soft drinks have any nutritive value? Discuss.

Most of them are harmful to health.

How do such chemical substances which are added to food and drinks affect the body?

You can search and gather information.

Organise discussions and seminars on this topic.

Soft drinks

The habit of using soft drinks is still prevalent among us. Soft drinks are also known as carbonated drinks, fizzy drinks and pop drinks. Many of these are made by passing carbon dioxide through water, adding artificial colours, preservatives, sucrose or artificial sugar, caffeine etc. Artificial sweeteners can stimulate our taste buds and make us crave more sweets. Aspartame, saccharin, fructose corn syrup etc. which are many times sweeter than sugar and relatively cheaper, are the main villains in sweets. Although they are lower in calories than sugar, they increase triglycerides in blood, production of bad fats etc. and lead to various health problems. Their regular use may cause non alcoholic liver cirrhosis and increased appetite. Such sweeteners increase the level of uric acid in the blood and lead to other diseases. Some studies also show that excessive consumption of soft drinks can cause obesity and tooth decay.

Let us assess

1. Define the following terms and answer the related questions given below.
   a. Solute - What is the solute in soda water?
   b. Solvent - Name the solvent that dissolves common salt.
   c. Solution - Differentiate between dilute solution and concentrated solution.
   d. Solubility - Explain what is meant by the solubility of copper sulphate at 25°C?
2. How much water in mL is needed to dissolve 200 g potassium nitrate for preparing a solution having a concentration of 20% ?
3. You must have seen that if sodium metal or sodium chloride salt is placed in water it disappears. Do the two changes occur in the same way? Justify your answer.
4. A solution of sodium chloride is given. Suggest a simple method to prove whether it is saturated or unsaturated.
5. Suppose we want to change a saturated solution to an unsaturated solution. Suggest any two methods.
6. The solubilities of certain salts in a saturated solution prepared in 100 g water, at different temperatures is tabulated below.

Solute	Temperature °C – Solubility (g/100 g water)				
	10°C	20°C	40°C	60°C	80°C
Potassium nitrate (KNO_3)	21	32	62	106	167
Sodium chloride (NaCl)	36	36	36	37	37
Ammonium chloride (NH_4Cl)	24	37	41	55	66

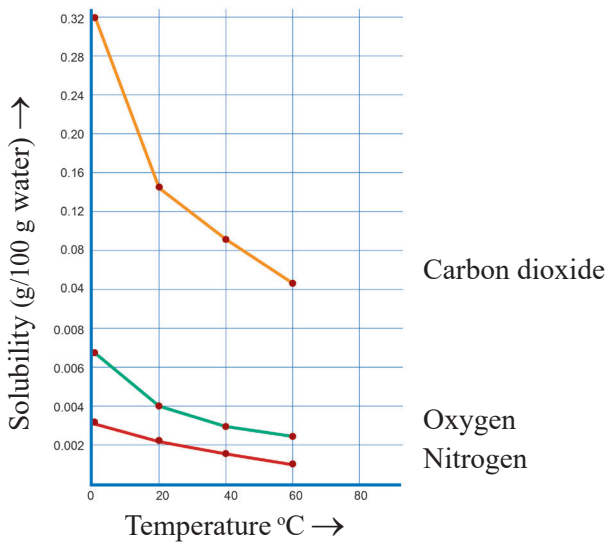
   a. Which salt shows the maximum solubility at low temperature?
   b. How does solubility change when temperature increases?
   c. What is the amount of solute required to prepare a saturated solution of potassium nitrate in 50 g water at 40°C?
   d. Which salt given in the table does not show much difference in solubility with varying temperature?

7. Haven't you noticed the instruction 'Shake well before use' on bottles containing certain medicines?
   a. To which of the following categories do these medicines belong?
      (Colloid, suspension, solution)
   b. What is the reason for the instruction on the label?

8. Classify and tabulate the mixtures given below.
   (Gold ornaments, dilute acid, muddy water, rice starch water, smoke, ink, amalgam, mayonnaise, blood, lime water, ayurvedic decoction.)

True solution	Suspension	Colloid

9. The solubility of three atmospheric gases in water is given in the graph below.



   a. Which gas shows maximum solubility in water?
   b. What is the solubility of oxygen at 20°C?
   c. What is the change in the solubility of gases as temperature increases?
   d. Suggest a method to increase the solubility of CO_2 in water.
   e. Prepare a note on the solubility of gases in water, compared with that of solids.
   f. What may be the changes that occur in nature if oxygen shows more solubility in water? Prepare a note.

10. A small crystal of copper sulphate is suspended in a supersaturated solution and an unsaturated solution of copper sulphate. What will be the observation on the next day?

11. Why are stabilisers used in soft drinks?

Extended activities

1. Prepare a supersaturated solution of sodium silicate (Na_2SiO_3) in a trough. It dissolves easily in hot water. After it reaches room temperature, add seed crystals of various chemicals to it. Copper sulphate, ferrous sulphate, ferric chloride, cobalt chloride, nickel sulphate or other available ones can be added. Keep the trough still. After a few days, it can be seen that chemicals have grown upwards from the crystals like spikes.

   Prepare a digital album by collecting photos of the products.

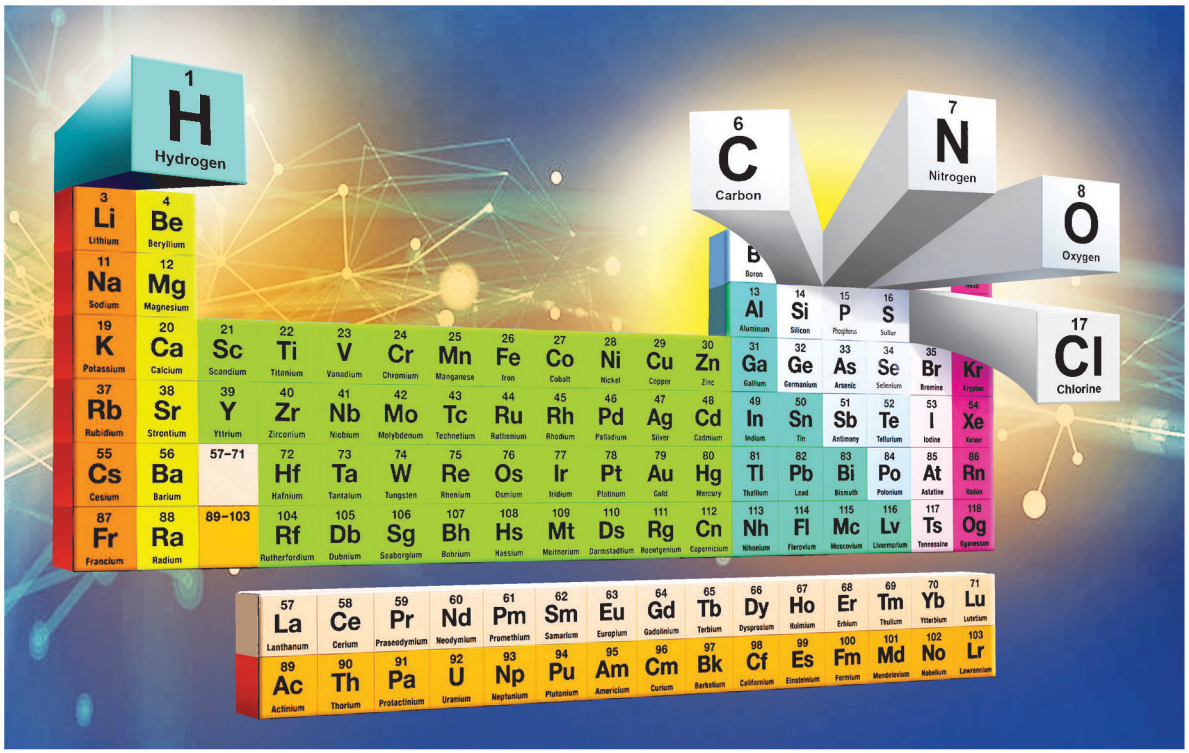
2. You might have seen the process of making tea in the kitchen. What are the ingredients used to make tea? Present the process of making tea using a note. The presentation should include terms such as solute, solvent, solution, dissolution, insoluble, filtration, precipitation etc.

3. You are familiar with several situations in which mixtures are used in everyday life. Make a table showing such situations and the mixtures used, and present in the class.

4. Diverse dietary styles and the desire to discover and try out new and delicious dishes are widespread among us. We also hear news about food poisoning nowadays. Prepare a script that calls for fostering a healthy food culture, and present it in the class in the form of a play.

   A collage can also be made by collecting newspaper articles and other notes related to food safety.

7 Non Metals



You know that the elements in the periodic table are classified into metals, non metals and metalloids. Examine the periodic table, find out some examples of metals, non metals and metalloids, and complete the table.

Metals	Non metals	Metalloids

Table 7.1

Hydrogen, carbon, oxygen, nitrogen and chlorine are some important non metals. You have learnt in the previous chapter about the families to which these elements belong. Let us examine the methods of their preparation and some of their physical and chemical properties.

Hydrogen

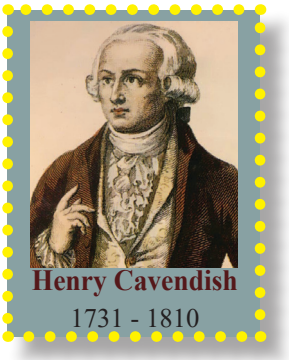
Hydrogen is the most abundant element in the universe. It is the major component in the sun and other stars. Hydrogen is seen in the atmosphere in a very small quantity in free state.

Complete the given table and write a short note on hydrogen.

Atomic number	
Mass number	
No. of electrons	
No. of protons	
No. of neutrons	
Solubility in water	
Isotopes	

Table 7.2

Preparation of hydrogen in the laboratory


Henry Cavendish
1731 - 1810

Hydrogen was discovered in 1766, by Henry Cavendish, a British scientist. He described it as 'inflammable air'. The name hydrogen is derived from the Greek word 'hydrogenes' which means something that produces water.

Arrange apparatus as shown in figure (7.1). Take 5 mL of dilute hydrochloric acid in a test tube. Add some zinc granules into it. Record your observation.

Is the gas produced hydrogen? How do you confirm it?

Insert a burning splint to the mouth of the test tube. What do you observe?

.....

Write the balanced chemical equation of the above reaction.

.....

Hydrogen is industrially prepared by the electrolysis of water.

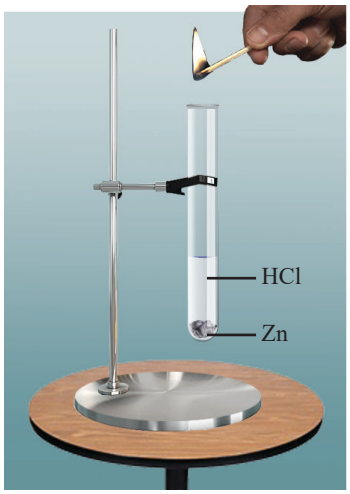


Figure 7.1

Properties of hydrogen

- Hydrogen is a colourless and odourless gas.
- Insoluble in water.
- Density is less than that of air.
- Hydrogen exists as diatomic molecules.
- Hydrogen gas burns with a pop sound.

Some important chemical reactions of hydrogen

1. When hydrogen burns in oxygen, water is formed.

$$2H_2 + O_2 \rightarrow 2H_2O + \text{Heat}$$

2. Hydrogen combines with chlorine in the presence of sunlight and forms hydrogen chloride.

$$H_2 + Cl_2 \xrightarrow{\text{sunlight}} 2HCl$$

- To which category do the above reactions belong?

  (Combination reaction, displacement reaction, decomposition reaction)

Uses of hydrogen

- For the industrial production of ammonia and methanol (CH_3OH).
- As a fuel.
- For the preparation of saturated oils like vanaspati.
- Hydrogen is used as a reducing agent to extract metals from metal oxides.

Hydrogen as a fuel

The calorific value of a fuel is the heat energy released from unit mass of the fuel on complete combustion.

The graph given below shows some fuels and their calorific values.

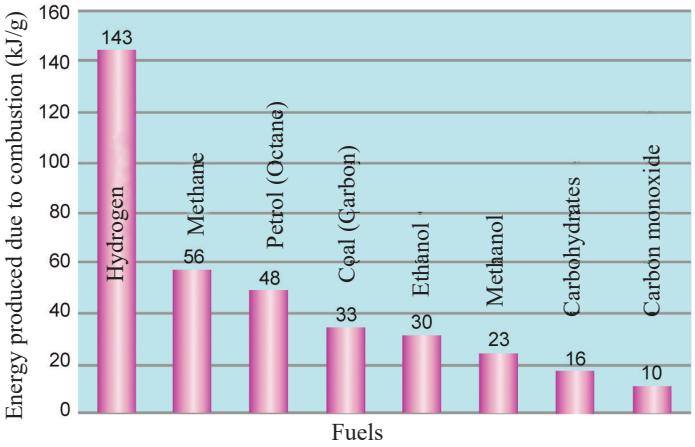


Figure 7.2

- Which fuel has the lowest calorific value?

  .....

- Which fuel has the highest calorific value?

  .....

- What is the product obtained when hydrogen burns in air?

  .....

After analysing the graph you might have understood that the calorific value of hydrogen is higher than that of other fuels.

What are the merits of hydrogen as a fuel?

- When hydrogen is used as a fuel, the possibility of pollution is very low, since water is the only product formed.
- High calorific value

Inspite of these merits, hydrogen is not used as a domestic fuel. This is due to some limitations. Write the limitations in a table.

- Hydrogen is a gas that burns with an explosion.
- It is difficult to store and distribute hydrogen.

If these limitations are overcome, hydrogen will become a universal fuel. The problems like the scarcity of fossil fuels and environmental pollution can thus be resolved.

- Which compounds of hydrogen are known to you?
- Which properties of hydrogen are used in the following situations?
  a. Balloons filled with hydrogen fly high in the air.
  b. Used as fuel.
- Prepare a note on the possibility of using hydrogen as a fuel.

Carbon

Almost all substances around us contain carbon. New carbon compounds are discovered or prepared day after day. Carbon is found both in the elemental state and in the combined state in nature.

Examine the periodic table and record the position, atomic number and electronic configuration of carbon in your science diary.

Allotropes of carbon

You are familiar with substances like charcoal, coal and diamond. They differ from one another in their properties. But do you know that they are different forms of carbon?

The different forms of the same element having different physical properties are known as allotropes and this phenomenon is called allotropy.

The allotropes of carbon are categorised into two, crystalline and amorphous. Examine the different types of carbon allotropes given in figure 7.3.

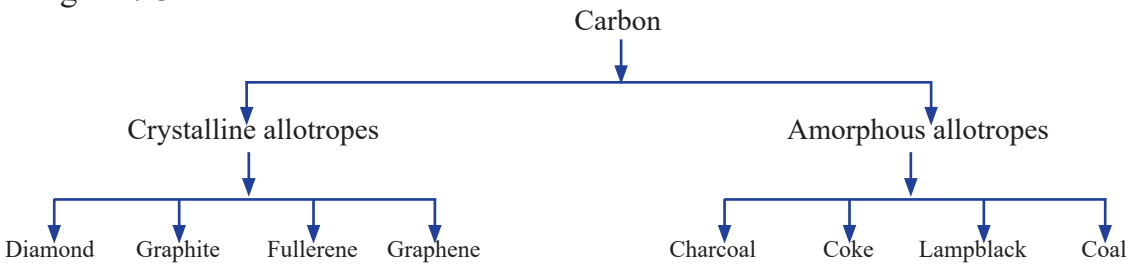


Figure 7.3

Crystalline allotropes

Crystalline allotropes have definite geometrical shape. Particles are arranged in a regular pattern in crystalline forms and the

arrangement is repeated in three dimensions. Let us get familiar with the different crystalline allotropes of carbon.

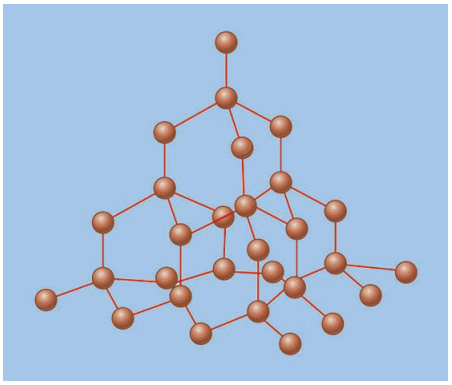


Figure 7.4

Diamond

Diamond is the hardest substance in nature. The peculiarities of diamond is due to its crystalline structure.

Let us examine the crystalline structure of diamond given in figure 7.4.

- In diamond, each carbon atom is covalently bonded to how many surrounding carbon atoms?

  .....

- What is the valency of carbon?

  .....

- Are free electrons present in diamond?

  .....

In diamond, each carbon atom is covalently bonded to four other carbon atoms surrounding it. This strong bond is responsible for the hardness of diamond. Due to the absence of free electrons in this crystalline structure, diamond does not conduct electricity.

Given below are some properties of diamond.

- Hardness is very high.
- Do not conduct electricity.
- High thermal conductivity.
- High refractive index.

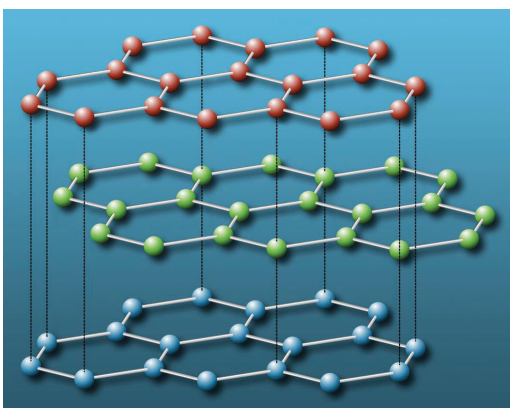


Figure 7.5

Examine the properties of diamond and find out the reason for using diamond for making ornaments and cutting glasses.

Graphite

Graphite is another crystalline form of carbon. Examine the structure of graphite in figure 7.5.

- In graphite, each carbon atom is covalently bonded to how many surrounding carbon atoms?

  .....

- How many free electrons are present on each carbon atom in graphite?

  .....

- Why does graphite conduct electricity?

  .....

In graphite, each carbon atom is covalently bonded to three other carbon atoms surrounding it.

As shown in the figure, graphite has a layered structure with each layer arranged one above the other. There is no covalent bonding between the layers of graphite. The force of attraction between these layers is weak. Hence, one layer can slide over the other. So, graphite is used as a lubricant.

Graphene

Graphenes consist of layers of two dimensional hexagonal carbon rings. Graphene is a single layer of graphite (Figure 7.6).

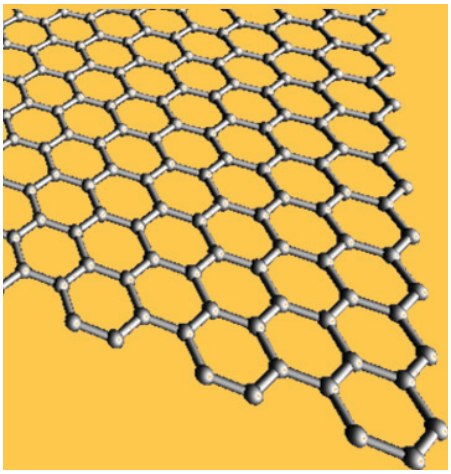


Figure 7.6

Properties of graphene

- One by two hundredth the weight of steel and one fifth the weight of aluminium.
- High electrical conductivity.
- High thermal conductivity.

Graphene has already emerged as a substance that can revolutionise the field of nanotechnology.

Fullerene

Let us examine the structure of fullerene, another allotrope of carbon (Figure 7.7). Fullerenes have a hollow spherical structure consisting of pentagons and hexagons. They are known as Buckyballs. Fullerenes with a cylindrical structure are used as carbon nanotubes. These are called Buckytubes. They have made a revolutionary impact on the field of information and communication technology.

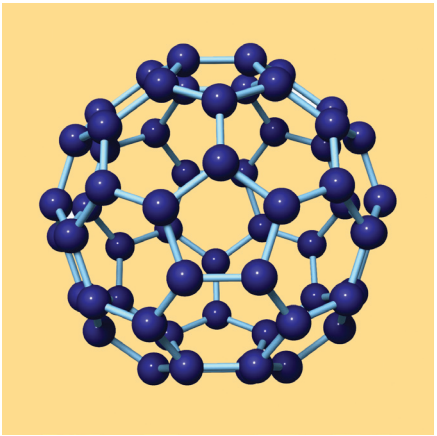


Figure 7.7

Amorphous allotropes

Amorphous allotropes are substances that do not have a definite crystal structure. Charcoal, coke, lampblack, coal etc. are different amorphous allotropes of carbon.

?

- Some uses of graphite are given below. Find out and write the characteristic properties that facilitate it.
  a. Used as electrode in dry cell.
  b. Used to make pencil lead.
  c. Used as lubricant.
- List out and compare the properties of graphite and diamond.

Compounds of carbon

- What are the carbon compounds that you know?
  - .....
  - .....
  - .....
  - .....
  - .....
  - .....
- Which of these compounds contain carbon and hydrogen?
  - .....
  - .....

Carbon dioxide (CO_2)

What is the major compound produced when carbon or carbon compounds burn in air?

Let us examine the properties of carbon dioxide and carbon monoxide.

Preparation of carbon dioxide in the laboratory

Examine the figure 7.8 and answer the given questions.

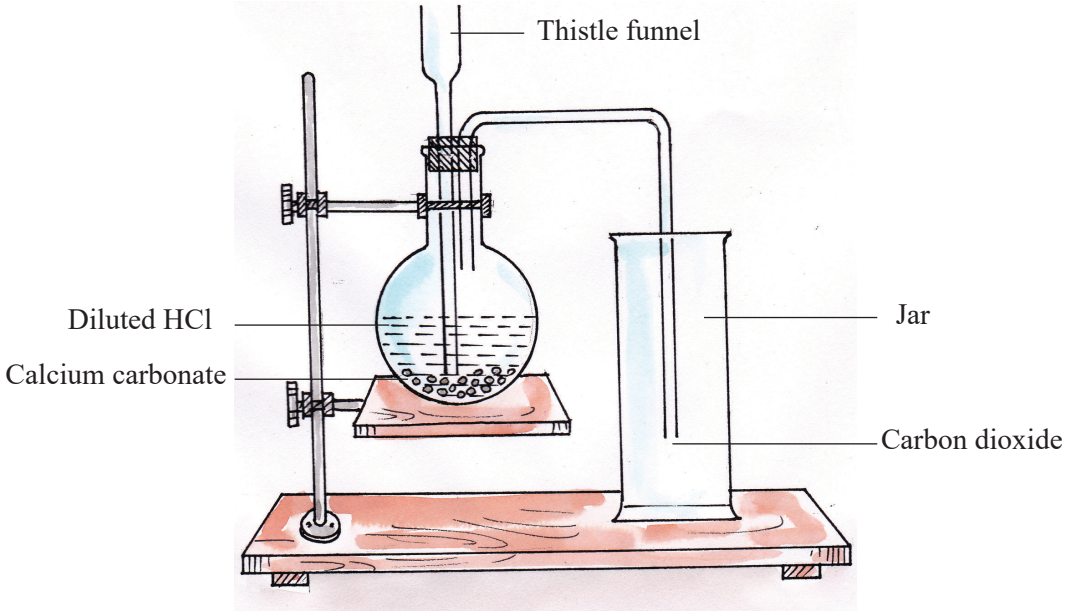


Figure 7.8

- What are the reactants used here?

  .....

- Complete the chemical equation of the reaction.

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + ...$$

- How can we identify that the gas formed here is CO_2?

Carbon dioxide gas is produced when calcium carbonate and dilute hydrochloric acid react with each other. When this gas is passed through lime water ($Ca(OH)_2$), it turns milky. Now, you have understood how carbon dioxide gas can be identified.

Uses of carbon dioxide

- In fire extinguishers.
- To make soda water and soft drinks.
- In the manufacture of washing soda ($Na_2CO_3.10H_2O$), and baking soda ($NaHCO_3$).
- In the manufacture of chemical fertilizers like urea.
- In carbogen (95% oxygen and 5% carbon dioxide) which is used for artificial respiration.
- Solid carbon dioxide is known as dry ice. It is used to create smoky effects in stage shows etc.

Carbon monoxide (CO)

During combustion, if the amount of carbon is very high or that of oxygen is low, the reaction takes place as given below.

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

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

Carbon monoxide reacts with the haemoglobin in blood and forms carboxyhaemoglobin. As a result, the capacity of blood to carry oxygen is decreased, leading to death.

Uses of carbon monoxide

- As gaseous fuel.
- To produce industrial fuels like water gas ($CO + H_2$) and producer gas ($CO + N_2$).
- As a reducing agent in metallurgy.

Carbonates and bicarbonates

Other compounds containing carbon are carbonates and bicarbonates. Eg. washing soda ($Na_2CO_3.10H_2O$), baking soda ($NaHCO_3$) and marble ($CaCO_3$). Carbonates and bicarbonates are salts of carbonic acid (H_2CO_3).

Method to identify carbonate salts

How can you identify whether a salt is a carbonate? Conduct the following experiment and write the observation and inference in the table given below.

Experiment	Observation	Inference
Add barium chloride ($BaCl_2$) solution to the given salt solution. Add dilute hydrochloric acid to the white precipitate formed.		

Table 7.3

If the white precipitate is soluble in dilute hydrochloric acid, the given salt is a carbonate.

- Tick the properties of carbon dioxide from the following.
  - Coloured / colourless
  - Helps combustion / does not help combustion
  - Odorous / odourless
  - Denser than air / lighter than air
  - Aqueous solution – Acidic / Basic
- Match the columns A and B suitably.

A	B
Washing soda	$NaHCO_3$
Carbon monoxide + Hydrogen	$Na_2CO_3.10H_2O$
Baking soda	Producer gas
	Water gas

Nitrogen

Nitrogen is the most abundant gas in the atmosphere. Nitrogen is present in all living beings. Nitrogen is an element that is essential for the growth of plants.

- Under normal circumstances, atmospheric nitrogen is inert. Write down the reason.

  .....
- Which gas helps combustion?

  .....
- Which gas helps to control the rate of combustion?

  .....

Plants cannot absorb nitrogen directly from the atmosphere. Let us examine how plants get atmospheric nitrogen.

1. Through thunder and lightning: The triple bond in the nitrogen molecule is broken down during thunder and lightning, and nitrogen combines with atmospheric oxygen to form nitric oxide (NO).

$$N_2 + O_2 \rightarrow .....$$

The nitric oxide thus produced combines with more oxygen to form nitrogen dioxide (NO_2).

$$2NO + O_2 \rightarrow 2NO_2$$

In the presence of oxygen, nitrogen dioxide dissolves in rain water and reaches the soil as nitric acid (HNO_3).

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

This nitric acid reacts with the minerals in the soil and forms nitrate salts which are absorbed by plants.

2. Through nitrogen fixation, rhizobium bacteria in the roots of leguminous plants absorb atmospheric nitrogen and convert it into compounds that can be absorbed by the plants.

- What are the methods by which we can supply the elements required for plant growth in large amounts?
  - Use of organic fertilizers
  - Use of chemical fertilizers

Notice the characteristics of chemical fertilizers and organic fertilizers given below. Write the merits and demerits of chemical fertilizers and organic fertilizers, based on table 7.4.

Organic fertilizers	Chemical fertilizers
Eco friendly.	Increase crop yield.
Maintain the original nature of the soil.	Easily available.
Delay in making the nutrients available.	Quick supply of the three nutrients (N, P, K).
Do not destroy microorganisms in the soil.	Change the organic structure of the soil.
More quantity is required.	Increase the acidity of soil.
Reduce the possibility of pollution.	Cause pollution.

Table 7.4

Fertilizers should be used scientifically and judiciously in the field of agriculture.

Physical properties of nitrogen

- Colourless, odourless gas
- Solubility in water is very low.
- Difficult to liquify.

Uses of nitrogen

- For the industrial preparation of ammonia.
- In the production of nitrogenous fertilizers.
- Liquified nitrogen is used as refrigerant.
- To inflate the tyres of vehicles.
- To avoid the presence of oxygen in food packets.

? • Conduct a debate in science club on the topic role of organic fertilizers and chemical fertilizers in agriculture.

Oxygen

Oxygen is the most abundant element in the earth's crust. Oxygen, which is known as breath of life, is a gas which is inevitable for the existence of life. Oxygen is found in free or combined state in atmospheric air, water, minerals and living organisms.

Preparation of oxygen in the laboratory

Observe the picture of the preparation of oxygen in the laboratory.

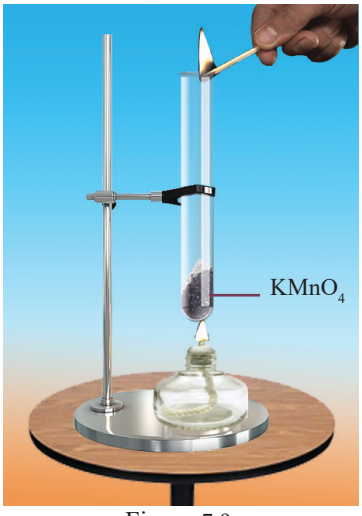


Figure 7.9

- Which is the reactant in this chemical reaction?

  .....

- Heat the boiling tube containing potassium permanganate.
- Insert a burning matchstick to the mouth of the boiling tube. What is the observation?

  .....

- Complete the chemical equation of the reaction.

$$2KMnO_4 \xrightarrow{Heat} K_2MnO_4 + MnO_2 + \_\_\_\_$$

- Pick out from the following the physical properties

Discovery of oxygen

Oxygen was discovered in 1774 by the British scientist Joseph Priestly. But the name 'oxygen' was given by the French scientist Lavoisier. The name oxygen is derived from the word 'oxygenes' which means 'acid producer'.

Joseph Priestly
1733 - 1804

suitable to oxygen. Write them down.

Colour	Yes / No
Odour	Yes / No
Solubility in water	Soluble / Insoluble
Nature of combustion	Burns / Helps to burn.

Table 7.5

Oxygen is manufactured by the electrolysis of water.

$$2H_2O \xrightarrow{\text{electrolysis}} 2H_2 + O_2$$

Important chemical properties of oxygen

- Oxygen reacts with metals and non metals to produce their oxides.
- Oxygen reacts with non metals like carbon and hydrogen to form carbon dioxide and water respectively.

$$C + O_2 \rightarrow .....$$

$$2H_2 + O_2 \rightarrow .....$$

Haven't you noticed that some metals lose lustre in the course of time due to their reaction with oxygen? You may have understood the reason for this.

Uses of oxygen

- Helps combustion.
- As an oxidising agent in rocket fuels.
- For artificial respiration.
- Oxyacetylene flame is used in welding.

Ozone (O_3)

You know that oxygen is a diatomic molecule. But, ozone (O_3) molecule is formed by the combination of three oxygen atoms. Ozone is found more commonly in the stratosphere.

Atmospheric oxygen absorbs ultraviolet radiation having high

energy and decomposes into oxygen atoms. The oxygen atoms thus formed combine with oxygen molecules to form ozone molecules.

$$3O_2 \overset{\text{UV radiation}}{\rightleftharpoons} 2O_3$$

This process takes place through the following steps.

$$O_2 \xrightarrow{UV} 2O$$

$$O_2 + O \rightarrow O_3$$

Ozone absorbs ultraviolet radiation having low energy to form oxygen again. As a result of this cyclic process, the amount of ozone in the atmosphere remains constant. The energy for these processes is obtained from the ultraviolet radiation from the sun. So, such harmful radiation does not reach the earth excessively. Ozone is a greenhouse gas.

Ozone layer depletion

Chlorofluorocarbon (CFC) causes the depletion of ozone layer. The chlorofluorocarbons which mix with the atmosphere, reach the stratosphere and undergo self dissociation to form chlorine. This chlorine decomposes the ozone molecule into oxygen. This disturbs the equilibrium of the ozone-oxygen cyclic process. The depletion of atmospheric ozone reduces the absorption of ultra violet radiation.

Chlorofluorocarbons (CFC)

Chlorofluorocarbons or CFC are a type of compounds that contain atoms such as chlorine, fluorine and carbon. They can be easily liquified by applying pressure. When the liquified CFCs evaporate, they produce a cooling effect. Therefore, they are used in refrigerators, AC etc. When these devices are discarded, they cause CFC emission. CFC causes the depletion of ozone layer. Nowadays, CFC is being replaced by compounds that do not contain chlorine. Such compounds include hydrofluorocarbon (HFC), liquified hydrocarbons, liquid ammonia, solid carbon dioxide etc. September 16 is observed as International Ozone Day.

?

- Prepare a note on the role of plants in maintaining the level of oxygen in the atmosphere. Present it in the class.
- Conduct a seminar on ozone depletion and its solutions.

Chlorine

The smell of bleaching powder ($Ca(OCl)_2$) is familiar to you. The presence of chlorine in bleaching powder is the reason for the smell. Chlorine does not exist freely in nature because it is highly reactive.

Complete the table about chlorine after analysing the periodic table.

Atomic number	
Electronic configuration	
Mass number/atomic mass	
No. of electrons	
No. of neutrons	
Valency	
Name of the element family	

Table 7.6

Preparation of chlorine

Let us examine the balanced chemical equation of the preparation of chlorine.

$$2KMnO_4 + 16HCl \rightarrow 2KCl + 2MnCl_2 + 8H_2O + 5Cl_2$$

Analyse figure 7.10 depicting chlorine preparation and write answers to the questions given below.

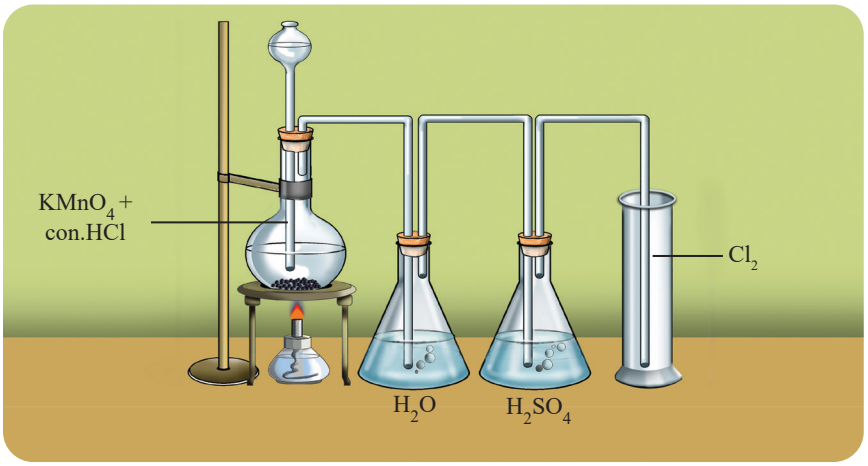


Figure 7.10

- Which are the chemicals required to prepare chlorine in laboratory?

  .....

- What are the products formed?

  .....

- The chlorine gas obtained is collected in the jar after passing it first through water and then through sulphuric acid. Why is it done so?

A small amount of hydrogen chloride vapour is also released along with the chlorine gas. Hydrogen chloride vapours dissolve in water when passed through it.

Sulphuric acid can absorb the water vapour in the chlorine gas. So it is passed through concentrated sulphuric acid.

Physical properties of chlorine

- Greenish yellow in colour.
- Pungent smelling.
- Denser than air.

Bleaching action of chlorine

Take two jars filled with chlorine gas. Take a coloured cloth and cut it into two pieces. Put a wet piece into one jar and the other dry piece of cloth into the second jar.

What happens to the colour of the cloth in the two jars?

……..

Analyse the chemical equations below.

$$H_2O + Cl_2 \rightarrow HCl + HOCl$$

$$HOCl \rightarrow HCl + [O]$$

Water reacts with chlorine to form hydrochloric acid and hypochlorous acid. Hypochlorous acid is unstable. So it decomposes to form hydrochloric acid and nascent oxygen. Nascent oxygen acts as a powerful oxidising agent to decolourise the coloured substances.

Preparation of bleaching powder

You may know that bleaching powder is used for the purification of water. How is it prepared?

Bleaching powder ($Ca(OCl)_2$) is prepared by passing dry chlorine gas through dry slaked lime.

$$2Ca(OH)_2 + 2Cl_2 \rightarrow Ca(OCl)_2 + CaCl_2 + 2H_2O$$

Uses of chlorine

- For bleaching.
- To prepare antiseptics and pesticides.
- As a disinfectant.

Identification of chloride salts

- Take 2 mL sodium chloride solution in a test tube. Add two or three drops of silver nitrate ($AgNO_3$) solution into it. What is your observation?

$$NaCl + AgNO_3 \rightarrow AgCl\downarrow + NaNO_3$$

- Add ammonium hydroxide (NH_4OH) solution to the white curdy precipitate (silver chloride) obtained. What happens to the precipitate?

The precipitate dissolves in ammonium hydroxide solution. This is how we can identify chloride salts. Take different chloride solutions and repeat the experiments.

- Some questions are given below. Find suitable answers from the box given. Write them down.

Nitrogen, nitric oxide, oxygen, carbon, carbon dioxide

- Which gas is obtained when potassium permanganate is heated?
- What is the product formed when nitrogen combines with oxygen at high temperature?
- Which reactant is used along with hydrogen for the manufacture of ammonia?

You have learned about some important non metals. You can learn more about non metals in higher classes.

Let us assess

1. Some gases are given in the following box. Choose suitable answers from the box and answer the questions below.

Hydrogen, chlorine, oxygen, nitrogen

   a. Which gas is formed in the thermal decomposition of $KMnO_4$?

   b. Which gas is used for the purification of water?

   c. Which element is essential for the growth of plants?

   d. Which is the inflammable gas obtained during the electrolysis of water?

2. Find examples of allotropes of carbon and complete the table.

Crystalline allotropes	Amorphous allotropes

3. An experiment is given to identify chloride salt. Write down the observations and inferences.

Experiment	Observation	Inference
i. Add $AgNO_3$ solution to the given salt solution.		
ii. Add NH_4OH solution to the precipitate formed.		

4. Find the suitable gas for each of the following situation.

   (Chlorine, nitrogen, CFC, oxgen)

   - As oxidising agent in rocket fuels.
   - Depletion of ozone.
   - To inflate the tyres of vehicles.

5. Potassium permanganate is heated in a boiling tube.

   a. A burning matchstick is inserted to the mouth of the boiling tube. Write down your observation.

   b. Which gas is produced?

6. Write the answers to the following questions on the preparation of chlorine gas in the laboratory.

   a. What are the chemicals required to prepare chlorine gas?

   b. Chlorine gas is collected by passing it through water. Why?

   c. Chlorine gas is passed through concentrated sulphuric acid. Why?

7. The bleaching action of chlorine requires moisture. Give reason.

8. "Chemical fertilizers must be banned completely and organic fertilizers must be promoted." What is your opinion about this argument? Justify your answer.

9. a. What are the chemicals required for preparing hydrogen in the laboratory?
   b. How will you identify that the gas obtained is hydrogen?

10. a. What are the merits of hydrogen when it is used as a fuel?
    b. What are the isotopes of hydrogen?
    c. Which among these is an isotope without a neutron?

11. a. What is meant by calorific value?
    b. Some fuels are given in the box. Which fuel has the highest calorific value?

Petrol, coal, ethanol, hydrogen, methanol

    c. Hydrogen is not used as a domestic fuel. What are the reasons for this limitation?

12. One of the crystalline forms of carbon is diamond. Diamond does not conduct electricity. Why?

13. a. Which allotrope of carbon is a conductor of electricity?
    b. Give reason for this.
    c. Write down any two uses of this allotrope.

14. Match the following.

A	B
Diamond	Nanotechnology
Graphite	Making of ornaments
Graphene	Lubricants

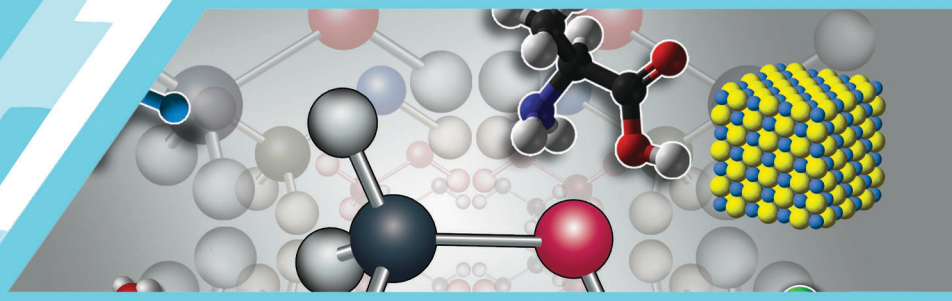
15. a. Dilute hydrochloric acid and calcium carbonate are taken in a test tube. Which gas is produced?
    b. Complete the chemical equation of the reaction.

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + \_\_\_\_\_ + \_\_\_\_\_$$

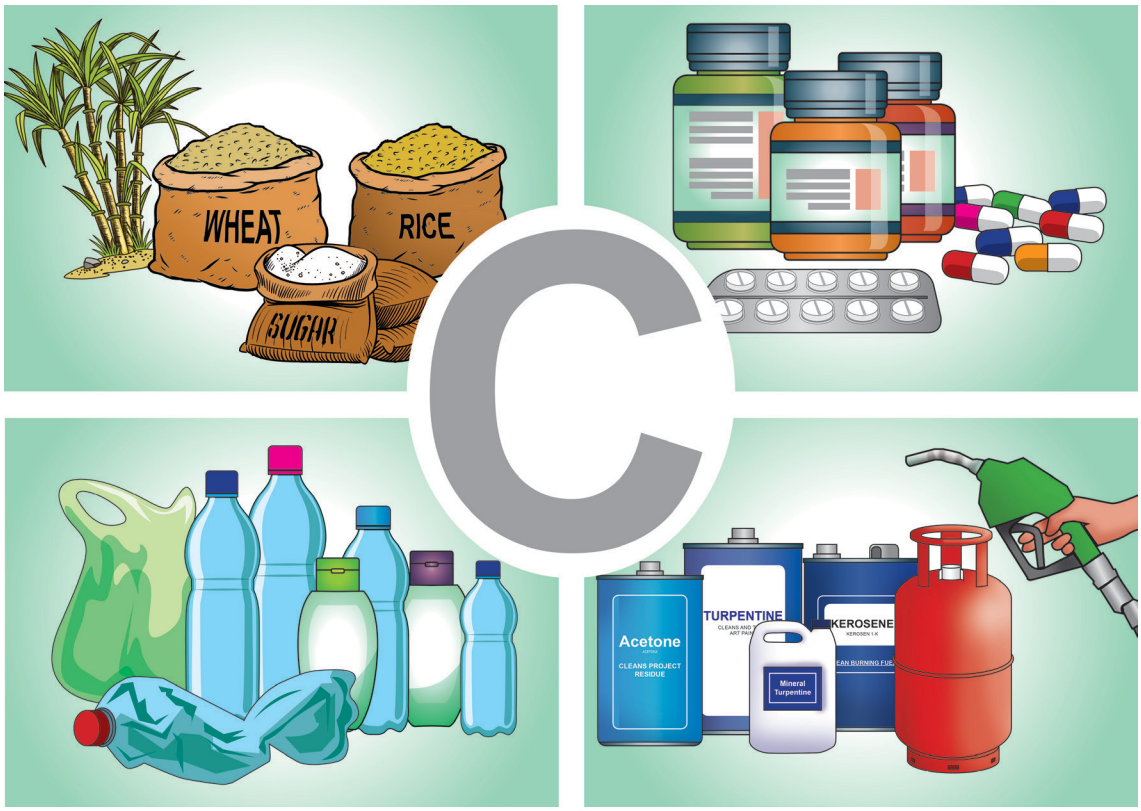
    c. The gas obtained is passed through clear lime water. Write down the observation.

Extended activities

1. Write a short note on the bleaching property of chlorine and present it.
2. Prepare a table showing the use of oxygen, nitrogen and hydrogen in daily life.
3. Visit any chemical fertilizer factory, prepare a project report and present it.



8 Organic Chemistry



Carbon is one of the elements which are most familiar to you. In the previous chapter, we discussed the compounds of carbon such as CO, CO_2, carbonates and bicarbonates. The compounds of carbon other than these are organic compounds. Organic Chemistry is the branch of chemistry that deals with organic compounds.

The branch of chemistry which deals with the study of carbon compounds was named 'organic chemistry' by the scientist Jons Jacob Berzelius. This name is derived from the belief that a vital force is necessary for the formation of organic compounds.

But in 1828, Friedrich Wohler, a German scientist, prepared urea by heating ammonium cyanate, an inorganic compound, which was a setback to the theory of vital force.

$$\underset{\text{Ammonium cyanate}}{NH_4CNO} \rightarrow \underset{\text{Urea}}{H_2N-CO-NH_2}$$

Besides, Kolbe prepared acetic acid (CH_3COOH) in 1845 and Berthelot prepared methane in 1856 from absolutely inorganic compounds. As a result, the relevance of the vital force theory was lost completely. Nevertheless, carbon compounds are still known as organic compounds because of their abundance and diversity.

There is no other branch of science that is so closely related to human life than organic chemistry. Almost every substance we see around us and use contains carbon. The total number of compounds of all other elements is only one tenth of that of carbon compounds. A table containing information about carbon atom is given below. Complete table 8.1 with the help of the periodic table and record it in your science diary.

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

Table 8.1

It is known that carbon has 4 electrons in its outermost shell and that the valency of carbon is 4. Because of this, carbon can form covalent bonds in different ways.

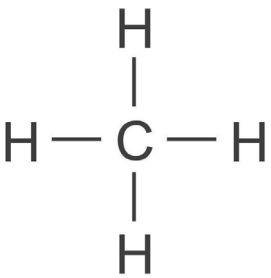


Figure 8.1

Hydrocarbons

The structure of an organic compound is given (Figure 8.1).

What are the constituent atoms in this compound?

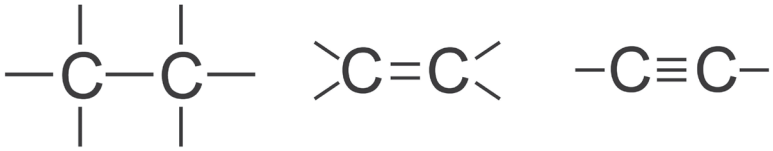
.....

What is the peculiarity of the bond between carbon and hydrogen?

.....

Do you know any other compounds that contain only carbon and hydrogen?

Look at the compounds given below. Complete the valency of carbon using hydrogen atom.



(i) (ii) (iii)

Figure 8.2

- What are the peculiarities of the bond between carbon atoms?

.....

Hydrocarbons are compounds that contain only carbon and hydrogen.

Now it is clear that in hydrocarbons, there are single bond, double bond and triple bond between carbon atoms.

Saturated hydrocarbons

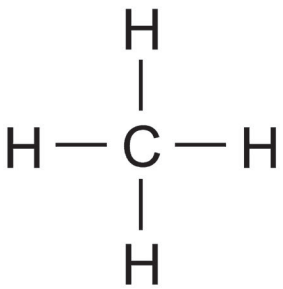
Analyse the structure of the given hydrocarbon and write its molecular formula.

Molecular formula .....

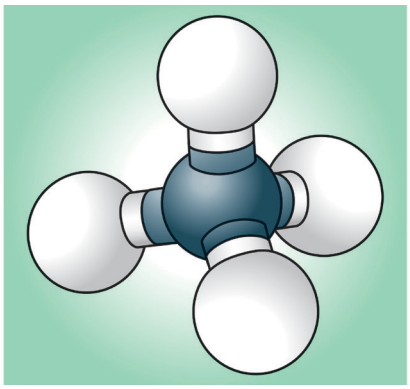
What is the type of covalent bond in this compound?

.....

The structure of another hydro carbon with two carbon atoms and having only a single bond between them is illustrated.

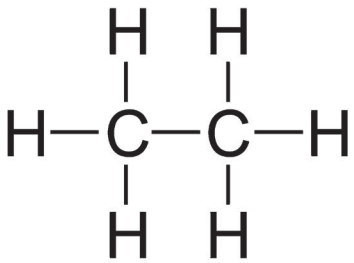


(Methane)
Structural formula

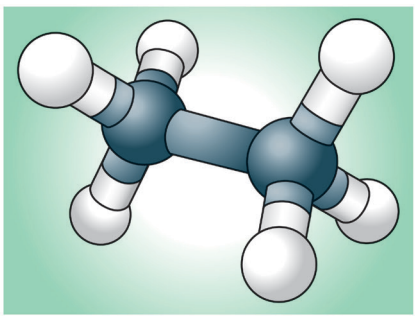


Ball and stick model of CH_4 molecule

Figure 8.3



(Ethane)
Structural formula



Ball and stick model

Figure 8.4

What is the molecular formula of this compound?

The structural formula of this compound (Figure 8.4) can also be represented as $CH_3 - CH_3$. Such a representation is known as condensed formula. Let us write the structure, condensed formula and molecular formula of these types of hydrocarbons including more carbon atoms.

Complete the table.

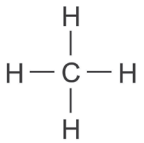
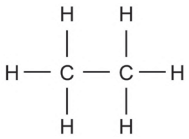
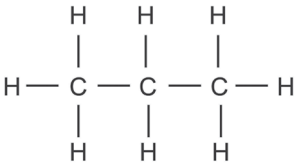
Number of carbon atoms	Structure of hydrocarbon	Condensed formula	Molecular formula	Physical state at room temperature
1		CH_4	CH_4	Gas
2		$CH_3 - CH_3$	C_2H_6	Gas
3		.....	C_3H_8	Gas
4	.....	$CH_3 - CH_2 - CH_2 - CH_3$	.....	Gas
5	.....	.....	C_5H_{12}	Liquid
6	.....	.....	.....	Liquid

Table 8.2

All the compounds given in table 8.2 have only single bond.

The open chain hydrocarbons having only single bonds between the carbon atoms are called alkanes.

In alkanes, since all the four valencies of each carbon atom are satisfied by single bonds, they are also known as saturated hydrocarbons.

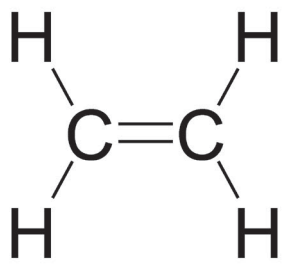
Analyse table 8.2 and answer the given questions.

- How many hydrogen atoms are present in an alkane having one carbon atom? .....
- How many hydrogen atoms are present in an alkane having 2 carbon atoms? .....
- What if there are 3 or 4 carbon atoms? .....
- What number is added to twice the number of carbon atoms to get the number of hydrogen atoms? .....
- If an alkane contains 'n' number of carbon atoms, how many hydrogen atoms will be there? (2n, 2n+2, 2n–2) .....
- Write the general formula of alkanes .....

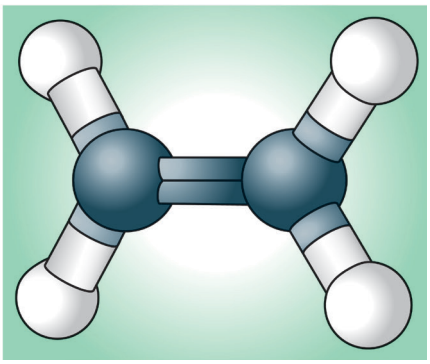
Unsaturated hydrocarbons

Hydrocarbons having double bond or triple bond between carbon atoms are commonly known as unsaturated hydrocarbons.

The structure of a hydrocarbon having a double bond between two carbon atoms is illustrated (Figure 8.5).



(Ethene)
Structural formula



Ball and stick model

Figure 8.5

- What is the molecular formula of the compound given above?
- Write its condensed formula.

Represent the structure of such hydrocarbons having double bond between any of the two carbon atoms, by adding more carbon atoms.

Complete the table given below.

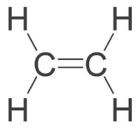
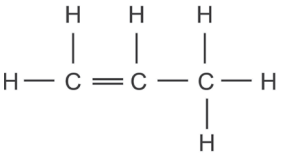
Number of carbon atoms	Structure of hydrocarbon	Condensed formula	Molecular formula	Physical state at room temperature
2		$CH_2 = CH_2$	C_2H_4	Gas
3		$CH_2 = CH - CH_3$	C_3H_6	Gas
4	.....	$CH_2 = CH - CH_2 - CH_3$	.....	Gas
5	.....	.....	.....	Liquid
6	.....	.....	C_6H_{12}	Liquid

Table 8.3

Hydrocarbons having at least one double bond between any two carbon atoms are called alkenes.

Analyse table 8.3

- What is the relation between the number of carbon atoms and the number of hydrogen atoms in alkenes?

  .....

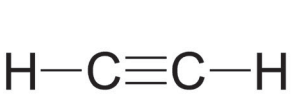
- If an alkene contains 'n' number of carbon atoms, how many hydrogen atoms will be there?

  .....

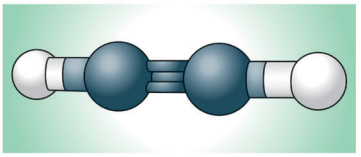
- Write the general formula of alkenes.

  .....

Look at the structure of a hydrocarbon having a triple bond between two carbon atoms.



(Ethyne)
Structural formula



Ball and stick model

Figure 8.6

- Write the molecular formula of the compound given above.
- Write its condensed formula.

Complete the table given below.

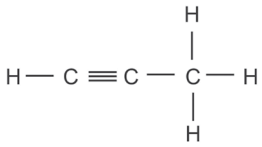
Number of carbon atoms	Structure of hydrocarbon	Condensed formula	Molecular formula	Physical state at room temperature
2	H – C ≡ C – H	CH ≡ CH	C_2H_2	Gas
3		CH ≡ C – CH_3	C_3H_4	Gas
4	.....	CH ≡ C – CH_2 – CH_3	C_4H_6	Gas
5	.....	.....	.....	Liquid
6	.....	.....	C_6H_{10}	Liquid

Table 8.4

Hydrocarbons with at least one triple bond between any two carbon atoms are called alkynes.

Analyse table 8.4

- In these, are the number of hydrogen atoms twice that of carbon atoms?

  .....

- What number is subtracted from twice the number of carbon atoms to get the number of hydrogen atoms in each of these?

  .....

- If an alkyne has 'n' number of carbon atoms, how many hydrogen atoms will be there?

  (2n+2, 2n, 2n–2)

- Write the general formula of alkynes.

  .....

?

Analyse the molecular formula of the hydrocarbons given below and classify them as alkane, alkene and alkyne.

C_5H_{10}, C_3H_4, C_2H_4, C_5H_{12}, C_6H_{12}, C_7H_{12}, C_9H_{20}, C_3H_8, C_4H_6, C_4H_8

Alkane	Alkene	Alkyne

Homologous series

- Analyse the molecular formulae C_2H_6 and C_3H_8.
- To which category do they belong?
  (Alkane, alkene, alkyne)
- What is the general formula of this category?
- What is the difference between C_2H_6 and C_3H_8 in the number of carbon and hydrogen atoms. Let us examine.

Compound	Number of carbon atoms	Number of hydrogen atoms
C_3H_8 C_2H_6	3 2	8 6
Difference in the number of carbon and hydrogen atoms.	1	.....

Table 8.5

- Have you understood that the difference in the number of carbon and hydrogen atoms in these is $–CH_2–$?
- Do C_4H_{10} and C_5H_{12} which belong to this category have the same difference?

Similarly, examine the difference in the number of carbon and hydrogen atoms between any two successive alkene compounds and the difference in the number of carbon and hydrogen atoms between any two successive alkyne compounds.

Alkene

- C_3H_6
- C_4H_8

What is the difference in the number of carbon and hydrogen atoms in these alkenes?
.....

- The general formula of alkene .....

Alkyne

- C_2H_2
- C_3H_4

What is the difference in the number of carbon and hydrogen atoms in these alkynes?
.....

- The general formula of alkyne .....

A series of such compounds is called homologous series.

A homologous series is a series of organic compounds that can be represented by a general formula and have a difference of $-CH_2-$ group between two successive members.

Note 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.

?

- The molecular formula of some hydrocarbons are given below.

$$C_2H_4,\ C_2H_6\ ,\ C_3H_4\ ,\ C_3H_8$$

a. Which of these compounds belong to the same homologous series?

b. Write the general formula of this homologous series.

- The molecular formula of hydrocarbons that belongs to the same homologous series are given below.

$$C_2H_2,\ C_3H_4,\ C_4H_6\ ,\ \underline{A},\ \underline{B}$$

a. Write the molecular formula of the compounds A and B.

b. To which category do these compounds belong? (Alkane, alkene, alkyne)

c. What is their general formula?

d. Draw the structure of compound A.

Nomenclature of hydrocarbons

You are now familiar with the structure, condensed formula and molecular formula of different types of hydrocarbons. Let us see how these hydrocarbons are named.

International Union of Pure and Applied Chemistry (IUPAC) takes the lead role in the naming of elements and compounds. IUPAC has put forward some rules for the naming of hydrocarbons. Let us know more about some of them.

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 progress of mankind. This organisation, formed in 1919, has its headquarters at Zurich in Switzerland. IUPAC takes the lead role in naming elements and compounds, standardising of atomic mass and physical constants, recognising new terms in chemistry etc.

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_6	=	Hex
C_2	=	Eth	C_7	=	Hept
C_3	=	Prop	C_8	=	Oct
C_4	=	But	C_9	=	Non
C_5	=	Pent	C_{10}	=	Dec

Naming of alkanes

Analyse the table given below.

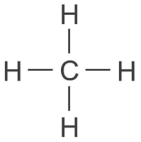
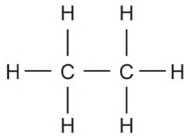
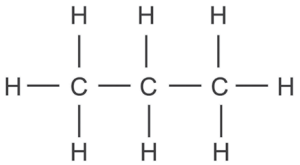
Number of carbon atoms	Structure of hydrocarbon	Condensed formula	Molecular formula	IUPAC name
1		CH_4	CH_4	Methane
2		$CH_3 - CH_3$	C_2H_6	Ethane
3		$CH_3 - CH_2 - CH_3$	C_3H_8	Propane

Table 8.6

Is it clear how the names are derived from word roots?

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

Word root + ane → Name of alkane

Meth + ane → Methane

Eth + ane → .....

Write the IUPAC names of alkanes having 4 to 10 carbon atoms.

Naming of alkenes

The IUPAC names of certain alkenes are given in the table below.

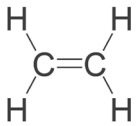
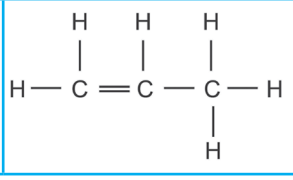
Number of carbon atoms	Structure of hydrocarbon	Condensed formula	Molecular formula	IUPAC name
2		$CH_2 = CH_2$	C_2H_4	Ethene
3		$CH_2 = CH - CH_3$	C_3H_6	Propene

Table 8.7

- Which is the suffix added here?

  .....

- Can you find out how the IUPAC names are given?

Word root +ene → Name of alkene

Eth + ene → Ethene

Prop + ene → .....

Write the IUPAC names of alkenes having 4 to 10 carbon atoms.

Naming of alkynes

Analyse how certain alkynes have been named.

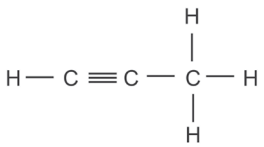
Number of carbon atoms	Structure of hydrocarbon	Condensed formula	Molecular formula	IUPAC name
2	$H - C \equiv C - H$	$CH \equiv CH$	C_2H_2	Ethyne
3		$CH \equiv C - CH_3$	C_3H_4	Propyne

Table 8.8

- How are alkynes named?

.....

Word root + yne → Name of alkyne

Eth + yne → Ethyne

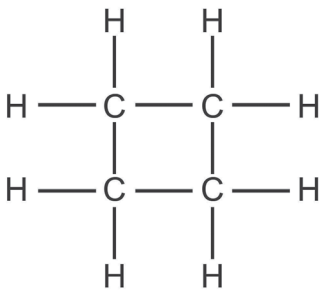
Prop + yne → .....

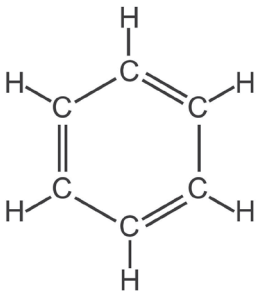
Write the IUPAC names of alkynes having 4 to 10 carbon atoms.

Cyclic or Ring compounds

You are familiar with numerous open chain compounds having single, double and triple bonds.

Notice the structure of a few carbon compounds given below .

1) 

2) 

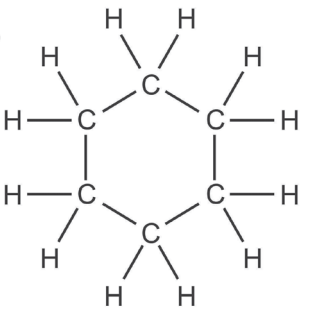
3) 

Figure 8.7

What is the peculiarity in the structures of these carbon compounds?

.....

Carbon atoms have the ability to combine with one another to form cyclic compounds. Cyclic hydrocarbon compounds can be classified into two groups namely alicyclic compounds and aromatic compounds.

Alicyclic compounds

Alicyclic hydrocarbons are cyclic hydrocarbons similar to open chain hydrocarbons like alkane, alkene and alkyne.

The structure and IUPAC name of some alicyclic hydrocarbons are given (Figure 8.8). Write their molecular formula.

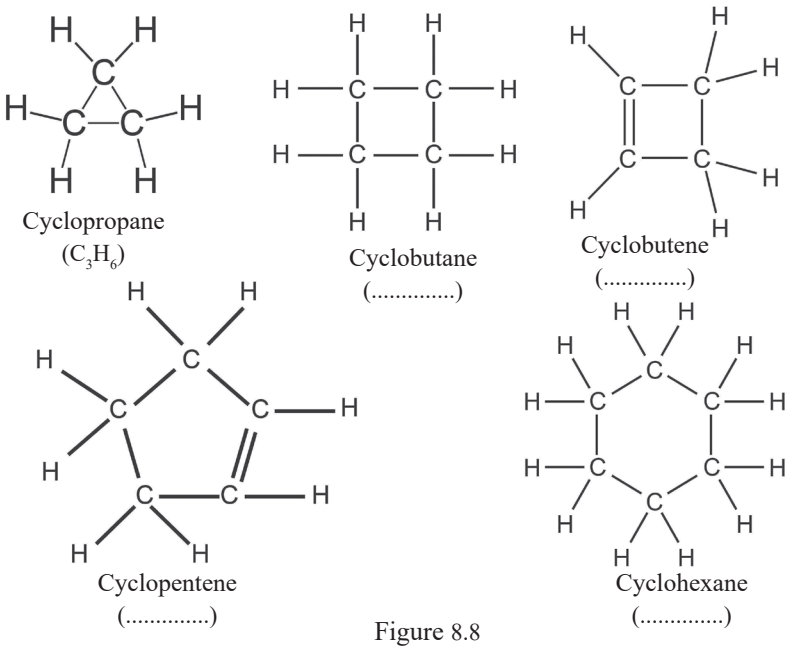


Figure 8.8

How are alicyclic compounds named?

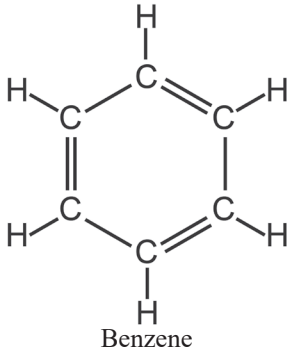
Alicyclic compounds can be named by adding the term 'Cyclo-' as prefix along with the IUPAC name of the hydrocarbon.

Aromatic hydrocarbons

Aromatic compounds are cyclic compounds having a unique aroma. Benzene is an aromatic compound having industrial significance. Note its structure (Figure 8.9).

- Write down the molecular formula of benzene.

.....



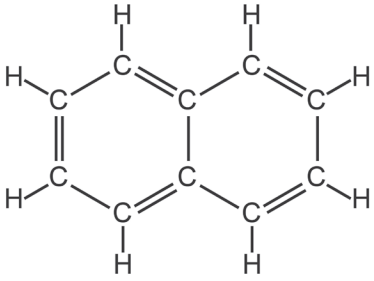
Benzene

Figure 8.9

Naphthalene is another aromatic hydrocarbon with a characteristic odour and a white crystalline form. Two benzene rings are fused together to form its structure. It is the main ingredient in mothball. The structure of naphthalene is given (Figure 8.10).

Write the molecular formula of naphthalene.

.....



Naphthalene

Figure 8.10

Structure of benzene

August Kekule
1829 - 1896

Benzene is a chemical which has been industrially prepared since the 19th century. In 1825, Michael Faraday discovered this compound experimentally. The scientists of those days were not able to explain its structure. August Kekule who had been doing studies on the structure of various chemical compounds tried to discover the structure of benzene. It is said that a dream that he saw led to the discovery of the structure of benzene. He published his research thesis on the structure of benzene in 1865. This discovery made Kekule world famous. The structure of benzene having six carbon atoms and six hydrogen atoms connected by alternate double bonds was proposed by him.

Catenation

Catenation is the ability of the atoms of an element to combine among themselves. Carbon has a high ability for catenation. This ability of carbon is one of the reasons for the large number of carbon compounds found in nature.

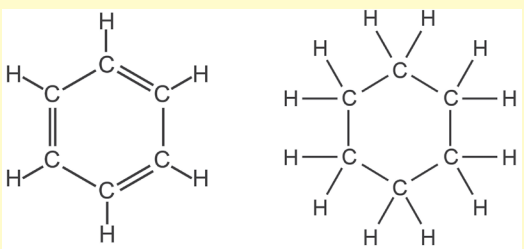
- The structural formula of a hydrocarbon is given below.

$$CH_2 = CH - CH_2 - CH_3$$

  a. Write the molecular formula of this compound.

  b. Draw the structure of a cyclic compound with the same molecular formula.

- The structures of two organic compounds are given below. Compare these.



Compound A Compound B

- You have seen that the number of carbon compounds is very high. List the reasons for this.

Petroleum

Crude oil or petroleum, a fossil fuel, is a mixture of various hydrocarbons and is mined from beneath the earth's surface. It is found among hard rocks that lie far below the surface of the earth (Figure 8.11).

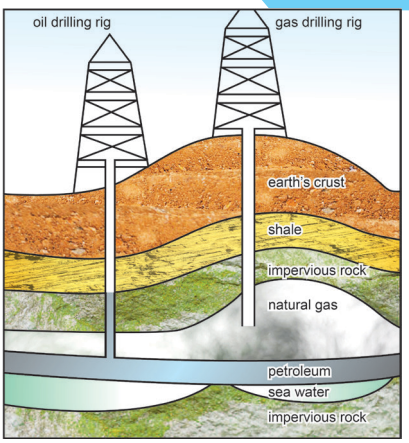


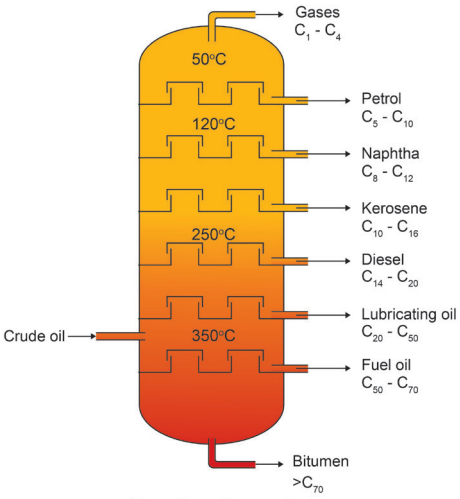
Figure 8.11

Petroleum is formed as a result of the chemical changes undergone by the remains of living organisms over a long period of time. Different components of petroleum are separated using the method of fractional distillation (Figure 8.12).

Some of the components obtained during the fractional distillation (Figure 8.12) of petroleum, and their uses are given in table 8.9.

The number of carbon atoms and the structure of the carbon chain are the important factors which influence the properties of fuels.

The gases obtained during fractional distillation can be condensed under suitable conditions and used for different purposes. The main component of Liquified Petroleum Gas (LPG), used for cooking, is butane (C_4H_{10}) which belongs to the category of alkane.



Fractionating column
Figure 8.12

Components	Number of carbon atoms present in the hydrocarbons	Uses
Gases	$C_1 - C_4$	Domestic/industrial fuel
Petrol	$C_5 - C_{10}$	Motor fuel
Naphtha	$C_8 - C_{12}$	Fuel used in thermal power station
Kerosene	$C_{10} - C_{16}$	Domestic fuel
Diesel	$C_{16} - C_{20}$	Fuel in diesel engine
Petroleum jelly (vaseline), grease	$C_{20} - C_{50}$	Lubricant, manufacture of cosmetics
Fuel oil	$C_{50} - C_{70}$	Used as fuel in thermal power station, ships, industrial furnaces and boilers.
Paraffin wax	$C_{60} - C_{70}$	Manufacture of wax, boot polish, wax paper, tarpaulin sheet etc.
Bitumen	Above C_{70}	Tarring of roads

Table 8.9

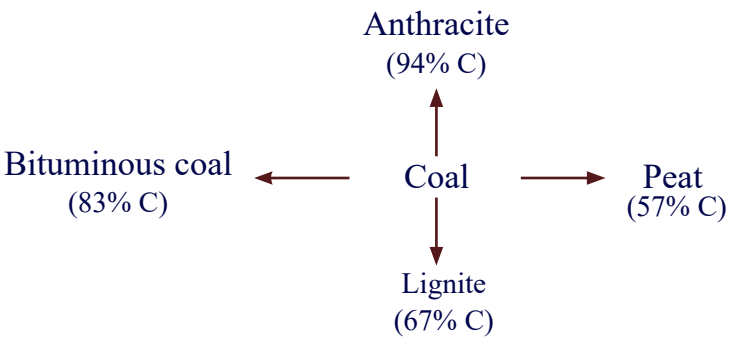
Coal

Coal is also a fossil fuel obtained from the depths of the earth, like petroleum.

Coal is formed as a result of the carbonisation of plant remains that lie buried in the soil for years.

Carbonisation is the process by which remains of plants are converted into carbon at high temperature and pressure in the absence of air.

Coal is mainly composed of carbon because plants contain carbon compounds. But, the amount of carbon present in different types of coal varies. Note the illustration given below, showing different forms of coal and their carbon content.



- Which form of coal has the highest carbon content?

  .....

- Which form of coal has the lowest carbon content?

  .....

Uses of coal

- As domestic and industrial fuel.
- For the manufacture of coke, coal tar, coal gas etc.
- The source of aromatic compounds like benzene, naphthalene, phenol etc.
- For the manufacture of synthetic petrol.
- In the manufacture of some fertilizers, medicines, perfumes etc.

Natural Gas

Natural gas is a fossil fuel. It is often found with petroleum. Its main constituent gas is methane.

CNG (Compressed Natural Gas) is used in many cities today as a pollution free vehicle fuel. Its main component is methane gas at high pressure. Liquified Natural Gas is called LNG. LNG is manufactured by liquifying methane gas under very high pressure. It is an ecofriendly fuel as it emits less carbon than other fuels. Under the GAIL (Gas Authority of India Limited) scheme, LNG is now being supplied in Kerala for industrial and domestic purposes as well.

Global warming

You are already familiar with many carbon compounds. Carbon dioxide is the main gas produced by the combustion of carbon and carbon compounds. Due to human activities and natural causes, the amount of carbon dioxide, methane and nitrous oxide gases in the atmosphere is increasing tremendously. These gases are called greenhouse gases.

You have learnt that ultraviolet and infrared rays reach the earth's surface along with sunlight. Infrared rays are heat radiations. Greenhouse gases present in the atmosphere trap a part of the infrared radiation that is reflected and radiated from the earth. So, the temperature of the earth and the atmosphere increases. This is called greenhouse effect.

The phenomenon of increase in the average temperature of the earth and the atmosphere is called global warming.

Greenhouse gases - Role in global warming

Greenhouse gases	Role in global warming	Annual growth rate
Carbon dioxide (CO_2)	55%	0.5%
Methane (CH_4)	15%	0.9%
Nitrous oxide (N_2O)	6%	0.3%
Chlorofluorocarbon (CFC)	10 – 24%	4%

Table 8.10

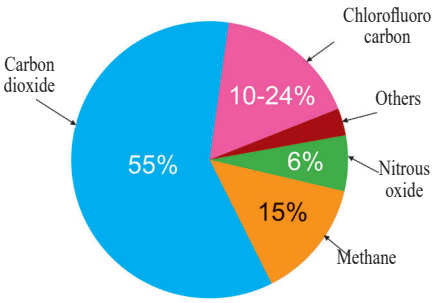


Figure 8.13

* Ozone and water vapour are also responsible for global warming.

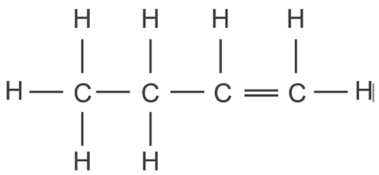
- What are the consequences of global warming? What are the ways to effectively counter global warming?

  Organise a panel discussion on this topic.

In this chapter, we learned the structure of a few organic compounds. Varieties of other organic compounds, their nomenclature and chemical properties can be learned in higher classes.

Let us assess

1. The structural formula of a hydrocarbon is given below.



   a. Write its condensed formula.

   b. Write its molecular formula.

   c. Draw the structure of the first compound of the homologous series to which this hydrocarbon belongs.

   d. Write the IUPAC name of this compound.

2. C_2H_6, C_3H_8, ……, C_5H_{12} belong to the same homologous series.

   a. Write the molecular formula of the missing compound.

   b. Write the name of the homologous series to which these compounds belong?

   c. Write the structural formula of C_2H_6 .

3. Molecular formula of some hydrocarbons are given below.

$$C_3H_8 , C_4H_8 , C_4H_{10} , C_3H_6$$

   a. Which among these are alkanes?

   b. What is the general formula of alkenes?

   c. Write the molecular formula of alkyne having 4 carbon atoms.

4. a. Write the molecular formula of the missing compounds in the homologous series.

Category A	C_2H_4	.....	.....	C_5H_{10}	.....	C_7H_{14}
Category B	CH_4	C_2H_6	.....	.....	C_5H_{12}	.....
Category C	.....	C_3H_4	.....	.....	.....	C_7H_{12}

   b. To which homologous series does category C belong?

   c. Write the general formula of category A.

5. The molecular formula of a few hydrocarbons are given below.

$$C_2H_4,\ C_2H_2,\ C_2H_6,\ C_3H_4,\ C_3H_8$$

a. Which among them belongs to the alkene group?

b. Which category does C_2H_2 belong to?

c. Which are the hydrocarbons having the general formula C_nH_{2n+2} ?

6. Two hints regarding a hydrocarbon are given below.

- It has 3 carbon atoms.
- The general formula of the category to which this hydrocarbon belongs is C_nH_{2n+2} .

a. Write the molecular formula and IUPAC name of this compound.

b. Draw the structure of this compound.

c. Write the molecular formula of the hydrocarbon having the same number of carbon atoms and having double bond.

7. Hints about a cyclic compound are given below.

It has 6 carbon atoms and 12 hydrogen atoms.

a. Draw the structure of this compound.

b. Write the structural formula of the open chain hydrocarbon having the same molecular formula.

c. Write the molecular formula of the alkane having the same number of carbon atoms.

8. A chain having carbon atoms is given below.

$$C = C - C - C - C$$

a. Complete the structure by adding hydrogen atoms to each carbon atom. Write its IUPAC name also.

b. Write the molecular formula of this compound.

c. Draw the structure of a cyclic compound having the same molecular formula.

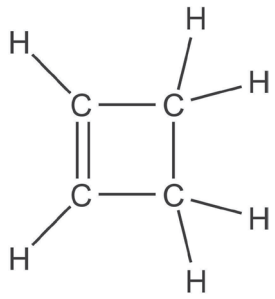
d. Write the IUPAC name of this cyclic compound.

9. The molecular formula of an alicyclic compound is C_4H_8.

a. Write the structural formula of this compound.

b. Write the structural formula of the open chain hydrocarbon having the same molecular formula.

10. The structure of an alicyclic compound is given below.



a. What is its molecular formula?

b. Write its IUPAC name.

c. Write the structural formula of an open chain hydrocarbon having the same molecular formula.

11. The molecular formula of a hydrocarbon is C_3H_6 .

a. Write the structural formula of this compound.

b. To which category does it belong?

(Alkane, alkene, alkyne)

c. Draw the structure of an alicyclic compound having the molecular formula C_3H_6 .

d. Write the IUPAC name of the compound.

12. a. Write the molecular formula of naphthalene.

b. Draw the structure of naphthalene.

13. a. What is the method used to separate the components from petroleum?

b. Butane, the main component of LPG, is an alkane. It has four carbon atoms. Write the structural formula of butane.

14. a. Which among the following gas does not cause global warming?

(Methane, carbon dioxide, nitrogen, nitrous oxide)

b. Write two ways to prevent global warming.

Extended activities

1. Prepare and exhibit the ball and stick model of alkane, alkene and alkyne compounds having 4 carbon atoms.
2. Present a seminar on the topic 'Global warming and climate change'.

   Hints : 1. Factors causing global warming

   2. Global warming and climate

   3. Consequences

   4. Remedies
3. Prepare and present a paper on the topic 'The importance of Organic Chemistry'.
4. The structural formula of a few organic compounds are given below.

   i. $CH_3 - CH_2 - OH$

   ii. $CH_3 - CH_2 - CH_2 - OH$

   a. Write the molecular formulae of these compounds.

   b. Are they homologous? Substantiate your answer.
5. Construct and exhibit a model of cyclic compounds having 6 carbon atoms.

CONSTITUTION OF INDIA

Part IV A

FUNDAMENTAL DUTIES OF CITIZENS

ARTICLE 51 A

Fundamental Duties- It shall be the duty of every citizen of India:

(a) to abide by the Constitution and respect its ideals and institutions, the National Flag and the National Anthem;

(b) to cherish and follow the noble ideals which inspired our national struggle for freedom;

(c) to uphold and protect the sovereignty, unity and integrity of India;

(d) to defend the country and render national service when called upon to do so;

(e) to promote harmony and the spirit of common brotherhood amongst all the people of India transcending religious, linguistic and regional or sectional diversities; to renounce practices derogatory to the dignity of women;

(f) to value and preserve the rich heritage of our composite culture;

(g) to protect and improve the natural environment including forests, lakes, rivers, wild life and to have compassion for living creatures;

(h) to develop the scientific temper, humanism and the spirit of inquiry and reform;

(i) to safeguard public property and to abjure violence;

(j) to strive towards excellence in all spheres of individual and collective activity so that the nation constantly rises to higher levels of endeavour and achievements;

(k) who is a parent or guardian to provide opportunities for education to his child or, as the case may be, ward between age of six and fourteen years.

CHILDREN'S RIGHTS

Dear Children,

Wouldn't you like to know about your rights? Awareness about your rights will inspire and motivate you to ensure your protection and participation, thereby making social justice a reality. You may know that a commission for child rights is functioning in our state called the ***Kerala State Commission for Protection of Child Rights.***

Let's see what your rights are:

- Right to freedom of speech and expression.
- Right to life and liberty.
- Right to maximum survival and development.
- Right to be respected and accepted regardless of caste, creed and colour.
- Right to protection and care against physical, mental and sexual abuse.
- Right to participation.
- Protection from child labour and hazardous work.
- Protection against child marriage.
- Right to know one's culture and live accordingly.
- Protection against neglect.
- Right to free and compulsory education.
- Right to learn, rest and leisure.
- Right to parental and societal care, and protection.

Major Responsibilities

- Protect school and public facilities.
- Observe punctuality in learning and activities of the school.
- Accept and respect school authorities, teachers, parents and fellow students.
- Readiness to accept and respect others regardless of caste, creed or colour.

Contact Address:

Kerala State Commission for Protection of Child Rights

'Sree Ganesh', T. C. 14/2036, Vanross Junction

Kerala University P. O., Thiruvananthapuram - 34, Phone : 0471 - 2326603

Email: childrights.cpcr@kerala.gov.in, rte.cpcr@kerala.gov.in

Website : www.kescpcr.kerala.gov.in

Child Helpline - 1098, Crime Stopper - 1090, Nirbhaya - 1800 425 1400

Kerala Police Helpline - 0471 - 3243000/44000/45000

Online ***R. T. E Monitoring : www.nireekshana.org.in***