(20) Which substance is present in poison of honey bee ?

(A) Lime (B) Calcium phosphate

(C) Mellitin (D) Pepsin.

2. Answer the following questions in brief :

(1) Write names of two Arrhenius acids and bases.

(2) Write products of reaction of acid with metal.

(3) Mention names of four methods of expressing concentration of a solution.

(4) Which scientist presented pH scale ? Write the formula of pH.

(5) Write names of two methods to measure approximate pH of aqueous solution.

(6) Mention names of two strong acids and two strong bases.

(7) Write names of two weak acids and two weak bases.

(8) Give definitions :

(i) Arrhenius acid, (ii) Arrhenius base, (iii) Bronsted-Lowry acid, (iv) Bronsted-Lowry base, (v) Concentration of solution, (vi) pH of solution, (vii) pOH of solution, (viii) Strong acid, (ix) Weak acid, (x) Strong base, (xi) Weak base, (xii) Neutralisation reaction, (xiii) 1 M concentration

(9) Mention the formula, name and physical state of the products of following reactions :

(1) $CO_2(g) + H_2O(l) \rightarrow$ (2) $Li_2O(s) + H_2O(l) \rightarrow$

(3) $H_2SO_4(aq) + 2KOH(aq) \rightarrow$ (4) $2HCl(aq) + Ca(s) \rightarrow$

(5) $2HNO_3(aq) + CaO(s) \rightarrow$ (6) $2HCl(aq) + Na_2CO_3(aq) \rightarrow$

(7) $NaOH(aq) + HCl(aq) \rightarrow$ (8) $BaCl_2(aq) + H_2SO_4(aq) \rightarrow$

(9) $Ca(OH)_2(aq) + CO_2(g) \rightarrow$ (10) $HNO_3(aq) + NH_4OH(aq) \rightarrow$

(11) $Na_2SO_4(aq) + Ba(OH)_2(aq) \rightarrow$ (12) $AgNO_3(aq) + NaCl(aq) \rightarrow$

3 (A) Answer the following questions :

(1) Write two chemical properties of acid.

(2) Write two chemical properties of base.

(3) Write two chemical properties of salt.

(4) Deduce pH + pOH = 14

(5) Explain the importance of pH in digestion of food.

(6) Write chemical equations of four neutralisation reactions.

(B) Solve the following problems :

(1) Calculate pH of an aqueous solution having H_3O^+ concentration equal to 7.9×10^{-11} M. Which nature, acidic, basic or neutral will be possessed by this aqueous solution.

(2) Calculate pH of 0.00424 M aqueous solution of KOH.

(3) How many times concentrated will be the aqueous solution having pH 11.9 as compared to aqueous solution having pH 8 ?

(4) How will you prepare 500 ml aqueous solution of 0.2 M H_2SO_4 ?

(5) How will you prepare 125 ml 0.03 M aqueous solution of KOH.

4. (A) Answer the following questions in detail :

(1) Explain giving example, Arrhenius acid-base theory. Mention the limitations of this theory.

(2) Discuss Bronsted-Lowry Acid-base theory.

(3) Discuss methods to measure pH of aqueous solution.

(B) Solve the following problems :

(1) $[OH^-]$ in aqueous solution A is = 4.3×10^{-4} M and $[H_3O^+]$ in aqueous solution of B is 7.3×10^{-10} M, pH of which solution will be less ? Which solution will be more basic ?

(2) Calculate the concentration of OH^- in aqueous solution having pH value 9.3.

(3) 8 gram NaOH is dissolved in water and the aqueous solution is made to 5 litres. Find pH of this solution.

5. (A) Answer the following questions in detail :

(1) With reference to pH scale,

(i) Write formula of pH and pOH

(ii) Mention pH and concentration of H_3O^+ or OH^- in acidic, basic and neutral aqueous solutions.

(iii) Mention limitations of pH scale.

(2) Explain importance of pH in everyday life.

(3) "The aqueous solution of the salt produced by neutralisation of weak acid and strong base possesses basic nature, while aqueous solution of salt produced by neutralisation of weak base and strong acid possesses acidic nature" - Explain.

(B) Solve the following problems :

(1) pH of aqueous solution of potassium hydroxide at 298 K temperature is 11.65. The initial volume of this solution is made 6 times by addition of water. What will be the pH of the diluted solution ?

(2) What will be the change in the value of pH if the concentration of aqueous solution of HNO_3 is increased to 0.05 M from 0.03 M ?

UNIT 8

METALS

8.1 Introduction

As studied in Standard-9, 114 elements are discovered till today. These elements are classified into metals, non-metals and semimetals (metalloids). Most of these elements are metals. They differ from other metals because of their individual property. Different metals are used at different places on the basis of their properties, viz. Aluminium is a light metal. A thin and strong foil like paper can be prepared from it. Also, it does not get corroded. Hence, aluminium metal is used for packing food materials and food products as well as filling vessels for cold drinks. Copper is useful in preparation of wires for conduction of electricity as it is a good conductor and is ductile. Gold, silver and platinum metals are inert and possess high lustre and they are used in preparation of ornaments. Liquid metal like mercury is used in thermometers. Lead metal is used in industries as a waterproof layer around the walls of the chimney. Lead metal is used in preparation of pipes for flow of water and to get protection from radiations. Thus pure forms of metals like gold, silver, copper, platinum, aluminium, mercury and lead are used in greater proportions, but we see certain things around us which are formed of more than one metal viz, steel, stainless steel, things of brass etc. If you will prepare a list of things made up of metals, you will be able to understand the importance of metals in our everyday life. In this unit we shall study in detail about the metallic elements.

8.2 Earth as Treasure of Elements

Different elements are obtained directly or indirectly from below mentioned three parts of the earth :

(1) Lithosphere : This part of the earth is formed of sand, clay and stone, in which metal elements like aluminium, copper, iron, calcium, sodium, etc. are in the forms of oxide or sulphide.

(2) Hydrosphere : In this part of the earth; water of seas, rivers, lakes and the ice of polar regions are included. In this part, non-metals like chlorine, fluorine and metals like sodium, potassium, magnesium, calcium etc. are obtained in the combined forms.

(3) Atmosphere : The cover of gases around the earth is called atmosphere. Mostly, non-metallic gases like nitrogen, oxygen, carbon dioxide etc. are mainly present.

Various metals are in larger proportion in the earth's crust, some metals are available in free state (form) from the crust of the earth, while some metals are obtained in the combined form. Metals whose activity is less are available in free state in nature. They are called noble metals e.g. Gold, silver, platinum etc. Metals having more activity are available in combined form in nature e.g. potassium, sodium, calcium, magnesium etc. **The inorganic elements or compounds which are available naturally from earth's crust are called minerals. If the proportion of a certain metal is more and if its extraction is advantageous, then the mineral is called ore.** In ores the impurities are minerals of other metals, clay, sand, etc. Ores are chiefly in the combined forms like silicate, carbonate, oxide, phosphate, sulphide etc. The chief ores available in India and their occurrences are shown in Table 8.1

Table 8.1 Metals and their Chief Minerals

Name of metal	Name of Mineral	Chemical formula of Chief Component	Occurrenes in India
Iron	Haematite Magnetite Siderite Iron Pyrites	Fe_2O_3 Fe_3O_4 $FeCO_3$ FeS_2	Madhya, Pradesh, Tamilnadu, Orissa, Bihar Goa
Aluminium	Bauxite	$Al_2O_3.2H_2O$	Gujarat, Maharashtra, Madhya Pradesh, Bihar
Copper	Cuprite Copper Pyrites Copper Glance Malachite	Cu_2O $CuFeS_2$ Cu_2S $Cu(OH)_2$	Bihar, Rajasthan
Calcium	Lime stone Dolomite Gypsum	$CaCO_3$ $CaMg(CO_3)_2$ $CaSO_4.2H_2O$	Gujarat, Rajasthan Madhya Pradesh
Silver	Horn Silver Silver Glance	AgCl Ag_2S	Bihar

8.3 Metallurgy

The metal is separated from its ore and is purified (refined) to make it more useful. **The process of separating metal from ore and purifying (refining) it is known as metallurgy**. The process of obtaining pure metal from ore is divided into five steps. (1) Powder from ore (2) Concentration of ore (3) Roasting, calcination and smelting (4) Reduction (5) Refining of metal

(1) Powdering of ore : Ores are obtained by digging from the earth's crust, in which minerals of other metals, clay, silica etc, are present as impurities. The bigger pieces of this ore is powdered by grinding in big mills of special type.

(2) Concentration of ore : The ores are concentrated on the basis of type of impurities and their percentage proportions. As a result most of the impurities are removed and the proportion of

ore is increased. This process is called concentration of ore. For this, (i) concentration or centrifugation on the basis of difference in densities (ii) froth flotation and (iii) magnetic separation methods are used.

(i) Concentration or Centrifugation on the basis of difference in densities : When there is large difference between densities of ores and the impurities in them, concentration of ore can be done by this method. In this method, the fine powder of ore is placed on a moving table with slots and it is moved rapidly so that the light particles of metal remain in the slot in the table because of centrifugal force. This process is known as centrifugation.

(ii) Froth Flotation method : Froth flotation method is used for concentration of the ores of the metals whose ores are in sulphide form. The concentration of sulphide ores of copper, lead and zinc metal are carried out by this method. In this method, the fine powder of the ore, and water are filled in a big vessel. The substances like pine, or turpentine oil are added to it. The sulphide particles of metals get wet and stick to it, while clay, particles of sand, do not get wetted. In this liquid mixture, air is passed with pressure through a tube as shown Fig 8.1. Hence, the froth is produced around the light particles of the sulphide ore and comes on the surface of the liquid mixture. Heavy particles like clay, sand etc, become wet by water and settled down at the bottom.

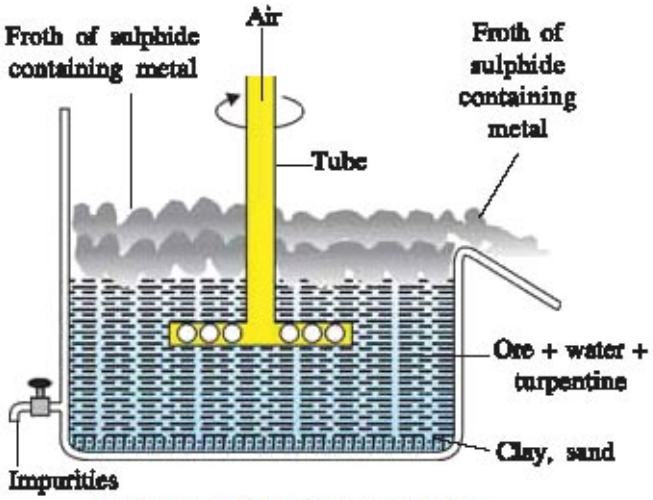


Fig. 8.1 Froth Flotation method

The sulphide ore of metal is removed with sieves in a second vessel and washed with water. By this method ores like copper pyrites are concentrated and clay, sand etc. are removed.

(iii) Magnetic separation : If impurity of iron is there in the ore, then the fine powder of the ore is allowed to fall on belt of leather. As shown Fig 8.2, there is a magnet at one end of the belt which attracts the iron particles and fall nearer, the remaining particles fall away because of not being attracted. Thus, by this method impurity of iron is removed from the ore. In the same way other impurities of the ores of iron are removed by this method.

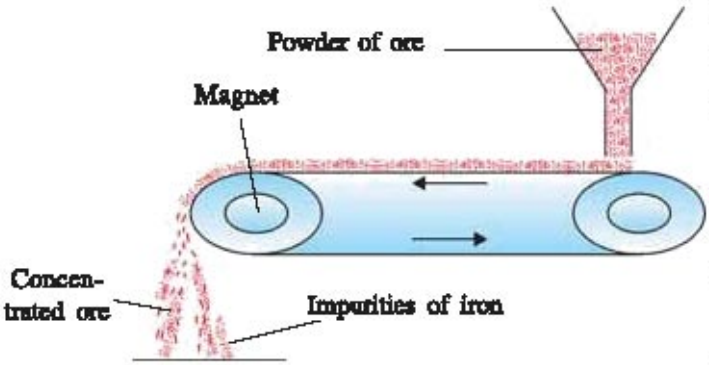


Fig. 8.2 Magnetic separation

(3) Roasting, calcination and smelting : Methods like roasting, calcination and smelting are used in conversion of concentrated ore into metal oxide.

Roasting : When sulphide containing ore is heated for a long time in presence of excess air, it is converted into metal oxide. **This method of converting sulphide containing ore into metal oxide is called roasting.**

$$2ZnS(s) + 3O_2(g) \xrightarrow{\Delta} 2ZnO(s) + 2SO_2(g)$$

$$2HgS(s) + 3O_2(g) \xrightarrow{\Delta} 2HgO(s) + 2SO_2(g)$$

$$2PbS(s) + 3O_2(g) \xrightarrow{\Delta} 2PbO(s) + 2SO_2(g)$$

Calcination : When carbonate containing ore is heated for a long time in absence of air it is converted into metal oxide. **This method of converting carbonate containing ore into metal oxide is called calcination.**

$$MgCO_3(s) \xrightarrow{\Delta} MgO(s) + CO_2(g)$$

$$ZnCO_3(s) \xrightarrow{\Delta} ZnO(s) + CO_2(g)$$

Smelting : If the ore is in melted form then it is called smelting.

(4) Reduction : Reduction is carried out to obtain metal from metal oxide. In reduction process the metal oxide is reacted with reducing agent like carbon or carbon monoxide. Also, any other reducing agent (metal) when reacted with metal oxide, a more stable, oxide forming metal by attracting more proportion of oxygen, metal is obtained.

Chemical Reduction : When metal oxide is heated in a blast furnace with carbon or carbon monoxide, metal is obtained.

$$MnO_2(s) + 2C(s) \xrightarrow{\Delta} Mn(s) + 2CO(g)$$

$$ZnO(s) + C(s) \xrightarrow{\Delta} Zn(s) + CO(g)$$

$$Fe_2O_3(s) + 3C(s) \xrightarrow{\Delta} 2Fe(s) + 3CO(g)$$

$$Fe_2O_3(s) + 3CO(g) \xrightarrow{\Delta} 2Fe(s) + 3CO_2(g)$$

When oxides of metals like chromium, iron, and manganese are heated with aluminium powder, metal is obtained by reduction of metal oxide.

$$Cr_2O_3(s) + 2Al(s) \xrightarrow{\Delta} 2Cr(l) + Al_2O_3(s)$$

$$Fe_2O_3(s) + 2Al(s) \xrightarrow{\Delta} 2Fe(l) + Al_2O_3(s)$$

$$3MnO_2(s) + 4Al(s) \xrightarrow{\Delta} 3Mn(l) + 2Al_2O_3(s)$$

Electrochemical Reduction : Some metals cannot be obtained by reaction of carbon with oxide of active metal. Oxides of active metals like sodium, magnesium, calcium, aluminium cannot be reduced by carbon, i.e. metals cannot be obtained by carbon from their corresponding metal oxides, because these metals possess more attraction towards oxygen than carbon. Hence, other method - electrochemical reduction method is used to obtain metals from oxides of active metals. In this method, electrodes of inert metals like graphite or platinum are used in electrochemical cell

Example : By electrochemical reduction of alumina (Al_2O_3), molten aluminium is obtained at cathode and dioxygen gas at anode.

Cathode (Negative pole) : $2Al^{3+}(l) + 6e^- \rightarrow 2Al(l)$

Anode (Positive pole) : $3O^{2-}(l) \rightarrow \frac{3}{2}O_2(g) + 6e^-$

Here, cathode (negative pole) works as a reducing agent.

(5) Refining of metals : The metal obtained by reduction method is not very pure. The method to obtain about hundred percent pure metal by removing impurities present in very small amounts in metal, is called refining. Refining of metals is mainly carried out by three methods :

(i) Electrolysis (ii) Liquefaction (iii) Zone refining

(i) Electrolysis : Metals like copper, zinc, gold and silver are refined by this method. In this method, the rod of impure metal is taken as anode and rod of pure metal is taken as cathode. The aqueous solution of salt of metal, is used as electrolyte. On passing electric current through electrolyte, anode dissolves in the electrolyte. The metal in the proportion of being obtained by dissolution of anode, is added to the electrolyte, the same proportion of metal is being deposited at the cathode. As there is no impurity in the metal deposited at the cathode, it is very pure. **Out of the impurities added to electrolyte by dissolution of anode, soluble impurities remain in the solution and insoluble impurities are collected at the bottom of the anode. It is called anodic mud.**

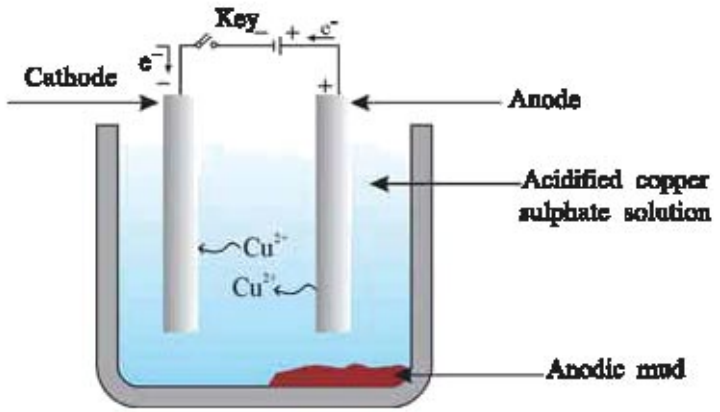


Fig. 8.3 Refining of copper by electrolysis

If copper is refined by this method, then rod of impure copper is arranged as anode and the rod of pure copper as cathode as shown in figure 8.3. The aqueous solution of copper sulphate is taken as the electrolyte. A little dilute sulphuric acid is added to it. When electric current is passed through the electrolyte the proportion in which copper from anode is dissolved in aqueous solution of copper sulphate, copper in the same proportion from copper sulphate solution is deposited at the cathode. Thus, the copper deposited at the cathode in this way has almost 100 % purity.

Anode (Positive pole) : $Cu(s)\ (Impure) \rightarrow Cu^{2+}(aq) + 2e^{-}$ (oxidation)

Cathode (Negative pole) : $Cu^{2+}\ (aq) + 2e^{-} \rightarrow Cu(s)$ (reduction)

Net reaction : $Cu(s)\ (Impure) \rightarrow Cu(s)\ (Pure)$

(ii) Liquefaction : This method is used for refining of metals having low melting point i.e. metals like tin, lead etc. which melt easily. In this method, a furnace having a slope is used. The temperature of this furnace is kept slightly higher than the melting point of the metal, so that when impure metal is passed on the slope, the metal in it is melted and collected in the vessel kept below. The melting points of impurities are higher and so do not melt at this temperature and found in solid form on the slope.

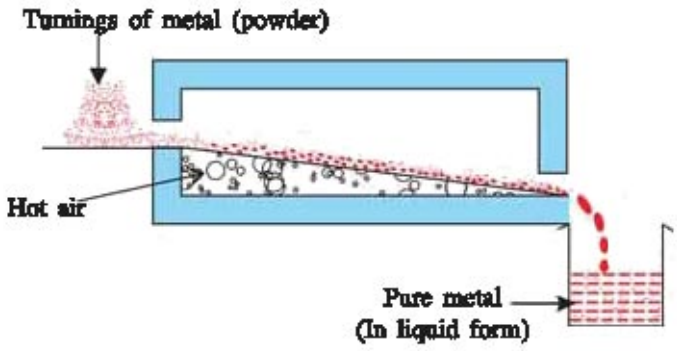


Fig. 8.4 Refining of metal by liquefaction method

(iii) Zone Refining : Trace impurities present in metal are removed by this method on the basis of the principle of fractional crystallization. Generally, these impurities remain more soluble in the form of molten metal. As the molten metal gets cooled, the solubility of impurities decreases and separates from the metal in the form of crystals, semi-metals like silicon, boron, germanium are used as semiconductors. The refining of these semi-metals is carried out by zone refining method.

After understanding the five steps of metallurgy, now we shall study the metallurgy of aluminium and iron.

8.4 Extraction of Aluminium From Bauxite

Aluminium is the most abundant metal available on the earth. The use of this metal on a larger scale started from the end of the nineteenth century because the extraction of this metal was very costly before this. Aluminium is extracted from bauxite ($Al_2O_3.2H_2O$). The extraction of aluminium from the ore bauxite is carried out in two steps : (1) To obtain alumina from bauxite ore. (2) To obtain aluminium metal from alumina by electrochemical reduction.

(1) To obtain alumina from bauxite ore : In bauxite, in addition to aluminum oxide (Al_2O_3) impurities like iron oxide (Fe_2O_3) and sand (SiO_2) are also present. On refining bauxite by Bayer's method, pure aluminium oxide is obtained which is also called alumina. In this method, bauxite powder is taken and concentrated (45%) sodium hydroxide solution is added and then heated in closed vessel at 433 K temperature and 5 to 6 bar pressure, for 6 to 8 hours, so that aluminium oxide present in bauxite is converted into sodium aluminate which is soluble in water.

$$\underset{\text{(Present in bauxite)}}{Al_2O_3(s)} + 2NaOH(aq) \rightarrow \underset{\text{(Sodium aluminate)}}{2NaAlO_2(aq)} + H_2O(l)$$

Iron oxide does not dissolve in sodium hydroxide. Hence, it can be removed by filtration, silica forms sodium silicate which is soluble in water. This sodium aluminate and sodium silicate are there in the filtrate. Excess of water is added to it and continuously stirred so that hydrolysis of sodium aluminate takes place and precipitates of aluminium hydroxide are obtained and the sodium silicate remains as impurity in the solution. Some precipitates of aluminium hydroxide are added from outside in order to make reaction simple and fast.

$$\underset{\text{Sodium aluminate}}{NaAlO_2(aq)} + 2H_2O(l) \rightarrow \underset{\text{Aluminium hydroxide}}{Al(OH)_3(s)} + NaOH(aq)$$

The precipitates are washed repeatedly with water, dried and on heating at 1473 K temperature pure aluminium oxide (alumina) is obtained.

$$\underset{\text{Aluminium hydroxide}}{2Al(OH)_3(s)} \xrightarrow{1473\,K} \underset{\text{Alumina}}{Al_2O_3(s)} + 3H_2O(g)$$

About 99.5% pure alumina is obtained by Bayer's method.

(2) To obtain aluminium from alumina by electrochemical reduction : The method to obtain aluminium from alumina by electrochemical method was invented by American chemist Charles Martin Hall and French scientist Paul Heroult in 1886. Hence, this method is also known as Hall-Heroult method.

Electric current cannot pass through solid form of alumina. Also, melting point of aluminia is very high 2348 K. Electrolysis at such a high temperature is very expensive. Hence, cryolite (Na_3AlF_6) is added so that electrolysis can be carried out easily. This mixture works as better

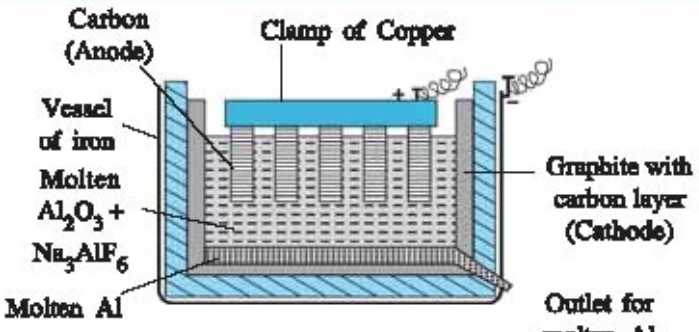


Fig. 8.5 Electrolytic cell

electric conductor than melted alumina. The melting point can be brought still lower by addition of feldspar (CaF_2).

As shown in Fig 8.5, the mixture of alumina, cryolite and feldspar is electrolysed in a vessel of iron having inner surface layered with carbon. In this cell, the rods of carbon are joined by copper clamp as anode and carbon layered graphite is taken as cathode. On passing the electric current molten aluminium is deposited on cathode and dioxygen gas is produced at the anode. The molten aluminium collected at the bottom of the cell is taken out.

$$\text{Cathode : } 2Al^{3+}(l) + 6e^- \rightarrow 2Al(l)$$

$$\text{Anode : } 3O^{2-}(l) \rightarrow \frac{3}{2}O_2(g) + 6e^-$$

The dioxygen gas produced at the anode reacts with rod of carbon and forms carbon dioxide. As a result anode is corroded. Hence, they are frequently replaced.

$$C(s) + O_2(g) \rightarrow CO_2(g)$$

8.5 Extraction of Iron by Blast Furnace

We have been using iron from a very long time (iron era). Iron has the second position amongst the elements available in most abundance on the earth. Iron reacts rapidly with moisture and oxygen and so it is not available in free state in nature. It is obtained in its oxide form (haematite Fe_2O_3, magnetite - Fe_3O_4), in carbonate form (siderite - $FeCO_3$) and sulphide form (iron pyrites - FeS_2) which are its minerals. Iron is mostly obtained by reduction of haematite in blast furnace. The blast furnace is narrow on the upper part, wide in the middle part and narrow at the bottom part. Its inner walls are prepared of fireproof bricks. Hot air is blown from the lower part of blast furnace.

Most of the impurities present in haematite are removed, and then, the concentrated ore is added into the blast furnace with the help of hooper as shown in Fig 8.6, with coke and lime

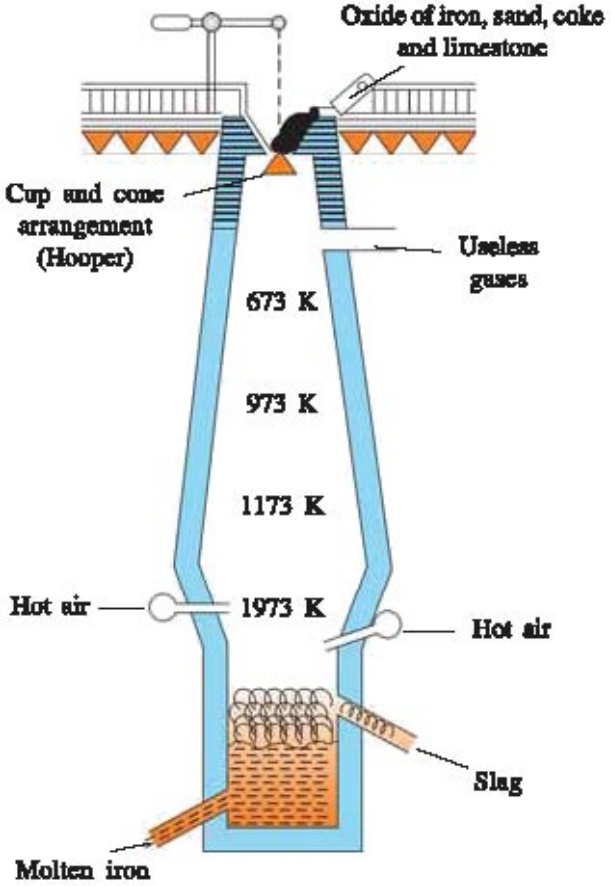


Fig. 8.6 Blast furnace

stone. Because of high temperature in blast furnace, certain reactions take place and molten iron is obtained.

(i) Coke combines with oxygen and forms carbon dioxide. This reaction being exothermic, the temperature of the furnace becomes 1773 K to 1973 K.

$$C(s) + O_2(g) \rightarrow CO_2(g) + \text{Heat}$$

(ii) Calcium oxide and carbon dioxide are formed in the blast furnace by decomposition of lime stone due to high temperature in blast furnace.

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

(iii) Hot carbon dioxide when goes up in the furnace combines again with coke and forms carbon monoxide. As this reaction is endothermic, the temperature of the furnace comes down to 1173 K

$$CO_2(g) + C(s) \rightarrow 2CO(g)$$

(iv) When temperature of the furnace is 673 K to 973 K, the iron oxide present in haematite is reduced to liquid iron.

$$3Fe_2O_3(s) + CO(g) \rightarrow 2Fe_3O_4(s) + CO_2(g)$$
$$Fe_3O_4(s) + CO(g) \rightarrow 3FeO(s) + CO_2(g)$$
$$FeO(s) + CO(g) \rightarrow Fe(l) + CO_2(g)$$

Calcium oxide formed during reaction (ii) combines with the impurity silica present in haematite and forms calcium silicate. It is known as slag.

$$CaO(s) + SiO_2(s) \rightarrow CaSiO_3(l)$$

Calcium silicate (Slag)

As this slag is lighter in weight than iron, it floats in molten iron. The important advantage of this is that molten iron is not converted into its oxide by oxygen. The moltern iron and slag are removed out by different paths from the bottom of the furnace. The molten iron cools down to solid form and iron blocks are prepared, while liquid slag is changing into a solid form by cooling and useful in construction of roads.

The extraction of iron from haematite is a continuous process. Once it starts operating the blast furnace can continue for ten years. The extraction of iron is carried out in India, at Bhilai, Durgapur, Rourkela, Jamshedpur etc.

8.6 Activity Series of Metals

The activity of every metal is not same. Some metals are more active and some metals are less active. The metals which lose electron easily and form ions are called more active metals. e.g. Fe, while less active metals do not lose electron easily. e.g. Au. The comparison of activity of metals can be done by comparison of reactions with oxygen, water and acid; but all the metals do not give these reactions. Hence, for the determination of activity of metals, displacement reaction is used. For the explanation of results obtained by displacement reaction, the principle taken into consideration is : **Less active metal can be displaced from the solution of its salt by the more active metal.'** For example, if piece of zinc metal is placed in a solution of copper sulphate, it becomes light blue coloured and at the end

becomes colourless and red brown coloured layer of copper is deposited on piece of zinc metal. If it is kept for a longer period, grains of red brown colour are obtained at the bottom.

$$Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$$

If a piece of copper metal is placed in a solution of zinc sulphate, chemical reaction like deposition of metal does not occur. Thus, zinc is more active metal than copper. You can do the activity in the laboratory for the study of this reaction, we shall try to determine the order of activity of metals by this type of activity.

Activity : 1

To determine order of activity of Zn, Fe, Cu and Ag metals.

- First of all take three test-tubes. Give them numbers 1 to 3.
- In test tube 1, 2 and 3 take the substances. 0.1 gram ferrous sulphate ($FeSO_4.7H_2O$), 0.1 gram copper sulphate($CuSO_4.5H_2O$) and 0.1 gram silver nitrate ($AgNO_3$).
- Add 10 ml. of distilled water to each test tube and dissolve the substance in it.
- With this keep ready a piece of zinc metal, iron nail or screw and piece of copper wire. (A thick copper wire can be taken out from electric wire) or copper strip.
- Now add piece of zinc metal in test tube - 1, iron nail or screw in test-tube-2 and piece of copper wire or thin strip in test tube-3.
- Place the three test tubes in order and observe the solutions and metal in each test tube.
- In about 5 minutes, you will see the metal from the solution being deposited on the metal added.
- After half an hour when observation of all the three test tubes is carried out, it will be observed that in test tube-1, iron metal showing colour of iron metal is deposited in the shining piece of zinc. In test tube-2, the nail or screw will appear brown coloured due to deposition of copper on it. In test tube-3, silver as shining white colour deposited on the wire or strip of copper.

  By keeping the test tubes for more than half an hour, more amount of metals will be found deposited.
- The colour of the solutions in the three test tubes will be respectively colourless from light green colour, light blue from dark blue colour and light blue colour from colourless.
- We will be able to conclude at the end of this activity that Zn is more active metal than Fe because Fe is displaced from solution of $FeSO_4$ by Zn i.e Zn>Fe. Fe is more active metal than Cu because Cu from solution of $CuSO_4$ is displaced by metal Fe. i.e Fe>Cu. Cu is more active metal than Ag because Ag is displaced from solution of $AgNO_3$ by Cu metal i.e Cu > Ag. Thus the order of activity of all the four metals will be Zn > Fe > Cu > Ag.

By such experiments, the activities of different metals can be determined and can be arranged in their descending (decreasing) order. This order is known as activity series. viz.

K > Na > Ca > Mg > Al > Zn > Fe > Pb > [H] > Cu > Hg > Ag > Au

Now, we shall study properties of metals.

8.7 Physical Properties of Metals

(1) Generally, the surface of metals is shining and can be polished.

(2) Generally metals are in solid form and heavy in weight but metals like mercury and gallium (at higher than normal temperatures) exist in the liquid form. Sodium, potassium, magnesium, aluminium etc. are relatively lighter metals.

(3) Most of the metals are hard, the hardness of various metals are different; metals like iron and copper can comparatively be cut with a knife, metals like sodium, potassium are relatively soft and can be easily cut with a knife.

(4) Some of the metals can be hammered and foils can be prepared by hammering. This property of the metals is known as malleability. This property is specially found in metals like gold, silver and aluminium. Hence, thin foils like thin strips are prepared from gold and silver and very thin foil like paper can be prepared from aluminium. Some metals are ductile and so thin wires of these metals can be prepared by drawing the metals. This property of metals like gold and silver has special property of ductility. 2 kilometer long wire can be drawn from one gram gold. Wires can also be prepared from metals like copper and aluminium, by drawing.

(5) Metals are good conductors of heat and electricity. The power of conduction of heat and electricity is very high for copper, silver and gold metals. Metals like lead and mercury are poor conductors of heat and electricity.

(6) Melting points and boiling points of metals are high. e.g. melting point of iron (1812 K) is very high.

(7) Metal can produce ringing sound by striking

(8) Alloy can be prepared by adding one metal to the other. They possess properties different from the original metals. Brass, German silver, gold ornaments are the examples of alloys.

8.8 Chemical Properties of Metals

Metal loses electron and changes to positive ion. Hence, they are called electropositive elements. The number of electrons lost by the metal is the valency of the metal.

$$Na \rightarrow Na^{+} + e^{-}$$
$$Mg \rightarrow Mg^{2+} + 2e^{-}$$
$$Cu \rightarrow Cu^{2+} + 2e^{-}$$
$$Al \rightarrow Al^{3+} + 3e^{-}$$

The metals show definite chemical properties because of the electrons in the outermost orbit of the metals.

(1) **Reaction of metal with dioxygen :** Metal elements can easily give electrons to dioxygen atom. Hence, metal elements combine with oxygen and form the oxides.

Metal + Dioxygen gas → Metal oxides.

$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

Magesium oxide.

Generally oxides of metal are basic. Oxides of metals like zinc oxide and aluminium oxide possess both acidic and basic properties. Such metal oxides are called amphoteric oxides. Most of the metal oxides are insoluble in water but some oxides dissolve in water and form alkali.

$Na_2O(s) + H_2O(l) \rightarrow 2NaOH(aq)$

Sodium oxide — Sodium hydroxide

$K_2O(s) + H_2O(l) \rightarrow 2KOH(aq)$

Potassium oxide — Potassium hydroxide

All the metals do not react with dioxygen with the same rate that is the reactivity of various metals with oxygen is different viz. metals like sodium and potassium if kept open in air, they burn. Hence, they are kept in kerosene. At normal temperature, thin layer of oxide is observed on metals like magnesium, aluminium, zinc and lead. This layer stops further oxidation of metal. If magnsium is heated at a temperature at which it can burn, then it burns with dazzling light and forms magnesium oxide. When iron is heated, it does not burn but becomes red hot. When copper is heated it also does not burn but the black colour substance observed on hot copper is copper oxide. Metals like gold, silver etc. do not react with dioxygen at high temperature.

(2) Reaction of metal with water : Metals on reaction with water form metal hydroxides or oxides and produce dihydrogen gas. But all the metals do not react with water. Metals like sodium and potassium react vigorously with cold water. The dihydrogen gas produced by vigorous reaction of sodium or potassium with water explodes and burns speedily.

Metal + Water → Metal hydroxide or Metal oxide + Dihydrogen gas.

$2K(s) + 2H_2O(l) \rightarrow 2KOH(aq) + H_2(g)$

$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$

The reaction of calcium with water is less vigorous.

$Ca(s) + 2H_2O(l) \rightarrow Ca(OH)_2(aq) + H_2(g)$

Magnesium metal does not react with cold water but by reaction with hot water, it forms magnesium hydroxide and dihydrogen gas.

$Mg(s) + 2H_2O(l) \rightarrow Mg(OH)_2(aq) + H_2(g)$

Aluminium, zinc and iron metals do not give reactions with cold or hot water, but react with water vapour and form oxides and dihydrogen gas.

$2Al(s) + 3H_2O(g) \rightarrow Al_2O_3(s) + 3H_2(g)$

$Zn(s) + H_2O(g) \rightarrow ZnO(s) + H_2(g)$

$3Fe(s) + 4H_2O(g) \rightarrow Fe_3O_4(s) + 4H_2(g)$

While, metals like lead copper, gold and silver do not react with water.

(3) Reaction of Metals with Acid : All the metals do not react with dilute acids but when the metal reacts with dilute acid, salt corresponding to metal and dihydrogen gas are produced.

Metal + dil.acid → Salt corresponding to metal + Dihydrogen gas

$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

$2Al(s) + 6HCl(aq) \rightarrow 2AlCl_3(aq) + 3H_2(g)$

$Mg(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2(g)$

$Fe(s) + H_2SO_4(aq) \rightarrow FeSO_4(aq) + H_2(g)$

Dihydrogen gas is not produced by reaction of metals with dilute nitric acid (HNO_3) because HNO_3 is a strong oxidising agent. It oxidises H_2 produced during the reaction to H_2O. Even then, magnesium and manganese metals produce dihydrogen gas with very dilute nitric acid.

(4) Reaction of Metals with Dichlorine : Metal reacts with dichlorine and forms metal chorides.

Metal + Dichlorine gas → Metal chlorde

$Ca(s) + Cl_2(g) \rightarrow CaCl_2(s)$

Calcium chloride.

$Mg(s) + Cl_2(g) \rightarrow MgCl_2(s)$

Magnesium chloride.

(5) Reaction of Metal with Dihydrogen : Generally metals do not give reaction with dihydrogen because metals have a tendency to lose the electron and so react with those elemen which can accept electron. But dihydrogen does not accept electron. They form compounds with other elements by electron sharing or losing electron.

Some active metals like Na, K, Ca combine with hydrogen and form hydrides of that metal.

Active metal + Dihydrogen → Metal hydride

$2Na(s) + H_2(g) \rightarrow 2NaH(s)$

Sodium hydride.

$2K(s) + H_2(g) \rightarrow 2KH(s)$

Potassium hydride.

$Ca(s) + H_2(g) \rightarrow CaH_2(s)$

Calcium hydride.

8.9 Corrosion

The effect of air and water is observed on the surface of many metals. e.g. if the things of iron remain in presence of moist air for a longer period, then their surface becomes brown coloured. Sometimes we find small foils coming out of it. The things of copper when remain in air for a longer time then green coloured layer of copper carbonate forms on its surface. **The erosion reaction of any metal with water or moisture when it comes in its contact is called 'metallic corrosion'** : Inert metals - gold, silver etc – are not corroded. Sometimes metallic corrosion reaction is advantageous because the layer formed by corrosion prevents the metal below this layer and it is not corroded. e.g. When aluminium metal is kept open in air, the thin layer of aluminium oxide is formed on the surface of the metal. It prevents the corrosion of the metal layers below this corroded layer. Hence, things of aluminium do not corrode. We shall test the reason for corrosion by doing an activity.

Activity : 2

To test the reason for corrosion :

- First of all take three test tubes and place three iron nails in each of them.
- Name the three test tubes as A, B and C.
- Pour water in test tube - A in such a manner that half the part of nails sink in water and then close the test tube with cork.
- Add boiled distilled water in test tube B so that the nails sink completely and add about 1 ml. oil. Close this test tube with cork.
- In test tube C, add little powder of anhydrous calcium chloride.
- By doing this, the nails in test tube A are in contact with both air and water. In test tube-B the nails are in contact with water only, they do not get air. In test tube-C anhydrous calcium chloride is present which is mositure absorbing (hygroscopic), and so dry air is in test tube C.

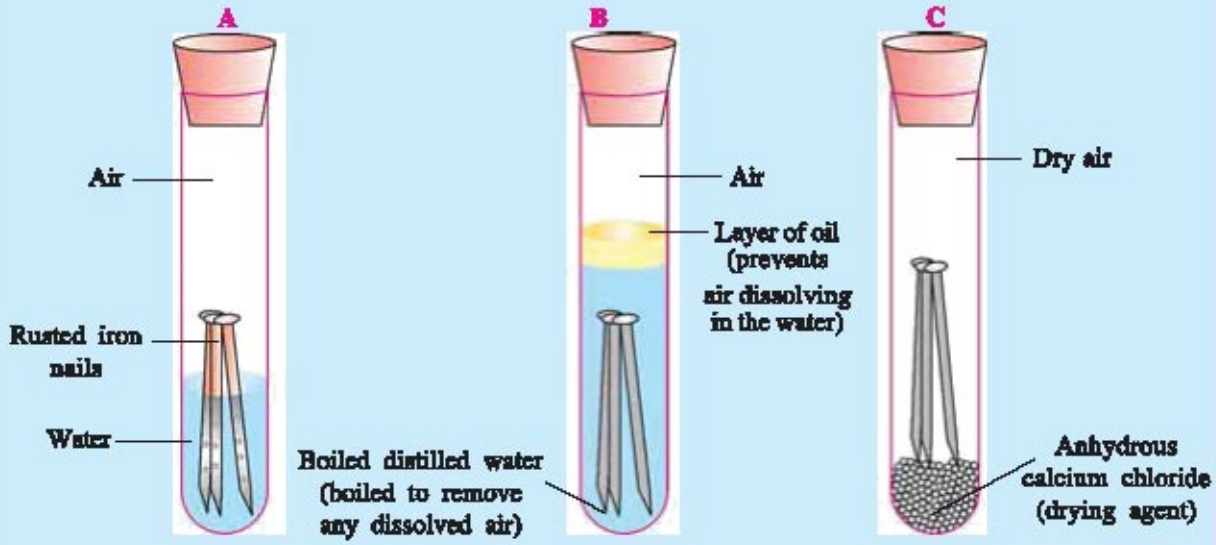


Fig. 8.7 Corrosion of metals

- Observe the nails in all the three test tubes after some days.
- On observation, we will find that nails in test tube A are corroded but nails in test tubes B and C are not corroded. This indicates that corrosion of metal takes place due to contact with both air and water.
- Perform this experiment in your laboratory after comprehending this experiment explained in detail in your practical book.

Loss of crores of rupees occur in the world due to corrosion. Hence, to decrease this loss, remedies to prevent corrosion become inevitable for us. By the activity we confirm our understanding that, corrosion takes place due to air and water both. Hence, it is clear that to prevent corrosion, the surface of the metallic things should be kept away from air and water.

Remedies for Prevention of Corrosion : (1) The easy and cheap method to prevent corrosion of iron is to apply paint on the surface of iron. The body of a car windows or pillars of iron can

be coloured and protection against corrosion can be obtained. If the applied colour is removed the corrosion reaction of that thing starts. Hence, it becomes essential to apply colour at the interval of definite periods.

(2) Sometimes protection against corrosion can be done by applying oil on the surface of things of iron, because the layer of oil does not allow the things of iron to come in contact with air or moisture. This method is practical for small tools of iron, like hammer, gardener's scissors, scissors for cutting metals, etc. But it is not favourable for huge things because at the end of very small interval of time, it becomes necessary to apply oil again.

(3) The corrosion of iron can be prevented by coating very fine layer of zinc metal on the surface of iron. In the iron coated with zinc if zinc is removed from the surface of iron, it does not get corroded because the more active zinc metal spreads over the open surface and prevents iron from corrosion. The iron sheets used in the roof of the house are galvanised sheets.

(4) To prevent corrosion of the iron plates of the steamer, metals like magnesium or block of zinc is used which is more active with the plates of iron in sea-water. By doing so, the plate of iron acts as anode. The corrosion of this zinc block takes place continuously in sea water. They are to be replaced at intervals. This is called sacrificial anode.

(5) Suitable chemicals which are called inhibitors can also be used so that they combine with the surface of the metal by chemical bond and prevent corrosion.

(6) Corrosion can be prevented by applying enamal paints on iron.

(7) As an effective remedy to prevent corrosion metal or non-metal and introducing changes in its properties, it can be saved from corrosion viz the stainless steel alloy prepared from 70% iron, 20% chromium and 10% nickel has no effect of air, water or alkali and it also does not get corroded. Hence, the utensils used in kitchen, instruments used in surgery, big vessels used in industries are prepared from stainless steel.

8.10 Alloys

We know that iron is the metal that is maximum used, but it is not in its pure form. The reason for this is that when it is hot, it is soft and gets easily pressed. But if very small amount of carbon (about 0.05%) is added, it becomes hard and strong. If nickel and chromium are added to iron, stainless steel is obtained. It is strong and does not get corroded. Thus, when any other substance is added to iron, its properties are changed. The substances added to it may be metal or non-metal. Thus, **homogeneous mixture of two or more metals or metal and non-metal is called an alloy.**

In preparation of alloy, firstly the chief metal is melted and the substance which is to be mixed is added in definite proportion and then melted again. Then this molten mixture is cooled. The alloy prepared by adding zinc metal to copper is known as brass. Cooking vessels, parts of machines, instruments of music are prepared from it. If one of the metals in an alloy is mercury, then it is called amalgam. The electrical conductivity of an alloy is less than that of pure metal. e.g., if impurity is there in copper, its electrical conductivity is less than that of pure copper. The melting point of an alloy is less than those of component elements. e.g. The meting point of the alloy prepared from lead and tin, is less and so it is used in soldering the electric wires. Components of some alloys, their properties and uses are shown in Table 8.2.

Table 8.2 Alloys, their compositiones, properties and uses

Alloy	Components	Properties	Uses
Steel	Iron, carbon	Hard and strong	In construction of building and bridge, manufacture of ships, and manufacture of spare parts of motorcycles.
Stainless steel	Iron, nickel chromium	Air, water and alkali do not affect and do not get corroded.	In preparation of utensils, blades, surgical instruments
Brass	Copper, zinc	Malleable, strong, corrosion resistant and can be easily shaped	In preparation of cooking utensils, parts of machines and instruments of music
Bronze	Copper, tin	Stronger and more corrosion resistant	In preparation of statues, coins and medals.
Magnalium	Aluminium, magnesium	Very light and hard	In preparation of scientific balance and light instruments.
Duralumin	Aluminium, copper and magnesium in trace proportions	Light, strong and corrosion resistant	In preparation of aircraft and pressure cookers.

8.11 Purity of Gold in Carat Unit

The purity of gold is expressed in carat unit. Pure gold is considerd as 24 carat. As it is very soft, the shapes of the ornaments prepared from gold get deformed in shapes, even if small pressure is applied. But if copper or silver is added in small proportion to pure gold, its strength can be increased. In our country, generally ornaments are prepared of 22 carat gold. 22 carat gold means the alloy of 22 parts pure gold and 2 parts copper or silver.

What have you learnt ?

- The inorganic elements or compound available naturally are called minerals.
- If the proportion of any definite metal is larger and extraction of that metal is advantageous, then the mineral is called ore of that definite metal.
- Ore is generally in the form of silicate, carbonate, oxide, phosphate, sulphide etc.
- The process of separating the metal from its ore and purifying it is known as metallurgy.
- **Five steps of metallurgy :** (1) Powder from ore (2) Concentration of ore (3) Roasting, Calcination and Smelting (4) Reduction (5) Refining of metal.

- **Two steps of extraction of aluminium from bauxite :** (1) To obtain alumina from bauxite ore (2) To obtain aluminium from alumina by electrochemical reduction.
- Fe is extracted from haematite (Fe_2O_3) by blast furnace
- **Activity series of metals :** K > Na > Ca > Mg > Al > Zn > Fe > Pb > [H] > Cu > Hg > Ag > Au

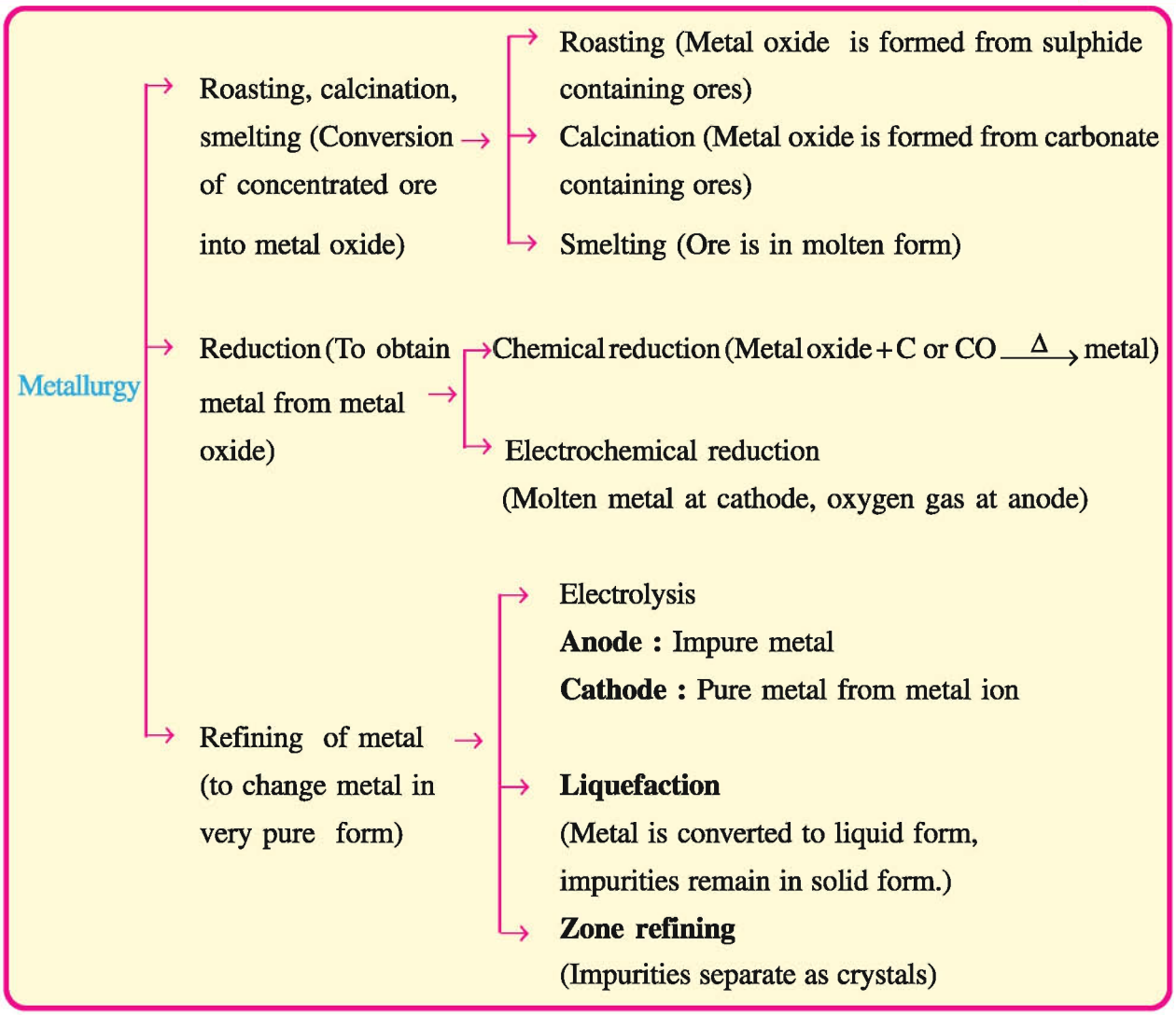
Physical properties of metals

- Metals are lustrous in solid form (except : Hg, Ga), Hard (except: Na, K). Heavy in weight (except : Na, K, Mg, Al).
- Possess property of ductility and malleability
- Melting points and boiling points are high
- Metals produce ringing sound when they are struck.
- Alloys can be prepared by adding one metal to the other metal.

Chemical properties of metals :

- Metal + dioxygen gas → oxide of metal
- Metal + water → metal hydroxide or metal oxide + dihydrogen gas
- Metal + dilute acid (HCl / H_2SO_4) → Salt of metal + dihydrogen gas
- Metal + dichlorine gas → metal chloride
- Active metal (Na, K, Ca) + Dihydrogen gas → Metal hydride
- The process of erosion of any metal when its surface comes in contact with air, water or moisture, is called corrosion.
- The homogeneous mixture of two or more metals or mixture of metal and non-metal is called an alloy. Stainless steel, brass, bronze, magnalium, duralumin and 22 carat gold are the examples of alloy.

Metallurgy
- Powder from ore - ore is ground and made powder
- Concentration of ore (Most of the impurities are removed and the ore is concentrated)
  - Concentration on the basis of difference in densities (when greater difference is there between densities of ore and impurities)
  - Froth flotation process (For concentration of sulphide containing ores)
  - Magnetic separation (when ore or impurity is iron)



EXERCISE

1. Select the proper choice from the given muitiple choices :

(1) What is the chemical formula of alumina ?

(A) Al_2O_3 (B) $Al_2O_3 . 2H_2O$ (C) $Al_2O_3 . H_2O$ (D) $NaAlO_2$

(2) Which of the following reactions is called roasting ?

(A) $ZnCO_3(s) \xrightarrow{\Delta} ZnO(s) + CO_2(g)$

(B) $2ZnS(s) + 3O_2(g) \xrightarrow{\Delta} 2ZnO(s) + 2SO_2(g)$

(C) $ZnO(s) + C(s) \xrightarrow{\Delta} Zn(s) + CO(g)$

(D) $Zn(s) + H_2O(g) \xrightarrow{\Delta} ZnO(s) + H_2(g)$

(3) Which of the following is an alloy ?

(A) Silver (B) Galium

(C) 22 carat gold (D) 24 carat gold

(4) During which reaction dihydrogen gas is not produced under normal conditions ?

(A) Metal + dilute sulphuric acid (B) Metal + dilute hydrochloric acid

(C) Metal + dilute nitric acid (D) Metal + water

(5) In which of the following, displacement reaction is possible ?

(A) Solution of NaCl + coin of copper (B) Solution of $MgCl_2$ + coin of aluminium

(C) Solution of $FeSO_4$ + coin of silver (D) Solution of $AgNO_3$ + coin of copper

(6) Which of the following reactions is not possible ?

(A) $Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$

(B) $Zn(s) + FeSO_4(aq) \rightarrow ZnSO_4(aq) + Fe(s)$

(C) $Fe(s) + CuSO_4(aq) \rightarrow FeSO_4(aq) + Cu(s)$

(D) $Cu(s) + FeSO_4(aq) \rightarrow CuSO_4(aq) + Fe(s)$

(7) By which reaction metal is obtained from metal oxide ?

(A) Liquefaction (B) Reduction (C) Calcination (D) Roasting

(8) Which of the following statements is incorrect ?

(A) Corrosion of copper takes place by contact with air and water

(B) The melting points and boiling points of metals are low.

(C) The method to convert carbonate containing ore to metal oxide is called calcination.

(D) The displacement of less active metals from their solution takes place by more active metal.

(9) Which alloy is used to solder the electric wires ?

(A) Copper + zinc (B) Aluminium + magnesium

(C) Lead + tin (D) Copper + tin

(10) Which metal is available in highest proportion on the earth ?

(A) Iron (B) Copper (C) Aluminium (D) Silver

(11) Which metal is used in thermometer ?

(A) Silver (B) Mercury (C) Sodium (D) Copper

(12) Which of the following substances is hygroscopic ?

(A) Cryolite (B) Feldspar

(C) Anhydrous calcium chloride (D) Slag

2. Answer the following questions in brief :

(1) In which three sections elements are classified ?

(2) Which metals are available in free state in nature ?

(3) In which form ores are available in nature ?

(4) Write names and formulas of two ores of iron.

(5) Write names and formulas of two ores of copper.

(6) Write names of the three methods for concentration of ores.

(7) Which two methods are used for reduction of metal oxides ?

(8) Write names of three methods used for refining of metals.

(9) What has been taken as anode and cathode for refining of metals in electrolysis method ?

(10) Which chief impurities are present in bauxite ?

(11) Which two substances are added along with alumina to obtain aluminium from alumina by electrochemical reduction ?

(12) Which substance is called slag ?

(13) Mention use of slag.

(14) Which general principle is taken into consideration in determination of activity series of metals ?

(15) Mention names of two softer metals.

(16) Write names of two metals which are bad conductors of electricity.

(17) Write names of two metal oxides which form alkali by dissolving in water.

(18) Which two metals burn with explosion in reaction with water ?

(19) Mention two examples of metals forming metal hydride with hydrogen.

(20) Which two metals are generally not corroded ?

(21) Stainless steel is a homogeneous mixture of which three metals ?

(22) Mention examples of two alloys.

(23) Write chemical formula of rust.

(24) Explain the following terms :

(i) Mineral (ii) Ore

(iii) Metallurgy (iv) Centrifugation

(v) Roasting (vi) Calcination

(vii) Anodic mud (viii) Metallic corrosion

(ix) Alloy (x) Galvanizing

(25) Mention the formulas, names and physical states of the products in the following reactions :

(i) $2PbS(s) + 3O_2(g) \rightarrow$

(ii) $MgCO_3(s) \xrightarrow{\Delta}$

(iii) $Fe_2O_3(s) + 3CO(g) \xrightarrow{\Delta}$

(iv) $Fe_2O_3(s) + 2Al(s) \xrightarrow{\Delta}$

(v) $2Al(OH)_3(s) \xrightarrow[\Delta]{1473\,K}$

(vi) $CaO(s) + SiO_2(s) \rightarrow$

(vii) $K_2O(s) + H_2O(l) \rightarrow$

(viii) $Mg(s) + 2H_2O(l) \rightarrow$

(ix) $Zn(s) + 2HCl(aq) \rightarrow$

(x) $Ca(s) + Cl_2(g) \rightarrow$

3. Answer the following questions :

(1) Describe the method to remove impurity of iron from ore.

(2) Explain the method of concentration of copper pyrites - the ore of copper.

(3) By which method conversion of ZnS and $ZnCO_3$ into ZnO can be carried out ? Explain writing chemical equation.

(4) Explain the refining of copper by electrolysis.

(5) Write four physical properties of metals.

(6) Write chemical equations of the reaction of magnesium metal with dioxygen gas, water, dilute hydrochloric acid and dichlorine gas.

(7) Mention the components and uses of brass and bronze.

4. Answer the following questions in detail :

(1) Write a short note : Earth – Treasure of elements

(2) Explain different methods of concentration of ores.

(3) Explain roasting, calcination and smelting.

(4) Explain chemical reduction and electrochemical reduction.

(5) Explain liquefaction and zone refining method for refining of metals.

5. Answer the following questions pointwise :

(1) Discuss the extraction of aluminium from bauxite.

(2) Explain extraction of iron from haematite.

(3) Write the activity series of metals. Discuss the experiment for determination of activity series of Fe, Cu and Ag metals.

(4) Discuss chemical properties of metals.

(5) Mentioning reasons for metallic corrosion describe the remedies to prevent it.

(6) What is an alloy ? Mention its advantages. Mention the name of three alloys and also mention the components in them, properties and uses.

UNIT 9

NON-METALS

9.1 Introduction

Out of 114 elements known till today in chemistry, 18 elements do not act like metals. These elements are called non-metallic elements. Non-metallic elements are shown on the right hand side in the modern Periodic Table. Non-metallic elements are found mainly in solid or gaseous form at room temperatures. Only bromine is found in the liquid form. Hydrogen, nitrogen, oxygen, chlorine, etc. are the examples of gaseous non-metal elements and carbon, sulphur, phosphorus etc. are the examples of non-metals in solid form. Number of non-metallic element is less but their contribution in everyday life is much more, viz dihydrogen gas (H_2) is used in the hydrogenation reaction in preparation of vegetable ghee from vegetable oil. Compounds of ammonia are used as fertilisers. In the production of ammonia in addition to dinitrogen, dihydrogen gas is used in a large amount. We know that vitamins, proteins, carbohydrates, enzymes, etc. play an important role in the development of every living entity. Carbon element is in the base of these components. In electrolysis cell and dry cell, carbon in the graphite form is used as an electrode. Oxygen of the air becomes useful for the living kingdom to exist and in combustion reaction. Sulphur is there in the elements present in plants and animals. It is present in protein, hairs, wool, onion, garlic, etc. Sulphur is used as fungicides and in the preparation of gun powder for guns. In this unit we shall study non-metals like hydrogen and sulphur and their important compounds.

9.2 Physical Properties of Non-metals

Non-metals possess physical properties opposite to those of metal. Non-metals do not possess properties of ductility and malleability. Non-metallic elements in solid form are brittle. The surface of non-metals is not lustrous, but as an exception iodine possesses luster. Non-metallic elements are generally soft but diamond is the hardest substance. Non-metallic elements are bad conductors of electricity and heat but **graphite is known as a good conductor of electricity.**

9.3 Chemical Properties of Non-metallic Elements

Non-metallic elements receive electrons easily and form negative ions. Hence, non-metallic elements are called electronegative elements.

$Cl + e^- \rightarrow Cl^-$

$O + 2e^- \rightarrow O^{2-}$

$S + 2e^- \rightarrow S^{2-}$

Now, we shall discuss the chemical properties of non-metallic elements.

(1) Reaction of non-metal with dioxygen gas : Non-metallic elements combine with dioxygen gas and form oxides. These oxides are either acidic or neutral but are not basic.

$$C\ (s) + O_2(g) \rightarrow CO_2(g)$$

Carbon dioxide

$$S\ (s) + O_2(g) \rightarrow SO_2(g)$$

Sulphur dioxide

$$P_4(s) + 5O_2(g) \rightarrow 2P_2O_5 \text{ or } P_4O_{10}\ (g)$$

Phoshorus pentoxide

Carbon dioxide, sulphur dioxide and phosphorus pentoxide are acidic. They form acids by reaction with water.

$$CO_2(g) + H_2O\ (l) \rightarrow H_2CO_3(aq)$$

Carbonic acid

$$SO_2(g) + H_2O\ (l) \rightarrow H_2SO_3(aq)$$

Sulphurous acid

$$2P_2O_5(g) + 6H_2O\ (l) \rightarrow 4H_3PO_4(aq)$$

Phosphoric acid

Carbon monoxide (CO), nitrous oxide (N_2O) and water (H_2O) are examples of neutral oxides.

(2) Reaction of non-metal with acid : Non-metallic elements are electron accepting elements. Hence, they are not able to displace easily hydrogen present in acid. Thus, the effect of dilute acids on non-metallic elements is not observed, viz. carbon and sulphur do not react with dilute hydrochloric acid or dilute sulphuric acid.

(3) Reaction of non-metal with dichlorine gas : Chlorides of non-metal are formed by reaction of dry dichlorine gas with non-metallic elements. These chloride compounds are generally volatile liquids or are in gaseous forms.

$$P_4(s) + 6Cl_2(g) \rightarrow 4PCl_3(g)$$

Phosphorus trichloride

(4) Reaction of non-metal with dihydrogen : Non-metallic elements on reacting with dihydrogen gas, form stable hydride compounds. These hydride compounds are formed by sharing of electrons between non-metallic element and hydrogen, e.g ammonia (NH_3), water (H_2O), methane (CH_4), hydrogen sullphide (H_2S) etc.

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

$$O_2(g) + 2H_2(g) \rightarrow 2H_2O(l)$$

$$C(s) + 2H_2(g) \rightarrow CH_4(g)$$

$$S(s) + H_2(g) \rightarrow H_2S(g)$$

9.4 Hydrogen

The word hydrogen is derived from the two Greek words - 'Hydro' means water and 'Gene' means to produce, i.e. it is known as water producer. The symbol of hydrogen is H. The discovery of hydrogen was made by a scientist from England - Henry Cavendish, in 1766. Hydrogen takes first place in the periodic table. It is the lightest element. Hydrogen atom being very active, does not possess independent (free) existence, but it possesses stable existence in the form of a dihydrogen (H_2) molecule or in combined form with any other element. Three out of the four parts of the earth are full of water which is a compound of hydrogen and oxygen. In living substances also it is in combined form with carbon element. Hydrogen is also observed in the space. When hydrogen is converted to helium by fusion reaction, then solar energy is produced.

(1) Preparation of Dihydrogen Gas : Dihydrogen gas can be prepared by reaction of metal with water or dilute acid. Dihydrogen gas is produced by reaction of very active metals like potassium, sodium or calcium with cold water.

$$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$$

$$Ca(s) + 2H_2O(l) \rightarrow Ca(OH)_2(aq) + H_2(g)$$

Less active metals like magnesium, zinc, iron etc, produce dihydrogen gas by reaction with vapour of water :

$$Mg(s) + H_2O(g) \rightarrow MgO(s) + H_2(g)$$

$$Zn(s) + H_2O(g) \rightarrow ZnO(s) + H_2(g)$$

$$3Fe(s) + 4H_2O(g) \rightarrow Fe_3O_4(s) + 4H_2(g)$$

(2) Preparation of Dihydrogen Gas (H_2) in Laboratory : In laboratory, for the preparation of dihydrogen gas, generally granular, pieces of zinc metal are taken in 500 ml conical flask as shown in Fig. 9.1. Dilute hydrochloric acid or dilute sulphuric acid is added through Thistle funnel. Dihydrogen gas is produced by the reaction between them. This gas is collected in a gas jar by downward displacement of water because it is a gas lighter than water.

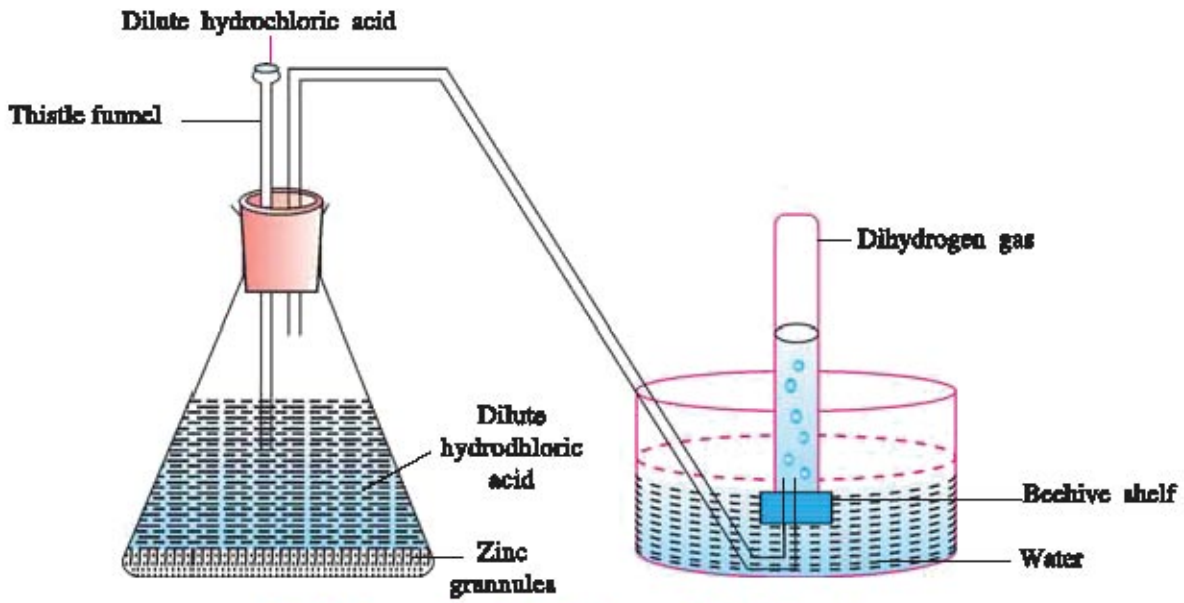


Fig 9.1 Preparation of dihydrogen Gas in Laboratry

Reaction :

$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$$

$$Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$$

(3) Industrial Manufacture of Dihydrogen Gas

In recent times, hydrogen gas is widely used in industries. The production of hydrogen gas can be carried out from natural gas. The chief component in natural gas is methane. When natural gas mixed with vapour of water is passed on a nickel catalyst at the temperature 1073 K and 30 bar pressure, chemical reaction takes place and a mixture of carbon monoxide and dihydrogen gas is obtained. This gaseous mixture is called **water gas.**

$$CH_4(g) + H_2O(g) \xrightarrow[1073\,K\ 30\,bar]{Ni} CO(g) + 3H_2(g)$$

By reaction of water gas again with vapour of water, more dihydrogen gas is produced and carbon monoxide is removed.

$$CO(g) + H_2O(g) \rightarrow CO_2(g) + H_2(g)$$

To separate dihydrogen gas from this gaseous mixture, it is passed through water at 30 bar pressure because, carbon dioxide gas dissolves in water as it is soluble in water but dihydrogen gas is insoluble in water and so it can pass through and dihydrogen gas is obtained. This way it can be collected in gas jar.

Also, pure dihydrogen gas can be obtained by electrolysis of pure water by using the apparatus called voltameter.

(4) Physical Properties of Dihydrogen Gas

- Dihydrogen is colourless, odourless and tasteless gas.
- Normally it is insoluble in water.
- It is lighter than air and also lighter than all other gases, so it is the lightest gas.
- As it does not show any effect on wet blue or red litmus paper, it is a neutral gas.

(5) Chemical Properties of Dihydrogen Gas :

(1) Reaction with dioxygen gas : Water is formed by reaction of dihydrogen gas with dioxygen gas

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$$

Dihydrogen gas forms explosive mixture with dioxygen gas.

When the mixture of these two gases burns, it explodes. As large amount of energy is produced by this reaction, it is used as fuel in space rockets.

Here, we should understand that when an ignited match stick is put into a gas jar it extinguishes. This shows that dihydrogen gas is not the supporter of combustion but when dihydrogen gas is burnt in presence of air or oxygen, it burns with a blue flame and produces steam i.e. H is combustible. Water can be obtained by cooling this steam.

(2) Reaction with Metal Oxide : Dihydrogen gas is a good reducing agent. It reduces easily, the metallic oxides of elements less active than zinc in the activity series and converts into metals viz. when copper oxide is heated in presence of dihydrogen, then it is reduced to copper metal and water is formed by oxidation of dihydrogen gas.

$$CuO(s) + H_2(g) \rightarrow Cu(s) + H_2O\ (g)$$

(3) Reaction with Dichlorine Gas : Dichlorine possesses more attraction towards dihydrogen. The mixture of equal proportions of dihydrogen and dichlorine explodes in presence of sunlight and produces fumes of hydrogen chloride gas in absence of sunlight.

$$H_2(g) + CI_2(g) \xrightarrow{\text{Absence of light}} 2HCl\ (g)$$

(4) Reaction with Active Metal : Dihydrogen gas combines with certain active metals like Na, K, Ca and forms the metallic hydride of that metal.

$$H_2(g) + 2Na(s) \rightarrow 2NaH(s)$$

$$H_2(g) + 2K(s) \rightarrow 2KH(s)$$

$$H_2(g) + Ca(s) \rightarrow CaH_2(s)$$

(6) Uses of Dihydrogen Gas :

- As one of the reactants in the production of ammonia gas by Haber's process.
- In hydrogenation reaction of preparation of vegetable ghee from vegetable oil in presence of nickel catalyst.
- In welding of metals and in oxyhydrogen flame for cutting metals.
- In industrial production of methanol and hydrochloric acid, as fuel in rockets and fuel cell for production of electricity.
- Dihydrogen gas gets adsorbed on solid alloy and can be released whenever required and can be stored to use it again.
- The calorific value of dihydrogen gas is the highest of all other fuels. By combustion of dihydrogen gas, water is produced and so there is no question of pollution. Thus, there is a possibility of hydrogen being an important source of energy in future.

9.5 Ammonia

Ammonia is a very important chemical. It is used in production of nitric acid, polymers and in production of artificial fertilisers. Ammonia was synthesized by German Chemist Haber. Hence, this method of production is known as Haber's process.

(1) Industrial Production of Ammonia Gas : Industrial production of ammonia gas is carried out by Haber's process. In this method dihydrogen and dinitrogen gases are mixed in 3:1 proportion by volume and then passed over iron catalyst at 200-300 bar pressure. Temperature about 773 K is maintained during this reaction. Substances like Al_2O_3, K_2O are added to increase the efficiency of the catalyst. Hence, they are called **promoters.** By cooling the reaction mixture at temperature lower than 273 K, ammonia can be separated from the unreacted N_2 and H_2 gases.

Thus, ammonia is obtained in the liquid form and N_2 and H_2 remained without reaction can be used again to take part in the reaction.

$$N_2(g) + 3H_2(g) \xrightarrow[200\text{-}300 \text{ bar [Fe]}]{773\,K} 2NH_3(g) + \text{Heat}$$

(2) Physical Properties of Ammonia Gas :

- Ammonia is a colourless gas.
- It possesses very intensive smell, causing irritation in the nose and eyes.
- It is lighter gas than air
- It is highly soluble in water.
- Aqueous solution of ammonia acts as a weak base. The concentrated solution of ammonia is called **liquor ammonia.**

(3) Chemical Properties of Ammonia Gas :

(1) Reaction with hydrogen chloride gas : By reaction of ammonia gas with hydrogen chloride gas, solid ammonium chloride is obtained.

$$NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$$

When a glass rod dipped in concentrated hydrochloric acid is placed near the vessel containing ammonia gas while dense fumes are produced of ammonium chloride is formed as small particles. In laboratory, this reaction is useful in testing of ammonia gas.

(2) Effect of ammonia as reducing agent : On passing ammonia gas over the hot cupric oxide (CuO) black coloured oxide is reduced and red brown coloured copper metal is obtained.

$$2NH_3(g) + 3CuO(s) \rightarrow 3Cu(s) + 3H_2O(l) + N_2(g)$$

(3) Catalytic oxidation of ammonia : On passing the mixture of ammonia and dioxygen gas over platinum catalyst heated at 1073 K temperature ammonia is oxidised to nitric oxide.

$$4NH_3(g) + 5O_2(g) \xrightarrow{[Pt]\ 1073K} 4NO(g) + 6H_2O(g)$$

The produced nitric oxide immediately combines with oxygen and gives brown coloured fumes of nitrogen dioxide.

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$$

This nitrogen dioxide reacts with water and forms nitric acid. This process to obtain nitric acid from ammonia gas is known as Ostwald's process.

$$3NO_2(g) + H_2O(l) \rightarrow 2HNO_3(aq) + NO(g)$$

(4) Effect of ammonia gas on litmus paper : Dry ammonia gas does not show any effect on litmus paper but aqueous solution of ammonia turns red litmus paper into blue. This indicates that aqueous solution of ammonia shows basic nature, because ammonia gas dissolves in water and forms weak base ammonium hydroxide which gives OH^- ion by ionisation in less proportion.

$$NH_3(g) + H_2O(l) \rightleftharpoons NH_4OH(aq) \rightleftharpoons NH^+_4(aq) + OH^-(aq)$$

Aqueous solution of ammonia is basic. Salt and water are formed by its reaction with acid, e.g. by reaction of aqueous hydrochloric acid with aqueous solution of ammonia. (NH_4OH) ammonium chloride (salt) and water are formed.

$$NH_4OH(aq) + HCl\ (aq) \rightleftharpoons NH_4Cl(aq) + H_2O(l)$$

(5) Reaction with metal ion : By reaction of aqueous solution of ammonia with aqueous solution of metal ion, metal hydroxide insoluble in water is formed, viz. blue coloured precipitates of cupric hydroxide are obtained by addition of solution of ammonium hydroxide to aqueous solution of cupric sulphate.

$$CuSO_4(aq) + 2NH_4OH(aq) \rightarrow Cu(OH)_2(s) + (NH_4)_2SO_4(aq)$$

But if excess of NH_4OH is added then precipitates dissolve and dark blue coloured solution is obtained, which is due to the formation of complex salt of copper with ammonia.

$$Cu(OH)_2(s) + 4NH_4OH(aq) \rightarrow [Cu(NH_3)_4]\ (OH)_2(aq) + 4H_2O(l)$$

Similarly ammonium hydroxide with ferrous sulphate, magnesium sulphate and aluminium chloride forms ferrous hydroxide, magnesium hydroxide and aluminium hydroxide respectively.

$$FeSO_4(aq) + 2NH_4OH(aq) \rightarrow Fe(OH)_2(s) + (NH_4)_2SO_4(aq)$$

$$MgSO_4(aq) + 2NH_4OH(aq) \rightarrow Mg(OH)_2(s) + (NH_4)_2SO_4(aq)$$

$$AlCl_3(aq) + 3NH_4OH(aq) \rightarrow Al\ (OH_3)(s) + 3NH_4Cl\ (aq)$$

(4) Uses of Ammona Gas :

- The important use of ammonia is in the preparation of fertilisers like ammonium nitrate, ammonium sulphate and diammonium phosphate.
- In preparation of nitric acid by Ostwald's process.
- In preparation of dyes, explosives and nylon etc.
- In preparation of baking soda and washing soda.
- In preparation of certain medicines like para aminobenzoic acid, folic acid, etc.

9.6. Sulphur

Many years ago sulphur was used as medicine in Ayurvedic medicines. Sulphur is available in nature in both free and combined forms. Sulphur is obtained in combined form with certain metal ions viz copper pyrites ($CuFeS_2$), zinc blende (ZnS), galena (PbS) etc. Sulphur is in noticeable proportion in petroleum and natural gas. The place of sulphur is in group-16 below oxygen in periodic table. The atomic number of sulphur is 16. Hence, its electronic configuration is 2,8,6. Sulphur also possesses property of catenation.

(1) Extraction of Sulphur : The method that is used for direct extraction of sulphur from the core of the earth is called Frasch method. This method is based on the low melting point of sulphur. In this method, as shown in Figure 9.2 three concentric pipes are passed below in the soil so that they touch the layer of the sulphur. Superheated water vapour is passed at 443 K temperature in the soil through the outermost cylinder. Sulphur melts because of its low melting point. Afterwards, air at high pressure is passed through the innermost cylinder so that sulphur and water in the central

cylinder come out on the outer surface and gets cooled. Sulphur is insoluble in water and so it can be easily separated.

Sulphur is also obtained from petroleum and natural gas. Firstly, sulphur compounds are converted into hydrogen sulphide (H_2S). Sulphur dioxide is obtained by its combustion. Sulphur is obtained in free state when sulphur dioxide is heated with H_2S in presence of Fe_2O_3 catalyst.

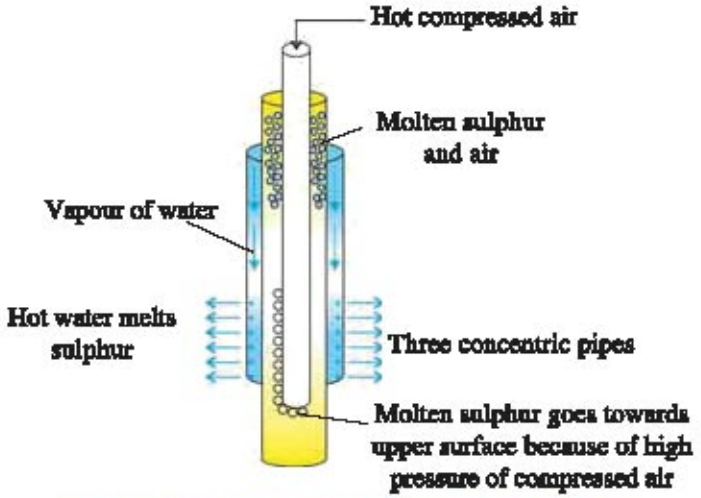


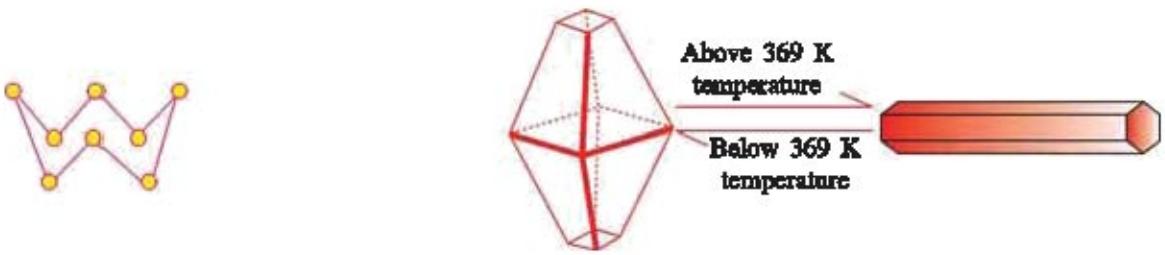
Fig. 9.2 Frasch method for production of sulphur

$$2H_2S(g) + 3O_2(g) \rightarrow 2SO_2(g) + 2H_2O(g)$$

$$SO_2(g) + 2H_2S(g) \xrightarrow[[Fe_2O_3]]{573\,K} 3S(s) + 2H_2O(g)$$

(2) Allotropes of Sulphur :

Two or more forms of an element having existence because of the different arrangements of atoms in allotropes of that element is called **allotropy**. There are two crysalline forms of sulphur in solid state like rhombic sulphur and monoclinic sulphur. These two forms are called **allotropes** of sulphur. Rhombic sulphur is stable at temperature lower than 369 K and monoclinic sulphur is stable at temperature higher than 369 K. Both these forms i.e. allotropes have same chemical properties but different physical properties because the crystal structures of allotropes are different. Rhombic sulphur possesses octahedral structure, while monoclinic sulphur possesses needle like crystals.



S_8 molecule (crown structure) | Rhombic sulphur (Octahedral shape) | Monoclinic sulphur (Needle shaped crystal)

Fig. 9.3 Allotropes of Sulphur

There is S_8 ring in both the allotropes of sulphur. When sulphur is heated then this ring will break, but as we go on heating the pieces of the ring, they combine with each other and get converted into small particles after being viscous. As a result of this liquid sulphur starts boiling.

Fig. 9.4 Effect of temperature on sulphur

(3) Physical Properties of Sulphur :

- Sulphur is yellow coloured solid substance having different allotropes.
- It is insoluble in water but is soluble in organic solvents like carbon disulphide and toluene.
- Its melting point is low (388 K).

(4) Chemical properties of Sulphur :

(1) Reaction with acid : In reaction of sulphur with hot concentrated sulphuric acid, sulphur dioxide is formed by oxidation of sulphur.

$$S(s) + 2H_2SO_4(l) \rightarrow 2H_2O(l) + 3SO_2(g)$$

On oxidation of sulphur by concentrated nitric acid, sulphuric acid is formed.

$$S(s) + 6HNO_3(aq) \rightarrow H_2SO_4(aq) + 6NO_2(g) + 2H_2O(l)$$

(2) Reaction with dihydrogen gas : Hydrogen sulphide is obtained by reaction of boiling sulphur with dihyrodgen gas.

$$S(l) + H_2(g) \rightarrow H_2S(g)$$

(3) Reaction with carbon element : Carbon disulphide is formed by the reaction of carbon with sulphur at high temperature.

$$C(s) + 2S(s) \rightarrow CS_2(l)$$

(5) Uses of Sulphur :

- In manufacture of sulphuric acid.
- In production of solvent like carbon disulphide.
- As antiseptic and fungicide in skin diseases.
- In vulcanization of rubber, preparation of fire crackers, preparation of dyes and preparation of insecticides.

9.7 Sulphur Dioxide

Sulphur dioxide gas is formed by reaction of sulphur with dioxygen.

$$S(s) + O_2(g) \xrightarrow{\Delta} SO_2(g)$$

Sulphur dioxide gas is present in the fumes exhausted by industries and in use of sulphur containing fuels by the automobiles. It is considered as a chief pollutant in spreading air pollution. Sulphur dioxide is responsible for the acid rain. This sulphur dioxide is oxidized into sulphur trioxide which forms sulphuric acid by dissolving in rain water. Buildings, bridges and trees are destroyed because of acid rain.

(1) Physical properties of sulphur dioxide :

- It is a colourless gas.
- It has intense smell that causes coughing and suffocation.
- Aqueous solution of sulphur dioxide possesses acidic property because it is an oxide of non-metal.

(2) Chemical properties of sulphur dioxide gas :

(1) Reaction with gas : Sodium sulphite is formed by passing sulphur dioxide gas through the solution of sodium hydroxide because sulphur dioxide is an acidic oxide.

$$SO_2(g) + 2NaOH(aq) \rightarrow \underset{\text{Sodium sulphite}}{Na_2SO_3(aq)} + H_2O(l)$$

Lime water becomes milky due to formation of calcium sulphite when sulphur dioxide gas is passed through decanted lime water.

$$SO_2(g) + Ca(OH)_2(aq) \rightarrow \underset{\text{Calcium sulphite}}{CaSO_3(s)} + H_2O(l)$$

But if sulphur dioxide in large proportion is passed through this solution the milky colour of solution disappears because of formation of soluble calcium hydrogen sulphite.

$$CaSO_3(s) + H_2O(l) + SO_2(g) \rightarrow \underset{\text{Calcium hydrogen sulphite}}{Ca(HSO_3)_2(aq)}$$

(2) Reaction with dioxygen gas : On reaction of sulphur dioxide gas with dioxygen gas in presence of vanadium pentoxide (V_2O_5) catalyst, sulphur trioxide gas is formed by oxidation of sulphur dioxide.

$$2SO_2(g) + O_2(g) \xrightarrow[723\,K]{[V_2O_5]} 2SO_3\ (g)$$

(3) Reaction with hydrogen sulphide gas : Sulphur is formed by reaction of sulphur dioxide gas with hydrogen sulphide gas. Here, sulphur dioxide acts as an oxidising agent and so H_2S is oxidised to S and SO_2 is reduced to S.

$$SO_2(g) + 2H_2S(g) \rightarrow 3S(s) + 2H_2O\ (l)$$

(4) Effect of sulphur dioxide as reducing agent : Sulphur dioxide gas reduces acidic potassium dichromate ($K_2Cr_2O_7$). Hence, orange coloured solution becomes green coloured solution due to the formation of chromic ion (Cr^{3+}) in the end.

$$\underset{\text{Orange colour}}{3SO_2(g) + 2H^+(aq) + Cr_2O_7^{2-}(aq)} \rightarrow \underset{\text{Green colour}}{3SO_4^{2-}(aq) + H_2O(l) + 2Cr^{3+}(aq)}$$

(3) Uses of Sulphur Dioxide Gas :

- In manufacture of sulphuric acid.
- It inhibits the growth of bacteria, hence it is used as preservative in juice of fruits, in jam and drying of fruits.
- Used for bleaching of wooden pulp in paper industry. Thus, it is a weak bleaching agent.

9.8 Sulphuric Acid

Sulphuric acid is an important industrial chemical. It is called the "King of Chemicals" because sulphuric acid is widely used in the production of most of the chemicals like fertilisers, paints synthetic fibres, soap and detergents.

(1) Production of Sulphuric Acid : Sulphuric acid is produced by contact process. In this process sulphur is burnt in air so that sulphur dioxide gas is formed. Sulphur dioxide gas with excess air is passed over solid vanadium pentoxide (V_2O_5) catalyst at 723 K so that sulphur trioxide gas is formed. For this reaction platinum catalyst was used but it became useless due to catalytic poisoning. In its place vanadium pentoxide is used.

$$S(s) + O_2(g) \rightarrow SO_2(g)$$

$$2SO_2(g) + O_2(g) \xrightarrow[723\,K]{[V_2O_5]} 2SO_3(g)$$

When sulphur trioxide is dissolved in water it forms sulphuric acid with very corrosive fumes but if sulphur trioxide gas is absorbed in concentrated sulphuric acid, fuming viscous liquid is formed. It is called fuming sulphuric acid or oleum ($H_2S_2O_7$). Oleum is diluted with water and sulphuric acid of desired concentration can be obtained.

$$SO_3(g) + H_2O(l) \rightarrow H_2SO_4(aq)$$

$$SO_3(g) + H_2SO_4(l) \rightarrow H_2S_2O_7(l)$$

Oleum

$$H_2S_2O_7(l) + H_2O(l) \rightarrow 2H_2SO_4(aq)$$

The production of sulphuric acid can be carried out by another method like Lead Chamber process. In this method sulphur dioxide is oxidised to sulphur trioxide by nitrogen dioxide (NO_2). The acid obtained by this method, is not of higher concentration and this process is also slow. Hence, contact process is used as the modern method for production of sulphuric acid.

(2) Properties of Sulphuric Acid : Sulphuric acid is used as concentrated sulphuric acid and dilute sulphuric acid is used in industries and laboratory. Here, we shall study its properties.

Properties of Concentrated Sulphuric Acid :

- Concentrated sulphuric acid is a colourless dense viscous liquid.
- 98% H_2SO_4 and 2% H_2O are there in it.
- It acts as an oxidising agent. It oxidises carbon and sulphur atoms into carbon dioxide and sulphur dioxide.

$$C(s) + 2H_2SO_4(aq) \rightarrow 2H_2O(l) + 2SO_2(g) + CO_2(g)$$

$$S(s) + 2H_2SO_4(aq) \rightarrow 2H_2O(l) + 3SO_2(g)$$

- It is a strong dehydrating agent. Hence, utmost care is to be taken while using it. If concentrated sulphuric acid falls on sugar, paper, wood etc. it removes water from it and burns it. Similarly, if this acid falls on skin, it absorbs water from muscular tissue and burns it. Now, we shall study the property as strong dehydrating agent of sulphuric acid by an activity.

Activity : 1

Test of Sulphuric acid for the property of Sulphuric acid as a strong dehydrating agent :

- First of all take some sugar in a test tube. Add few drops of concentrated sulphuric acid to it.
- Now you observe the substance in the test tube.
- On observing, you will find the sugar in the test tube being changed to black coloured substance. Now, the question will arise that why this has happened ?

Sugar contains carbon, hydrogen and oxygen elements. The concentrated sulphuric acid removes hydrogen and oxygen from the sugar as water. Carbon remaining in sugar is left as black substance, by burning.

$$\underset{\text{Sugar (sucrose)}}{C_{12}H_{22}O_{11}(s)} \xrightarrow{\text{Concentrated } H_2SO_4} \underset{\text{Black substance}}{12C(s)} + 11H_2O(l)$$

- In a test tube take little crystalline copper (II) sulphate ($CuSO_4.5H_2O$). Note the colour of the substance.
- Add few drops of concentrated sulphuric acid in the test tube.
- Now, you continue observing colour of the substance in the test tube.
- On observation, you will find that the crystal of copper sulphate slowly changes into white.

The reason for this is that by addition of concentrated sulphuric acid to copper sulphate ($CuSO_4 \cdot 5H_2O$) the water of crystallization in it is removed. Anhydrous copper sulphate ($CuSO_4$) obtained this way, is colourless.

$$(CuSO_4 \cdot 5H_2O) \xrightarrow{\text{Concentrated } H_2SO_4} CuSO_4(s)$$

Properties of dilute sulphuric Acid :

- In dilute sulphuric acid, there is 10% sulphuric acid and 90% water.
- Dilute sulphuric acid can be prepared by adding concentrated sulphuric acid slowly to water. As heat is produced during this, pieces of ice are placed around the vessel. At this stage, we will have the definite idea that dilute sulphuric acid cannot be prepared by adding water to concentrated sulphuric acid. Definitely, it can be prepared but the difficulty is that when concentrated acid is added to water, heat is produced in large proportion and so there is possibility of drops of acid to fall on our body.
- It turns blue litmus into red.
- It produces sulphate of metal and dihydrogen gas when reacted with metal.

$$Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(q)$$

$$Fe(s) + H_2SO_4(aq) \rightarrow FeSO_4(aq) + H_2(g)$$

- It produces sulphates of metal, water or carbon dioxide gas when reacts with oxides, hydroxides or carbonates of metal.

$ZnO(s) + H_2SO_4(aq) \rightarrow ZnSO_4\ (aq) + H_2O(l)$

$CuO(s) + H_2SO_4(aq) \rightarrow CuSO_4\ (aq) + H_2O(l)$

$2NaOH(s) + H_2SO_4(aq) \rightarrow Na_2SO_4\ (aq) + 2H_2O(l)$

$CaCO_3(s) + H_2SO_4(aq) \rightarrow CaSO_4\ (aq) + H_2O(l) + CO_2(g)$

- It produces sodium sulphate and carbon dioxide by reaction with sodium carbonate or sodium bicarbonate.

$Na_2CO_3(s) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + H_2O(l) + CO_2(g)$

$2NaHCO_3(s) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + H_2O(l) + CO_2(g)$

- As two hydrogen atoms of sulphuric acid can be displaced, it is known as dibasic or diprotic acid. If one hydrogen atom is displaced, then hydrogen sulphate (acid-salt) and if two hydrogen atoms are displaced, then sulphate salt (neutral salt) is formed.

$NaOH(aq) + H_2SO_4(aq) \rightarrow NaHSO_4(aq)\ (\text{Acid salt}) + H_2O(l)$

$2NaOH\ (aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq)\ (\text{Neutral salt}) + 2H_2O(l)$

(3) Uses of Sulphuric Acid :

- In industries for production of fertilisers, plastic, fibers, dyes, pigments, paints, detergents.
- As a reagent in analysis of chemical substances in laboratory.
- To obtain acids like HCl, HBr from their salts.

What have you learnt ?

Only 18 elements out of 114 elements known till today, do not behave as metals. These elemetns are called non-metallic elements.

Some important Non-metallic Elements

Non-metallic Elements	Physical State	Importance
Carbon	Solid	Element carbon is present in vitamins, proteins, carbohydrates, enzymes etc. Graphite used in electrolysis and dry cell in the form of carbon.
Sulphur	Solid	It is present in the substances present in plants and animals. It is also present in proteins, hair, wool, onion and garlic. Sulphur is used as fungicide and in gun powder.
Hydrogen	Gas	In hydrogenation reaction of preparing vegetable ghee, in production of ammonia gas.
Nitrogen	Gas	Used as dinitrogen gas in production of ammonia gas.
Oxygen	Gas	Oxygen of air is useful for living kingdom to survive and in combustion reaction.

Physical Properties of Non-metallic Elements

- Brittle
- Soft (Exception Diamond)
- Lustreless (Exception Iodine)
- Bad conductors of electricity and heat (Exception graphite – good conductor of electricity)

Chemical Properties of Non-metallic elements

Non-metallic Element →
- $O_2(g)$ → Oxide
- Dilute acid → Reaction does not occur
- $Cl_2(g)$ → Chloride of non-metal
- $H_2(g)$ → Stable hydride

Hydrogen : Hydrogen atom does not exist free because it is very active. But as a dihydrogen molecule (H_2) or in compound with other element, it possesses stable existence.

Physical properties of dihydrogen gas :

$$CH_4\ (g) + H_2O\ (g) \xrightarrow[1073\,K\ 30\,bar]{Ni} CO(g) + 3H_2(g)$$

$$CO(g) + H_2O(g) \rightarrow CO_2(g) + H_2(g)$$

In addition, pure dihydrogen can be obtained by electrolysis of pure water using apparatus voltameter

Physical properties of dihydrogen gas

- Colourless, Odourless, Tasteless
- Insoluble in water
- Lightest gas
- Neutral towards litmus

Chemical properties of dihydrogen gas :

Dihydrogen gas (H_2) →
- $O_2(g)$ → water
- Metallic oxide of the metal less active than zinc → Corresponding metal
- $Cl_2(g)$ → Hydrogen chloride gas
- Absence of sunlight
- Active metal → Metallic hydroxide of corresponding metal.

Ammonia :

Industrial production of ammonia gas (Haber's Process)

Dihydrogen gas + Dinitrogen gas (Volume 3 : 1) $\xrightarrow[Al_2O_3,\ K_2O\ (Promoters)]{200\text{-}300\ bar,\ 273\,K\,[Fe]}$ Ammonia gas $\xrightarrow{273\,K}$ Lower than Liquid ammonia

$$N_2\,(g) + 3H_2\,(g) \underset{Al_2O_3,\ K_2O\ (Promoters)}{\overset{773\ K\ [Fe]}{\rightleftharpoons}} 2NH_3\,(g) + \text{Heat}$$

Physical properties of ammonia gas

- Colourless
- Intense odour
- Lighter than air
- Highly soluble in water
- Aqueous solution is basic

Chemical properties of ammonia gas

Ammonia gas (NH_3) →
- HCl(g) → Ammonium chloride
- Hot CuO(s) → Copper metal
- O_2 (g), [Pt]1073 K → Nitric oxide
- Aqueous solution of salt of metal → Metal hydroxide insoluble in water

Sulphur : Sulphur is obtained free and in combined form in nature. Sulphur possesses property of catenation

Extraction of Sulphur : The method used directly to extract sulphur from the earth is called Frasch method.

$$2H_2S(g) + 3O_2(g) \rightarrow 2SO_2(g) + 2H_2(g)$$

$$SO_2(g) + 2H_2S(g) \xrightarrow[[Fe_2O_3]]{573\ K} 3S(s) + 2H_2O(g)$$

Allotropes of Sulphur : Two or more than two forms of an element having existence because of different arrangements of atoms of element in similar physical state are called allotropes. This property of the elements is called allotropy. The chemical properties of allotropes are same but physical properties are different. Sulphur has two allotropes : rhombic sulphur and monoclinic sulphur in solid state.

$$\text{Rhombic sulphur} \underset{\text{Temperature less than 369 K}}{\overset{\text{Temperature higher than 369 K}}{\rightleftharpoons}} \text{Monoclinic sulphur}$$

Physical properties of Sulphur

- Yellow coloured
- Insoluble in water, soluble in organic solvent
- Low melting point (388 K)

Sulphur Dioxide :

Sulphur dioxide gas is formed by reaction of sulphur with dioxygen gas.

$$S(s) + O_2(g) \xrightarrow{\Delta} SO_2(g)$$

Physical properties of Sulphur Dioxide

- Colourless
- Intensive odour
- Aqueous solution acidic in nature

Sulphuric Acid : Sulphuric acid is called "King of Chemicals" because it is very useful in preparation of most of the chemicals. Sulphuric acid is manufactured by contact process. Sulphuric acid is used as concentrated sulphuric acid and as dilute sulphuric acid in industries and in laboratory.

Dilute sulphuric acid (H_2SO_4) →

- Metal → Sulphate salt of metal + dihydrogen gas
- Metallic oxide → Sulphate salt of metal + water
- Metal hydroxide → Sulphate salt of metal + water
- Metal carbonate → Sulphate salt of metal + water + carbon dioxide gas
- Metal bicarbonate → Sulphate salt of metal + water + carbon dioxide gas

EXERCISE

1. Select the proper choice from the given multiple choices :

(1) Which non-metallic element is in liquid form ?

(A) Carbon (B) Hydrogen (C) Bromine (D) Phosphorus

(2) With which of the following elements carbon does not give reaction ?

(A) Dichlorine gas (B) Dioxygen gas

(C) Dihydrogen gas (D) Dilute hydrochloric acid

(3) Which of the following oxides is of neutral nature ?

(A) CO_2 (B) SO_2 (C) P_2O_5 (C) N_2O

(4) Which of the following gases is insoluble in water ?

(A) H_2 (B) CO_2 (C) NH_3 (D) SO_2

(5) Which of the following gases is used as preservative in juice of fruits and jams ?

(A) NH_2 (B) SO_2 (C) H_2 (D) CO_2

(6) Which of the following acids is called king of chemicals ?

(A) HNO_3 (B) H_2SO_4 (C) HCl (D) CH_3COOH

(7) Which of the following gases is combustible ?

(A) CO_2 (B) H_2 (C) SO_2 (D) NH_3

(8) Which of the following acts as catalyst in production of ammonia by Haber's porcess ?

(A) Al_2O_3 (B) K_2O (C) V_2O_5 (D) Fe

(9) Make the correct pairs from below mentioned (X) and (Y).

(X)	(Y)
(a) Extraction of sulphur	(1) Contact Process
(b) Production of nitric acid	(2) Frasch method
(c) Production of sulphuric acid	(3) Haber's process
(d) Production of ammonia gas	(4) Ostwald's method

(A) (a-4) (b-3), (c-2), (d-1) (B) (a-2) (b-4), (c-1), (d-3)

(C) (a-3), (b-2), (c-4), (d-1) (D) (a-4), (b-2), (c-3), (d-1)

(10) Make correct pairs from below mentioned (X) and (Y).

(X)	(Y)
(a) Dehydrating agent	(1) Sulphur dioxide gas
(b) In preparation of fire crackers	(2) Concentrated sulphuric acid.
(c) Weak bleaching agent	(3) Dihydrogen gas
(d) Lightest gas	(4) Sulphur

(A) (a-4), (b-3), (c-1), (d-2) (B) (a-3), (b-2), (c-4), (d-1)

(C) (a-3), (b-1), (c-2), (d-4) (D) (a-2), (b-4), (c-1), (d-3)

(11) Make the correct pairs from below mentioned (X) and (Y).

(X)	(Y)
(a) Sulphurous acid	(1) H_3PO_4
(b) Sulphuric acid	(2) $H_2S_2O_7$
(c) Oleum	(3) H_2SO_3
(d) Phosphoric acid	(4) H_2SO_4

(A) (a-2), (b-3), (c-1), (d-4) (B) (a-4) (b-2), (c-1), (d-3)

(C) (a-3), (b-4), (c-2), (d-1) (D) (a-2), (b-3), (c-1), (d-4)

2. Answer the following questions in brief :

(1) Give two examples of non-metallic elements which are in solid form.

(2) Give two examples of non-metallic elements which are in gaseous form.

(3) The mixture of which two gases is known as water gas ?

(4) Which two substances are used as promoters in manufacture of ammonia gas by Haber's process ?

(5) What is meant by liquor ammonia ? Write its chemical formula.

(6) What is meant by allotropy and allotropes. ?

(7) Write two allotropes of sulphur.

(8) Mention the effect of litmus paper on aqueous solution of ammonia.

(9) Mention the formulas of the products, name and physical state of the following reactions :

(i) $P_4(s) + 5O_2(g) \rightarrow$ .....

(ii) $SO_2(g) + H_2O(l) \rightarrow$ .....

(iii) $P_4(s) + 6Cl_2(g) \rightarrow$ .....

(iv) $O_2(g) + 2H_2(g) \rightarrow$ .....

(v) $Mg(s) + H_2O(g) \rightarrow$ .....

(vi) $3Fe(s) + 4H_2O(g) \rightarrow$ .....

(vii) $CO\ (g) + H_2O(g) \rightarrow$ .....

(viii) $3NO_2\ (g) + H_2O(l) \rightarrow$ .....

(ix) $S(s) + 6HNO_3(aq) \rightarrow$ .....

(x) $SO_3(g) + H_2SO_4(aq) \rightarrow$ .....

(xi) $C_{12}H_{22}O_{11}(s) + Con\ H_2SO_4(l) \rightarrow$ .....

(xii) $CaCO_3(s) + dil\ H_2SO_4(aq) \rightarrow$ .....

(10) Mention the missing information in $\square$ in the following chemical reactions :

(i) $\square + H_2O(l) \rightarrow H_2SO_4(aq)$

(ii) $S(s) + \square \rightarrow SO_2(g)$

(iii) $\square + H_2O(l) \rightarrow H_2CO_3(aq)$

(iv) $S(s) + H_2(g) \rightarrow \square$

(v) $2Na(s) + \square \rightarrow 2NaOH(aq) + H_2(g)$

(vi) $Zn(s) + H_2O(g) \rightarrow ZnO(s) + \square$

(vii) $CH_4(g) + H_2O(g) \xrightarrow[1073\,K,\,30\,bar]{\square} CO(g) + 3H_2(g)$

(viii) $CuO(s) + \square \rightarrow Cu(s) + H_2O(g)$

(ix) $H_2(g) + \square \rightarrow 2KH(s)$

(x) $MgSO_4(aq) + \square \rightarrow Mg(OH)_2(s) + (NH_4)_2SO_4(aq)$

(xi) $SO_2(g) + 2H_2S(g) \xrightarrow[573\,K]{\square} 3S(s) + 2H_2O(g)$

(xii) $2SO_2(g) + O_2(g) \xrightarrow[723\,K]{\square} 2SO_3(g)$

(xiii) $CuSO_4\ 5H_2O(s) +\ con.\ H_2SO_4(l) \rightarrow \square$

3. Write answers of the following questions :

(1) Mention physical properties of non-metallic elements.

(2) Mention physical properties of dihydrogen gas.

(3) Write uses of dihydrogen gas.

(4) Write physical properties of ammonia gas.

(5) Write chemical equations, to obtain nitric acid from ammonia gas by Ostwald's process.

(6) Write uses of ammonia gas.

(7) Mention physical properties of sulphur.

(8) Mention the chemical reactions of sulphur with acids, dihydrogen gas and carbon element.

(9) Mention uses of sulphur.

(10) Write physical properties of sulphur dioxide gas.

(11) Mention uses of sulphur dioxide gas.

(12) Write uses of sulphuric acid.

(13) Give difference between concentrated sulphuric acid and dilute sulphuric acid.

4. Answer the following questions in detail :

(1) Explain with diagram the method for preparation of hydrogen gas in laboratory.

(2) Explain with chemical equations the industrial production of dihydrogen gas.

(3) Discuss Haber's process for industrial manufacture of ammonia.

(4) Write short note : Allotropes of sulphur.

(5) Explain contact process for production of sulphuric acid.

(6) Explain chemical properties of dilute sulphuric acid.

5. Answer the following questions pointwise :

(1) Explain chemical properties of non-metallic elements.

(2) Explain chemical properties of dihydrogen gas.

(3) Describe Frasch's method of extraction of sulphur.

(4) Discuss chemical properties of sulphur dioxide gas.

UNIT 10

Mineral Coal and Mineral Oil

10.1 Introduction

The rocks on the earth are made up of minerals. Metals like silver, copper and gold are available in original form of element in the minerals but most of the minerals are compounds of two or more elements. Some substances like mineral coal and petroleum available from the crust of the earth are formed from the fossils of living elements and residues of vegetation in the prehistoric time. It is the most important and significant mineral wealth given by the nature. Thus, mineral coal and petroleum are the important energy sources available from nature. Mineral coal is like a black rocky substance, which is very useful in industrial field, steel industry, thermal power station, production of steel and extraction of metals. Petroleum or natural mineral oil is a thing known from ancient times. It contains liquids which can be easily evaporated, sticky, black and semisolid substance, soft materials like wax. Petroleum is a viscous oil, black dense liquid having specific smell. Petroleum is the mixture of many hydrocarbons containing hydrogen and carbon elements. In addition, substances having nitrogen, sulphur and oxygen are also present in small proportions. The composition of the mineral oil depends on the place from where it is obtained. Hence, the mineral oil available from different places, is of different types.

The important general useful components like petroleum gases, gasolene, diesel, kerosene, lubricating, oils, asphalt, etc. are available from petroleum. These component substances are used as fuel and at different places viz. Liquefied Petroleum Gas (LPG) and kerosene in the lantern and petromax to obtain light, as fuel for motor cars, diesel engine etc. Asphalt is used in construction of roads. The main basic requirement of modern age is the mineral coal and petroleum. The modern life is not possible without it, because carbon and hydrocarbon compounds (organic compounds) are available in the largest proportion.

10.2 Mineral Coal

Mineral coal is available from the earth's crust by combustion of fossils of plants and animals. Crores of years ago, plants and animals were buried in the earth's crust and remained accumulated there. In the crust of the earth, at high temperature and pressure, the components of plants and animals were converted into large proportion of mineral coal at the end of the chemical reaction. The fuel of this type of mineral coal is called fossil fuel. Mineral coal is a non-renewable source

of energy. In the world, mineral coal is mainly available in China, America, U.K. Germany, Poland and India. In India, mineral coal is mainly available from Jharkhand, Madhya Pradesh, Orissa, West Bengal and Andhra Pradesh. In Gujarat, near Thangadh in Saurashtra and sulphur containing lower type of mineral coal is available in Kachchh.

In the mineral coal, mainly carbon and hydrogen and in addition, more or less proportion of nitrogen, sulphur, phosphorus, potassium etc, elements are present as compounds.

The mineral coal also contains inorganic substances.

The main types of mineral coal are as given below :

(1) Peat :

Peat contains about 28% carbon. The primary state of transformation of coal from wood is called peat. It is called rough coal. Wax, acetone (CH_3COCH_3), acetic acid (CH_3COOH), methanol (CH_3OH) as well as cyclic organic compounds are available from destructive distillation of peat.

(2) Lignite :

Lignite contains about 28 to 30% carbon. It contains volatile matter and moisture also. The heat (energy) of lignite is about 27 kJ g^{-1}. It is used as fuel in railway engines, thermal power stations and small and big industries. Lignite is used to obtain coal gas and coal tar is obtained as residue, in which cyclic hydrocarbons, phenol, cresol and other compounds are present.

(3) Bituminous coal :

Bituminous coal contains about 78 to 86% carbon. It also contains volatile matters and moisture in some proportion. Its heat energy is about 30 kJ g^{-1}. It is used as fuel in the production of steel and in production of electricity.

(4) Anthracite :

Anthracite is a matured form of mineral coal. It contains about 94 to 98% carbon. It contains small proportion of volatile matter and moisture. Its heat energy is about 33 kJ g^{-1}. When pure anthracite burns, smoke or smell is not produced and the amount of residue is very less. Hence, anthracite is considered as the best type of coal.

10.3 Destructive Distillation of Mineral Coal

Mineral coal is heated in an iron retort at 1273 K. Volatile substances are separated due to this. The hot gases are passed through the tubes cooled by keeping them in water. Hence, the substances which are soluble in water are dissolved in water and the other insoluble substances settle down in water. Afterwards, these gases come out; they are purified and used for heat and energy. We know it as "coal gas". The coal remained in the retort is known as coke. It is used for burning and in preparing steel from iron.

The black sticky liquid substance which is insoluble in water and settles down is called tar. Earlier it was a problem as how to remove this tar, but later on it was found that many important substances are there in it. At that time its value was appreciated.

Generally, in advanced countries, the coal obtained from the mines is not allowed to burn directly, but the coke resulted after taking out the useful coal gas, ammonia, coal tar and coke from the mineral coal in laboratory.

Activity : 1

Take mineral coal in a hard glass test tube. Take some water in the second test tube. Arrange the apparatus as shown in the Fig. 10.1 Heat the coal on the Bunsen burner and pass the vapour coming out from it through the water in the test tube. After sometime, it will be found that coal tar is collected at the bottom of the test tube filled with water.

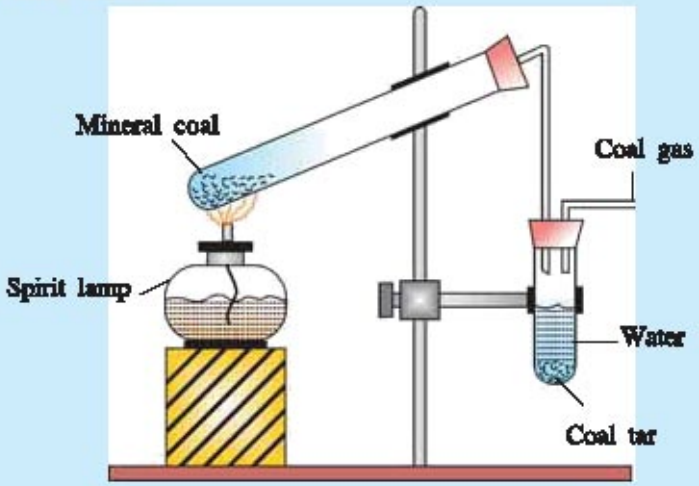


Fig. 10.1 Destructive Distillation of mineral coal

The gas will come out through the tube connected with the upper part of the test tube. The gas starts burning when a lighted match stick is brought near the end of this tube. This gas is coal gas. The portion that is left out in the tube containing mineral coal is called coke. The ammonia produced during the reaction is absorbed in water which can be tested with red litmus paper. It turns red litmus paper blue.

Coke :

Coke is black-brown coloured hard and porous substance. It contains about 80% carbon. It is used as smokeless fuel in the production of water gas. The mixture of carbon monoxide and hydrogen ($CO + H_2$) gas is obtained when water vapour is passed over hot coke. It is called water gas.

$$\underset{\text{Coke}}{C(s)} + \underset{\text{Steam}}{H_2O(g)} \longrightarrow \underbrace{(CO + H_2)(g)}_{\text{Water gas}}$$

Coke is not mainly used as fuel, but its main use as reducing agent is to obtain metal from metal oxide.

Coal Tar :

Coal tar is dark black coloured liquid. Mostly different types of organic compounds are present in it. In the earlier times, it was used in the preparation of organic compounds like explosives, dyes, artificial fibres, drugs, pesticides. In the modern time, organic substances are obtained from petroleum products instead of coal tar.

Coal gas :

Mostly carbon monoxide and some other gaseous hydrocarbon compounds are present in coal gas. This mixture of gases is combustible and so it is used as a fuel.

10.4 Petroleum

Mineral oil is known by one or the other name from ancient times. It had been noted that asphalt obtainable from mineral oil was used in construction work in the year 5000 BC. It is also mentioned that it was used as natural gas for the lamps in China in 1900 BC. The "Lakshagruh" mentioned in 'Mahabharat' must have been prepared from tar like easily combustible substance. At some places where the oil or the gas that was coming out of the cracks in the earth used to burn accidentally and so it was worshipped as holyfire. e.g. Eternal fire of Bookie. In Trinidad, when this type of oil after coming out in large amount, the volatile substances were completely evaporated and now-a-days the pond of tar is left out as residue. In Gujarat, near Ghogha port, gas comes out from the land. Even then, the large scale production of petroleum had started after the earlier half of the nineteenth century. At present, petroleum supplies one third part of the requirement of world's energy. Half the portion of the total production of organic compounds is obtained from petroleum. This way, petroleum is very important in the modern age. The meaning of petroleum is the oil of rock (mineral oil).

Origin and discovery :

The mineral oil has been originated from the fossils of plant and animal kingdoms burried under the surface of sea in prehistoric times. The pressure, heat and microorganisms present at the bottom of the earth must have played very important role for this, the mineral oil mixed with water flows and gets collected in caves as oil pond in the form of oil. It is called crude oil. Generally the rocks above these oil ponds are very hard. A reaction takes place on innumerable small marine living beings and marine vegetation for lacs of years. During this reaction petroleum is formed.

Scientist Berthelot proposed that by the reaction of carbon dioxide in water with alkali metal the gas named acetylene and other oily substances must have been formed. While, Mendeleve suggested that carbides of metals on reaction with acidic water, substance like petroleum would have been formed. Many other scientists have supported these ideas but the formation of mineral oil has not been explained by them.

Sometimes such substances were available during digging of wells. It was used as "medicine for massage" in those time. While digging well for water in Pennsylvania Samuel Killer found mineral oil instead of water. George Beal and Steelman established the company for the search of oil. Their main purpose was to extract natural oil in large proportion to use for other industrial uses. They entrusted this work to Adverd Drac. Drac started the digging work with the tools available for digging the wells in Pennsylvania. He got oil at the depth of 21 meters in the village named. Titusville on 27th of August 1859. This was the first well of petroleum.

Mainly mixture of methane and hydrocarbon containing 1 to 4 carbons is present in natural gases. Generally, petroleum is obtained by drilling in the region of sedimentory rocks.

The possibility of mineral oil in India was found some years after the Drac's well. Oil was obtained at the depth of 34 meters at the place named Makum near Dibrugarh on 26th of August 1867. 1350 litres of oil was drilled from this well each day. This was the first well in Asia. A good proportion of oil was found in the countries like Saudi Arabia, Iraq, Iran, Kuwait, America, Russia, England, Maxico, China, Brahmadesh, Burma (Myanmar), Galacia, Hungary, Trinidad etc. Oil fields are also there in India. At present petroleum is available at Ankaleshwar, Cambay (Khambhat),

Navagam, Sanand, Kalol in North and Central Gujarat and also near the end of the South Gujarat known as "Bombay High". The proofs of availability of underground petroleum are there in Gujarat, North Gujarat in Jotana, Santhal, Ambasan etc. Also, proofs have been obtained for the existence of reservoirs of petroleum in Kachchh, Saurashtra, Rajasthan, West Bengal and basins of Godavari and Kaveri rivers. In India, Oil and Natural Gas Commission (ONGC) which is at present known as Oil and Natural Gas Corporation Limited has been formed for the search of oil and the development.

Petroleum is dark brown or black coloured oily liquid. Mainly hydrocarbons, oxygen and sulphur containing certain organic compounds are present in it.

Impure Petroleum and its components :

The petroleum available from the wells is impure. Its colour is from light green to brown and upto black. It contains natural gas, water, clay, sand etc. as impurities.

Chemically, mineral oil is mainly a mixture of hydrocarbons. It contains sulphur, nitrogen and oxygen containing substances in small proportions. The mineral oil available from different countries have different compositions. The following chemicals are mainly present in petroleum.

(1) **Paraffin hydrocarbon :** These substances are aliphatic compounds having long chain. Their general formula is C_nH_{2n+2}. These substances are mixture of straight and branched paraffins. The proportion of substances having simiple chains is more. The petroleum of America and the oil available in Ankaleshwar are of this type.

(2) **Naphthalene hydrocarbon :** These compounds are cyclic and their general formula is C_nH_{2n}. They are saturated hydrocarban six to seven carbon atoms are present in them. e.g. Methyl cyclohexane, cyclopentane and their derivatives.

The oil available in many parts of our country is of this type.

(3) **Aromatic compounds :** This type of compounds are in very less proportion in mineral oil. Their general formula is C_nH_{2n-6}. These compounds are also cyclic but there is specific type of unsaturation e.g. Benzene, toluene, xylene etc. Oil available from Bornio is of this type.

(4) **Asphalt :** Many complex solid substances are available from asphalt type black mud type oil. In these compounds, substances containing oxygen, nitrogen and sulphur with carbon and hydrogen are present. Sulphur containing compounds like thiophene, hydrogen sulphide etc. are available. Alcohol, phenol etc. are also obtained as oxygen containing compounds. While pyridine is present as heterocyclic based nitrogen compounds. The oil from Ankleshwar of Gujarat contains 0.4% sulphur containing compounds, while oil available from Kalol has only 0.03% sulphur. The presence of sulphur compounds in mineral oil is very harmful. Hence, it is most important to refine it before taking mineral oil in use.

10.5 Refining of Petroleum

The impure oil available from the wells is carried by pipes or tankers to refinery for purification. The natural gas is separated from it in the initial stage. The oil is allowed to settle in many large tanks in refinery and the waste and water are separated. Then the fractional distillation of it is carried out.

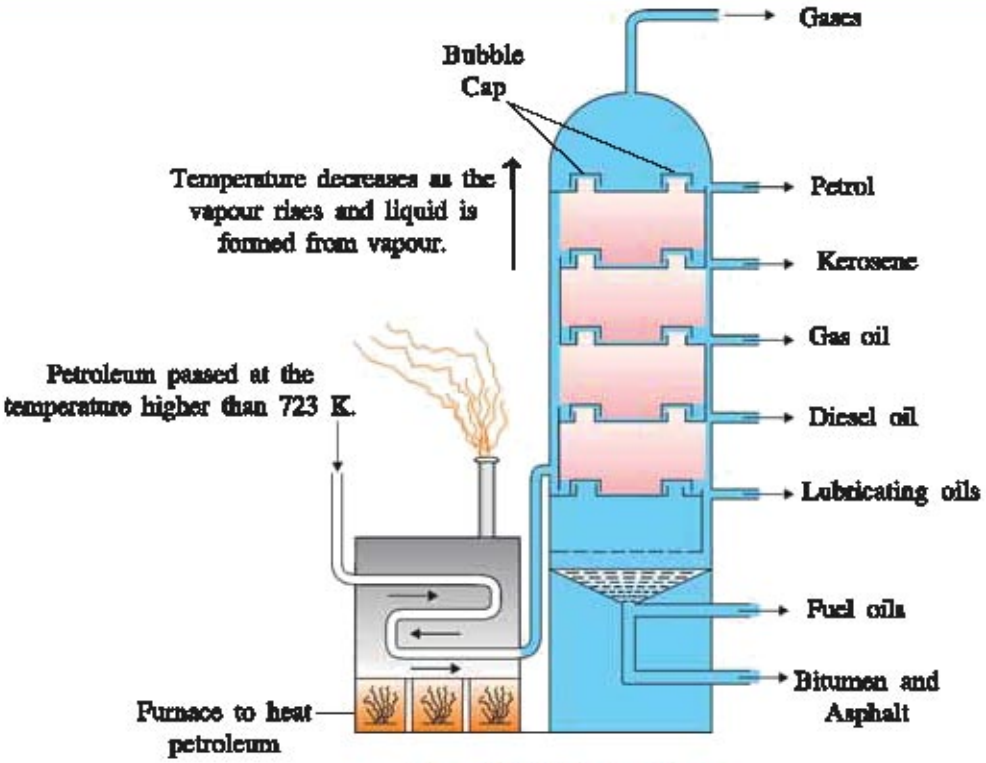


Fig. 10.2 Distillation Tower

Fractional distillation of Petroleum : The purpose of this distillation is not to separate each hydrocarbon individually but are separated in fractions having specific properties useful in industry. Each of these fractions is being distilled in definite range of temperatures, and it is a mixture of certain compounds.

As shown in Fig. 10.2 petroleum is heated in the furnace and then sent to fractionating column, in the form of vapour. This column is of 2 to 4 meter diameter and is 30 to 60 meter high. Perforated shelves are fixed in it, and on each of these shelves there is a cover like a cap. This specific construction is called bubble cap (Fig. 10.2). The substances which do not distil are collected at the lower part of the column. The vapour of petroleum gets cooled while going up in the column and falls down in the form of liquid and the vapour rises up. Thus, a dense contact remains between vapour and liquid. The vapour passed through the liquid is collected on the shelves. Thus, substances having higher boiling points come down in the form of liquid and the substances having lower boiling points go up in the form of vapour. In this way, distillation continues near each shelf. Hence, compounds having nearby boiling points can be separated. Thus, substances having lower boiling points are collected in the shelves of the upper part and the substances having higher boiling points are collected in the shelves of the lower part. The number and the distance of the shelves are so arranged that a certain fraction is collected in the shelves at certain height. This description gives only simple explanation of the principle. In reality many such fractionation columns are used. And the entire process of refining is very complex. The properties and uses of the different fractions obtained by fractional distillation are given below :

(1) **Petroleum Gases :** Hydrocarbons from C_1 to C_4 are present in this fraction. These gases are useful for petrochemicals, foul smell containing sulphide is added to gases

for household uses. Hence, if it comes out accidently, it gives warning by its intense smell. e.g. LPG, PNG (Piped Natural Gas)

(2) **Gasolene :** In this fraction, hydrocarbons from C_5 to C_{12} are present. The boiling range of this fraction is 343 to 473 K. It is used as fuel for aeroplanes and motors. The hydrocarbons with C_5 to C_7 carbons are separated from this fraction and used as solvents.

(3) **Kerosene :** In this fraction the hydrocarbons have C_{12} to C_{15} carbons. Its boiling range is 473 to 548 K. It is used as fuel in kerosene lamps, stoves, jet planes and rockets.

(4) **Gas oil or Diesel oil :** C_{15} to C_{18} carbon containing hydrocarbons are in this fraction. They are available at temperature higher than 523 K. It is used as fuel in diesel engine. Naptha is obtained from this fraction.

(5) **Lubricating oil :** C_{16} to C_{20} carbon containing hydrocarbons are present in this fraction. It is used for lubrication and cracking. This fraction is cooled and the wax is taken out after freezing.

(6) **Asphalt (Tar) :** C_{21} to C_{40} carbon containing hydrocarbons are in this fraction. It is useful for preparation of roads.

(7) **Coke :** It is deposited on the inner side of the furnace used for heating the petroleum. Carbon for electric cells is obtained from this. This carbon is known as petroleum coke. As this carbon is pure, it is used for preparation of electrodes and carbon tiles. This type of tiles resist the corrosion. Hence, it is used in chemical industries for the protection of vessels.

The products obtained by fractional distillation of petroleum and their uses are shown in Table 10.1.

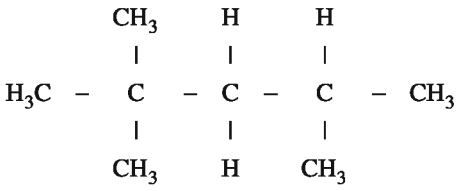
Table : 10.1 The products obtained by fractional distillation of petroleum and their uses

	Fraction	Number of carbon	Temperature range	Uses
1.	Gases	C_1 to C_4	298 K	As fuel.
2.	Petrol	C_5 to C_{10}	303 K to 393 K	As fuel in vehicles
3.	Naphtha	C_8 to C_{10}	393 K to 453 K	As solvent in petrochemicals
4.	Kerosene	C_{12} to C_{15}	473 K to 548 K	As fuel in household and jet planes
5.	Diesel	C_{15} to C_{18}	533 K to 613 K	In trucks, buses, pumps for water, diesel engines, as fuel. Generators for production of electricity
6.	Lubricating oil	C_{16} to C_{20}	above 613 K	As lubrication oil in machine and to prepare grease, vaseline, wax etc.
7.	Fuel oil	–	773 K	As fuel in steamers and electric power houses
8.	Tar	C_{21} to C_{40}	Dense liquid left after fractional distillation.	Preparation of roads, for water proofing
9.	Petroleum coke	–	deposited carbon	In preparation of electrodes of battery and carbon tiles.

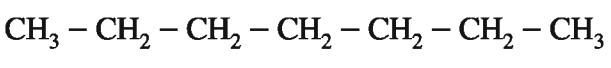
Octane Number :

Gasolene which is generally known as petroleum is mainly used as fuel in the internal combustion engines of cars. The mixture of gasolene and air from carburettor is collected in the cylinder of the engine. Here, the mixture is pressed by a piston. When the sparks of the electricity are released, the flame spreads from one end to the other in the cylinder and the gaseous mixture is systematically combusted. The piston moves immediately in cylinder and the combusted gases are going out. This force gives velocity to the car. This reaction occurs repeatedly. In certain circumstances, when electric spark occurs, the nearby gaseous mixture experiences contraction and before the flame reaches there, it burns with explosion. Certain type of sound is created in the cylinder by unsystematic combustion which is known as knocking. More the pressure, more will be the knocking. It is very necessary to obtain more horse power and to decrease the magnitude of use of fuel. Because of the thrust on the piston of cylinder due to knocking, there is more wear and carbon is deposited on the inner part of cylinder.

From the study of composition of hydrocarbons and by knowing, it is found that the knocking of simple chain hydrocarbons is more while knocking of branched chain hydrocarbon is less or negligible. Iso octane is considered standard for the comparison of fuels. Its octane number is taken as 100 because of its negligible knocking. As knocking of n-heptane takes place, its octane number is taken as 0.



Isooctane : Octane number 100
(2,2,4, trimethyl pentane)



n-Heptane : Octane number 0

The octane number of any sample of gasolene is equal to the same efficiency of the mixture of isooctane and n-heptane, its octane number is same. e.g. the efficiency of a sample of fuel is equal to that of mixture of 90% isooctane and 10% n-hetane, then its octane number is considered to be 90. The octane number of normal alkane is higher than alkene to cyclic paraffin and simple chain hydrocabons than branched chain hydrocarbons have very high octane number. Octane number of aromatic hydrocarbons is very high.

After a long research work two methods have been discovered to increase octane number of gasolene. (1) Gasolene obtained by straight run from fractional distillation of mineral oil or virgin gasolene undergoes reforming or some similar transformation processes. By this the simple chain hydrocarbons in original gasolene are transformed to branched chain hydrocarbon and its octane number increases. If this reaction is carried out on fractions after gasolene, the proportion of gasolene can be increased. This matter is important because the demand of gasolene obtained from this method is more than that obtained from mineral oil. (2) The quality of gasolene can be improved by addition of substances to gasolene which increases the octane number. In America, Midgal and Boeid discovered in 1922, a substance having such properties called tetraethyl lead – $(C_2H_5)_4Pb$. In the gasolene used in motors, 1 ml tetraethyl lead is added to every 4 litre of gasolene. The octane number of such gasolene is 75-85; some diethylene dichloride of dibromide is added to it so that lead may not deposit on spark plug when gasolene is combusted. Hence, lead is removed with exhaust gases in the form of lead chloride or lead bromide.

Cracking of Hydrocarbons :

Generally about 18% gasolene is obtained from mineral oil. The proportion of kerosene etc. is more in the fraction having higher boiling points after the gasolene fraction. But its demand is less, while demand for gasolene is more. Hence cracking reactions are developed so that proportion of gasolene increases. There are three advantages of these reactions. (1) To obtain more gasolene, (2) The octane number of the gasolene available is high and (3) Unsaturated organic gases that are obtained, can be the important raw material for the petrochemicals.

In this reaction, kerosene naphtha, diesel and wax are also used. These substances are in the form of vapours passed from the layer of the catalysts at above 773 K temperature. Generally Al_2O_3, SiO_2 are used as catalyst. In the modern method small spheres of catalyst are allowed to fall from above in the column and the vapour of kerosene etc. is allowed to go up higher.

In the above reaction, hydrogen, methane and unsaturated hydrocarbons are also obtained. As these substances are the raw materials for preparation of petrochemical cracking units into existence. From such units, mainly cracking of naptha occurs and unsaturated alkene compounds are obtained. Some of the reactions occurring during catalytic cracking are shown below :

Isomerization :

In this reaction, simple chain substances are converted into branched chain substances.

$$CH_3-CH_2-CH_2-CH_2-CH_2-CH_3 \longrightarrow H_3C-\underset{\underset{H}{|}}{\overset{\overset{CH_3}{|}}{C}}-\underset{\underset{H}{|}}{\overset{\overset{CH_3}{|}}{C}}-CH_3$$

(n-hexane) (2,3 dimethyl butane)

Dehydrogenation :

In this reaction saturated substances are converted into unsaturated substances.

$$CH_3-CH_2-CH_2-CH_3 \longrightarrow CH_3-CH_2-CH=CH_2+H_2$$

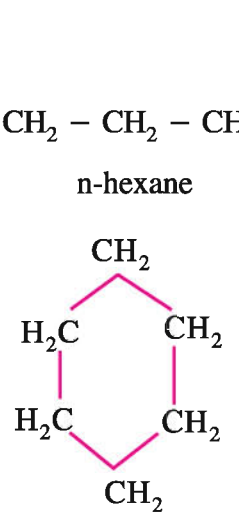
(n-butane) But-1-ene

Aromatization :

In this reaction the various chain containing substances, are converted into cyclic substances and cyclic compounds are converted into aromatic substance by losing hydrogen.

$$H_3C-CH_2-CH_2-CH_2-CH_2-CH_3 \longrightarrow \text{Cyclohexane} + H_2(g)$$

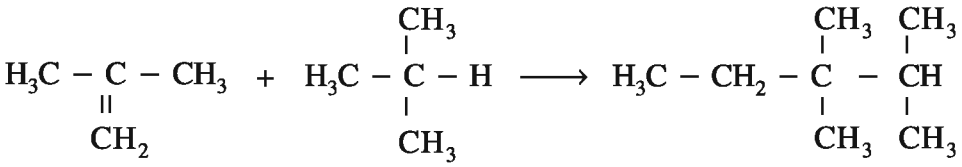
n-hexane



$$\longrightarrow \text{Benzene} + 3H_2$$

Alkylation :

In this reaction, medium size molecules are obtained by reaction between smaller molecules.

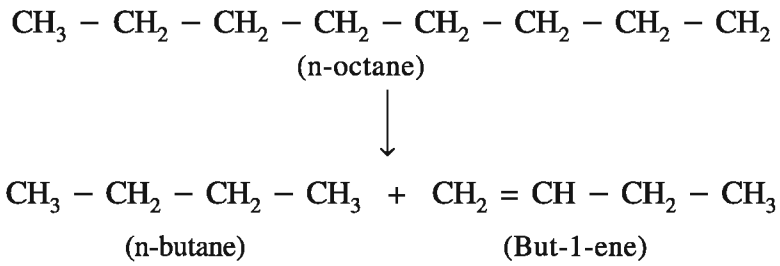


2- Methyl propene (isobutene) | 2-2 Dimethyl propane (isobutane) | Isooctane.

Better gasolene can be obtained by carrying out this reaction separately.

Cracking :

In this reaction, big molecules crack (break) into smaller molecules



(n-octane) ↓ (n-butane) + (But-1-ene)

When this reaction takes place in presence of hydrogen, unsaturated substances become saturated.

10.6 Natural Gas

Petroleum has originated from complex chemical reactions continuously occurring in the earth's crust. Natural gas is collected over the petroleum in the rocks. The gas available with petroleum is called natural gas. It is obtained as oily liquid along with petroleum or independently in the gaseous form. During drilling in the earth's crust natural gas is obtained first and then the petroleum comes out and the gas that is obtained is called natural gas.

The main hydrocarbon in natural gas is methane. In addition, gaseous hydrocarbons like ethane, propane and butane are also present. It can be sent easily to proper places through pipelines. By such an arrangement, it is available as fuel for house-hold uses in the cities like Vadodara, Ankleshwar, Surat, Bharuch and now in Ahmedabad in Gujarat. Natural oil fields are found at the places like Tripura, Jaisalmer, Bombay high, Basin area of Krishna and Godavari rivers.

Hydrogen gas can be produced on a larger scale from natural gas and from it, ammonia and urea can be obtained. Natural gas is now used as fuel in the gas-based thermal power stations. As many industries based on natural gas have developed in Gujarat, the gas which was being wasted is found to be very valuable. Natural gas is used as fuel in Dhuvaran thermal power station in Gujarat. LPG and CNG are known natural gases.

LPG and CNG :

LPG (Liquefied Petroleum Gas) means liquefied petroleum gas contains gases mainly butane and in small proportions propane and butene. The gaseous mixture is liquefied under high pressure

and filled in cylinders at high pressures. To know the leakage of the gas from the cylinder, methyl mercaptan having very bad smell is mixed. LPG is mostly used as household fuel.

CNG (Compressed Natural Gas) contains mostly methane and in some proportion ethane and propane are present. By reducing its volume at high pressures, it is used as a fuel in place of petrol in automobile engines like trucks, buses, etc. As CNG is completely combusted, the additional poisonous gas does not spread pollution but sometime because of incomplete combustions, it heats up the mechanical machinery of the vehicle which is the disadvantage of CNG.

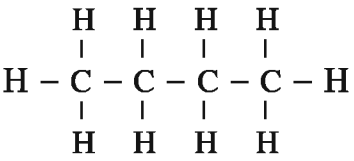
10.7 Tetravalency and Catenation of Carbon

Carbon and its compounds are present in mineral coal and petroleum. The organic compounds which contain carbon and hydrogen are called hydrocarbons. They are generally known as organic compounds. Organic compounds are present in different types of compounds in living viz. carbohydrates, protein etc.

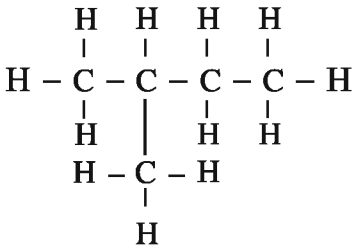
Innumerable useful things like grain, pulse, sugar, tea, coffee, paper, cotton, wool, synthetic resins, kerosene, petrol, diesel, cooking gas, drugs, dyes, rubber, plastic, perfumes etc. contain mainly organic compounds. Really organic compounds are distributed in large proportion in nature. The total number of organic compounds are in larger number as compared to the total compounds available from all the elements except carbon. In addition to this, many organic compounds are obtained by synthesis in laboratory over and above the organic compounds present in nature. Hence, it can be said that carbon is a unique element.

Carbon element is in the 14th group of the periodic table. The atomic number of carbon is six and its electronic configuration is 2, 4. There are four electrons in its valence orbit. Carbon contains four valence electrons in excited state. The atoms of carbon share these four electrons with four electrons of other elements and form four covalent bonds.

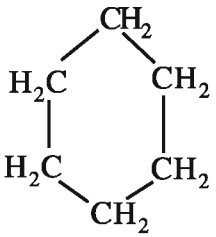
One carbon atom forms covalent bonds with carbon atoms through normal chain, or cyclic chain.



(Normal chain structure)



(Iso chain structure)

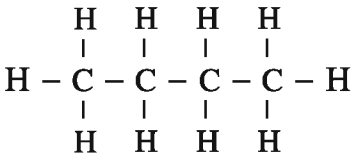


(Cyclic chain structure)

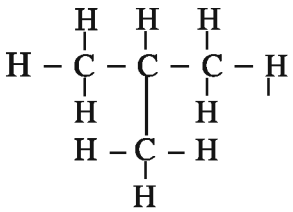
Because of this specific property of combination by valence bond between carbon–carbon atoms and as a result large number of organic compounds of abnormal types have been prepared. This specific property of carbon is called catenation. **The combination of more than one atom of the same element is called catenation.**

Because of this catenation property of carbon, compounds having different structural formula and compounds having different physical properties are observed. Such organic compounds having molecular formula same but different structural formula are called isomers. This type of phenomenon is called isomerism, viz.

(i) Butane (C_4H_{10}) has two isomers



n – Butane



2 – Methyl propane

(Isobutane)

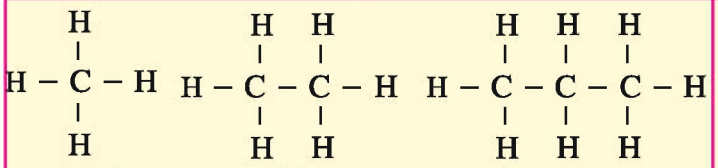
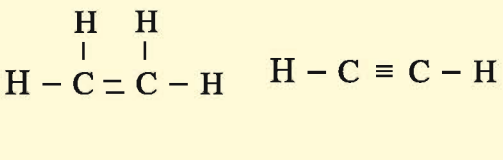
10.8 Hydrocarbons

As seen earlier, compounds containing carbon and hydrogen are called hydrocarbons. In these hydrocarbon compounds, methane (CH_4), ethane (C_2H_6), propane (C_3H_8), ethene (C_2H_4), propene (C_3H_6), ethyne (C_2H_2), propyne (C_3H_4) are included.

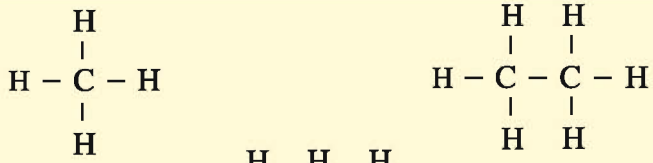
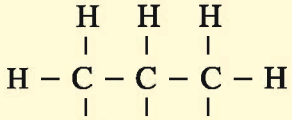
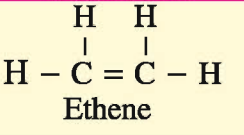
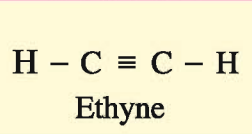
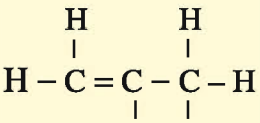
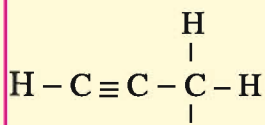
Classification of Hydrocarbons : Hydrocarbons are considered to be the simplest organic compounds in organic chemistry. Only carbon and hydrogen elements are present in them. Hence, they are called hydrocarbon compounds.

Hydrocarbons are classified by two methods. Their classification is done on the basis of number of covalent bonds between carbon-carbon atoms : (i) Saturated hydrocarbon and (ii) Unsaturated hydrocarbon.

In saturated hydrocarbons, all the four valencies of carbon are completed by covalent single bond with other atoms. While, in unsaturated hydrocarbons, the two carbon atoms are combined by double or triple bond.

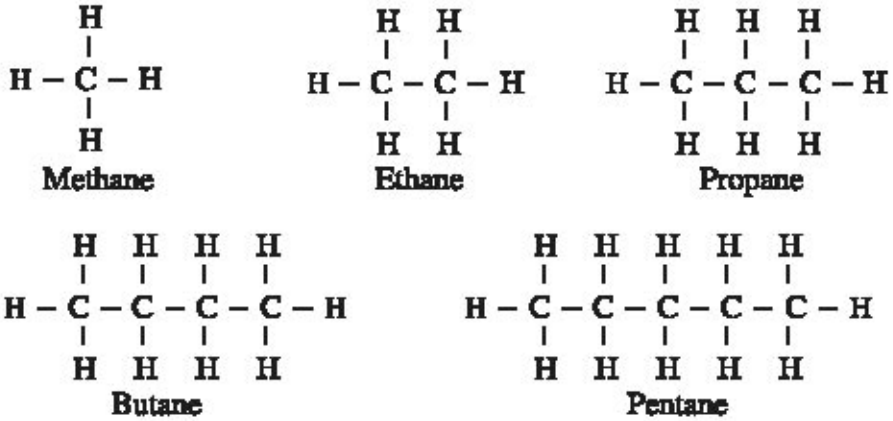
<table>
<tr><th colspan="3">Hydrocarbon</th></tr>
<tr><th colspan="2">Saturated Hydrocarbon</th><th>Unsaturated Hydrocarbon</th></tr>
<tr><td colspan="2"> 
Methane Ethane Propane</td><td> 
Ethene Ethyne</td></tr>
<tr><td colspan="2">Compounds containing single bond.

Alkane
General formula (C_nH_{2n+2})</td><td>Compounds containing covalent double bond or triple bond

Alkene (C_nH_{2n}) | Alkyne (C_nH_{2n-2})</td></tr>
<tr><td colspan="2">Compounds containing single bond</td><td>Compounds containing double bond | Compounds containing triple bond</td></tr>
<tr><td colspan="2"> 
Methane Ethane
 
Propane</td><td> 
Ethene
 
Ethyne
 
Propene
 
Propyne</td></tr>
</table>

10.9 Saturated Hydrocarbons

In saturated hydrocarbons, each carbon atom is combined with other atoms by only one single covalent bond viz. Methane (CH_4), ethane (C_2H_6), propane (C_3H_8), butane (C_4H_{10}) pentane (C_5H_{12}) etc..



When the overlapping of two or more orbitals nearby to each other, having very less difference in energy levels, the same number of orbitals having similar shape, and same energy are formed is called hybridization and the orbitals produced by this method are called hybrid orbitals.

The first simple member of saturated hydrocarbon is methane. As there is C–C single bond in this compound, the sp^3 hybridization taking place in this can be explained as follows :

In the excited state of carbon atom, the electronic configuration of its outermost orbit having unpaired electrons- one of 2s and three of 2p orbitals overlap and four hybrid orbitals having same shape and energy are obtained. This is called sp^3 hybridization. The unpaired electrons have same energy. In methane, four similar orbitals having unpaired electron and formed by sp^3 hybridization at carbon atom, they arrange in tetrahedral shape. Here, the bond angle between any two orbitals is of 109° 28'. Now, the overlapping of each of four hybrid orbitals obtained by sp^3 hybridization with 1s type unpaired electron of four hydrogen atom with opposite spins takes place and four covalent bonds are formed. The bonds formed this way, by sharing of electrons with two unpaired electrons with opposite spins, are called σ bonds.

Thus, four C–H bonds have same bond length and the bond angle is 109° 28'

If any one hydrogen present in methane molecule, is substituted by CH_3 group, ethane is obtained. By substitution of any hydrogen atom of ethane by CH_3 group propane (C_3H_8) is obtained. This way, the series of butane (C_4H_{10}), pentane (C_5H_{12}) etc. are obtained. This series of saturated hydrocarbons is called alkane series. The general formula of alkane series is C_nH_{2n+2} where n = Number of carbon atoms in the molecule.

At the end of the name of the members of this series have suffix – ane.

If each member of the organic compound series differs from its earlier and latter differs by carbon and hydrogen in the number (CH_2) is called Homologous series. Almost all the types of organic compounds have homologous series.

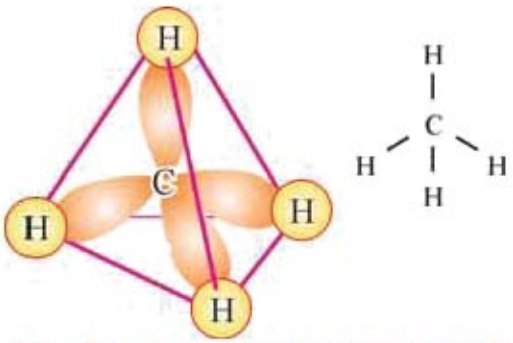


Fig . 10. 3 Three dimensional geometrical structure of molecule of methane.

Characteristics :

(1) Each member of the series can be expressed by general molecular formula viz. each member of alkane series can be expressed by general formula C_nH_{2n+2}

(2) The difference in molecular formula between two successive members of the series is equal to CH_2.

(3) There is difference of 14 u between molecular masses of any two successive members of the series.

(4) Same number of prefix or suffix is applied to each member of the series in their nomenclature.

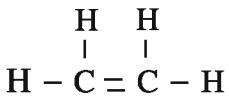
(5) The molecular mass of the member of series increases due to increase in the atoms of carbon and hydrogen. Hence, the physical properties based on the molecular masses of the members, viz boiling point, melting point, density, solubility etc. have gradual change. The homologous series of alkane compounds and their characteristics are given in Table 10.2.

Table : 10.2 Characteristics of homologous series of Alkanes

Sr. No.	Number of carbon	Name of alkane	Molecular formula	Molecular Mass (u)	State
1.	n = 1	Methane	CH_4	16	Gas
2.	n = 2	Ethane	C_2H_6	30	Gas
3.	n = 3	Propane	C_3H_8	44	Gas
4.	n = 4	Butane	C_4H_{10}	58	Gas
5.	n = 5	Pentane	C_5H_{12}	72	Gas/liquid
6.	n = 6	Hexane	C_6H_{14}	86	Gas/liquid

10.10 Unsaturated Hydrocarbons

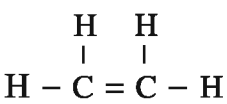
In unsaturated hydrocarbons, the nearby any two carbon – carbon atoms are combined by a double bond ($-C=C-$) or triple bond ($-C\equiv C-$) i.e. there is double bond or triple bond because of sharing of two-two or three-three electrons of any two nearby carbon atoms viz. Ethene (C_2H_4), ethyne (C_2H_2) etc.



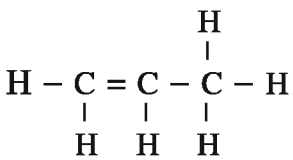
Ethene (Ethylene)

Ethyne (Acetylene)

The hydrocarbons in which any two nearby carbon atoms are combined by a double bond unsaturated hydrocarbons are called alkenes. viz ethene (C_2H_4), propene (C_3H_6), butene (C_4H_8), pentene (C_5H_{10}).



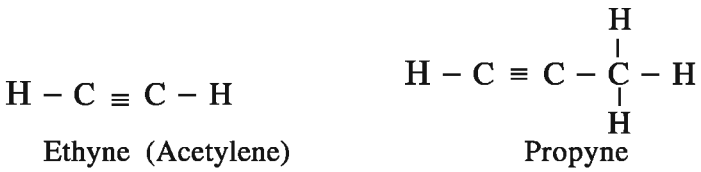
Ethene (Ethylene)



Propene (Propylene)

The general formula of alkene series is C_nH_{2n} where n = the number of carbon atoms. The first simple member of this series is ethene. The difference of CH_2 is observed between two neighbouring members in the series and the difference of 14 in atomic mass unit is there. This series is called alkene homologous series.

The hydrocarbon in which the nearby two carbon atoms are combined by a triple bond, such unsaturated hydrocarbons are called alkynes. viz. ethyne (C_2H_2), propyne (C_3H_4), butyne (C_4H_6), pentyne (C_5H_8) etc.



Ethyne (Acetylene) Propyne

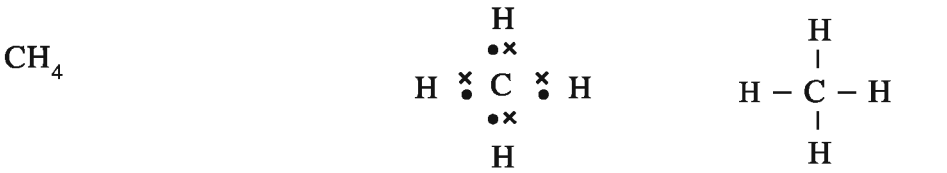
The general formula of the alkyne series is C_nH_{2n-2}, where n = number of carbon atoms in the compound. The alkene and alkyne homologous series are shown in Table 10.3.

Table 10.3 Homologous series of alkenes and alkynes

Number of carbon	Alkene (C_nH_{2n})			Alkyne (C_nH_{2n-2})		
	Molecular formula	Name of alkene	Molecular mass	Molecular formula	Name of alkyne	Molecular mass
n = 2	C_2H_4	Ethene	28	C_2H_2	Ethyne	26
n = 3	C_3H_6	Propene	42	C_3H_4	Propyne	40
n = 4	C_4H_8	Butene	56	C_4H_6	Butyne	54
n = 5	C_5H_{10}	Pentene	70	C_5H_8	Pentyne	68
n = 6	C_6H_{12}	Hexene	84	C_6H_{10}	Hexyne	82

10.11 Methane

The moleular formula, electronic formula and the structural formula of methane are as follows :



Molecular formula Electronic formula Structural formula

Occurrence of methane :

Methane gas is the chief constituent in Marsh gas available from the mines of mineral coal and gas collected over petroleum in the sedimentary rocks in the crust of the earth. In addition, methane is a chief constituent in dung, excretion of animals, and gobar gas, sewage gas and biogas obtained from decomposition of plant and animal waste.

Preparation :

Methane gas is obtained by heating sodium acetate and soda lime (3:1 proportion mixture of sodium hydroxide and calcium oxide)

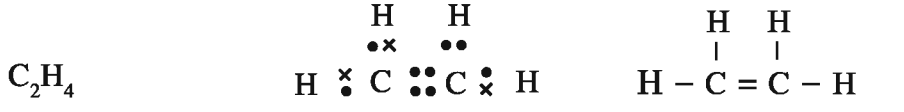
$$\underset{\text{Sodium acetate}}{CH_3COONa} + \underset{\text{Sodalime}}{\overset{CaO}{\underset{NaOH}{+}}} \xrightarrow{\Delta} \underset{\text{Methane}}{CH_4} + \underset{\text{Sodium carbonate}}{Na_2CO_3}$$

Methane gas collected by downward displacement of water proves that it is insoluble in water. It is colourless and odourless gas. It is lighter than air. Observe by dropping a burning piece of paper into a test tube filled with methane gas. It is a combustible gas and so it is a combustible substance. It burns with blue flame when burnt in air and gives carbon dioxide and water.

$$\underset{\text{Methane}}{CH_4} + \underset{\text{Di-oxygen}}{2O_2} \rightarrow \underset{\text{Carbon dioxide}}{CO_2} + \underset{\text{water}}{2H_2O} + \text{Heat}$$

10.12 Ethene (Ethylene)

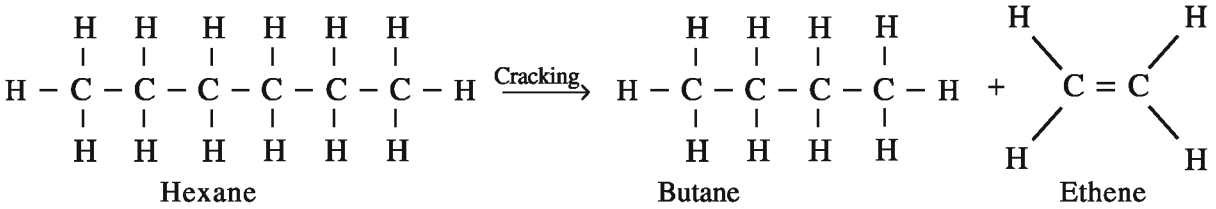
The molecular formula, electronic formula and structural formula of ethene is as follows :



(Molecular formula) (Electronic formula) (Structural formula)

Cracking Method :

Cracking means to break organic molecules and to prepare small molecules. When alkanes containing more number of carbon atoms is heated at suitable temperature, lower hydrocarbons having less number of carbon atoms are formed by cracking. If it is heated in absence of the catalyst, it is called thermal cracking and if heated in presence of the catalyst, it is called catalytic cracking. By cracking of saturated hydrocarbon hexane, saturated hydrocarbon butane and unsaturated hydrocarbon ethene are obtained.



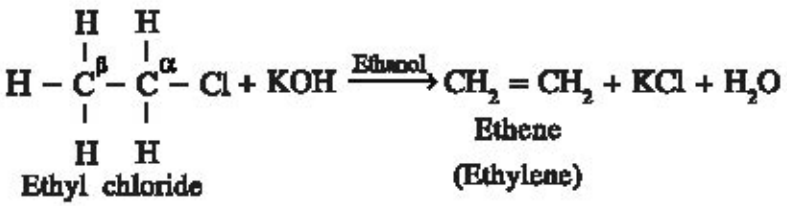
General methods of preparation of Ethene :

(1) Ethene from alcohol : Ethene is formed by heating ethanol with con. H_2SO_4 or H_3PO_4 at 443 K temperature. During this reaction a molecule of water is removed and so this reaction is known as dehydration of alcohol.

$$\underset{\text{Ethanol}}{CH_3CH_2OH} \xrightarrow[\text{OR } [H_3PO_4]]{443\,K\ [H_2SO_4]} \underset{\text{Ethene}}{CH_2 = CH_2} + H_2O$$

(2) Ethene from alkyl halide :

Ethene is formed by the reaction of ethyl chloride with alcoholic potassium hydroxide. Halogen of α-carbon of alkyl halide and hydrogen of b - carbon are removed. Hence, it is b - elimination or dehydrohalogenation reaction.



Ethene is obtained by cracking reaction of kerosene or wax. Unsaturated hydrocarbon is mostly obtained from petroleum by cracking method.

Preparation of ethene in laboratory : Mix 3 ml kerosene or melted wax and one tea spoon sand in a hard glass test tube. Then insert, some small pieces of China clay or porcelain in the front part of the test tube. Arrange this test tube as shown in Fig. 10.4. Heat the test tube on the spirit lamp till the pieces of porcelain becomes red hot and then immediately heat the sand containing kerosene or wax. Continue heating alternately the pieces of porcelain and the sand. When alkene vapour from wax passes through porcelain piece, ethene gas will be liberated by cracking. Collect the gas in gas jar by downward displacement of water. Collect gas jars with ethene and make the observation as follows for ethene gas.

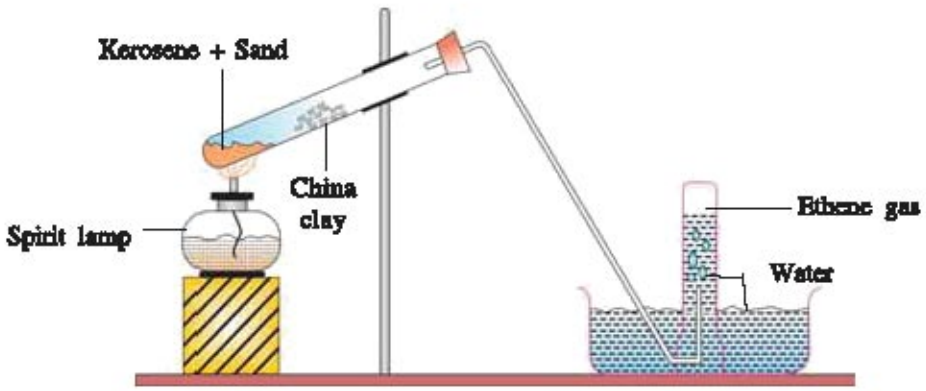
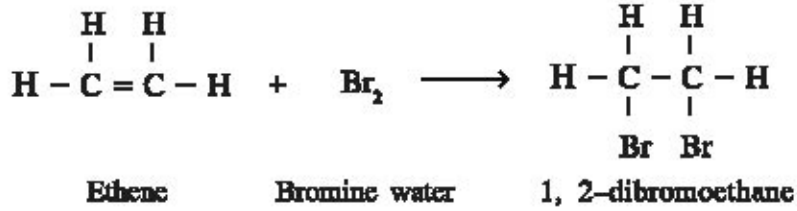


Fig : 10.4 Preparation of ethene

Ethene gas is insoluble in water. It is colourless and odourless gas. It is lighter than water. Drop a burning piece of paper in the test tube and observe whether gas is combustible. When burnt in presence of air, it burns with sooty flame i.e. it is a combustible substance. The soot produced is called carbon black. By taking ethene in one test tube and shaken after adding bromine water to it, the brown colour of bromine water disappears and 1, 2 dibromoethane is obtained. This reaction indicates the property of unsaturation.



Ethene also removes the pink colour of dilute alkaline solution of potassium permanganate ($KMnO_4$) and makes it colourless. This reaction also indicates the property of unsaturation of ethene.

General chemical reactions of Ethene :

As carbon-carbon double bond is present in ethene, and one π bond present in it being weak breaks easily and the molecule of the reactant is added.

(1) Reaction with Hydrogen : Ethane is obtained by heating ethene with hydrogen in presence of catalyst Pd or Pt or Ni. This reaction is called hydrogenation reaction. This reaction is useful for preparing vegetable ghee from vegetable oil.

$$\begin{array}{l} H \quad H \\ | \quad | \\ H - C = C - H \end{array} + H_2 \xrightarrow[[Pd/Pt/Ni]]{473\ K} CH_3 - CH_3$$

Ethene — Ethane

(2) Reaction with halogen : Dihalogen containing ethene if obtained by reaction of ethene with halogen in which the ethelenic π double bond breaks and halogen molecule is added.

$$CH_2 = CH_2 + Cl_2 \rightarrow ClCH_2 - CH_2Cl$$

Ethene — Dichlorine — 1, 2 - Dichloro ethane

(3) Reaction with halogen acid : The reaction of ethene with halogen acid is called hydrohalogenation reaction. Reaction with hydrochloric acid is called hydrochlorination.

$$CH_2 = CH_2 + HCl \rightarrow CH_3CH_2Cl$$

Ethene — Hydrochloric acid — Chloroethane (Ethylchloride)

(4) Polymerization : When number of molecules of ethene under specific conditionas combine polymer named polythene is formed. This reaction is called polymerization. In polythene molecule carbon atoms of number of ethene molecules combine with one another and forms a chain. Ethene is called a monomer.

$$nH_2C = CH_2 \rightarrow \left[CH_2 - CH_2\right]_n$$

Ethene — Polythene

ICI company of England first of all prepared polythene in 1933. Polythene is used in preparation of buckets, pipes, bags and boxes. In addition, it is very essential for other household products and industrial production.

10.13 Ethyne (Acetylene)

Molecular formula, electronic formula and structural formula of ethyne are as follows :

C_2H_2	$H \times C \vdots\vdots C \times H$	$H - C \equiv C - H$
Molecular formula	Electronic formula	Structural formula

Acetylene is one of the chief substances for petrochemical industries. Earlier it was prepared from calcium carbide. But now it is prepared from natural gas because it is cheaper. At present, 30% of total production of acetylene is obtained from methane.

Preparation of Ethyne : Ethyne gas is obtained by the reaction of calcium carbide with water.

In a conical flask, take two to three small pieces of calcium carbide. Arrange the conical flask as shown in Fig. 10.5. Now, on adding water through Thistle funnel, chemical reaction takes place and ethyne is produced. Collect the ethyne gas in gas jars by downward displacement of water.

Chemical Reaction

$$CaC_2 + 2H_2O \rightarrow HC \equiv CH + Ca(OH)_2$$

Calcium carbide Water Ethyne Calcium hydroxide

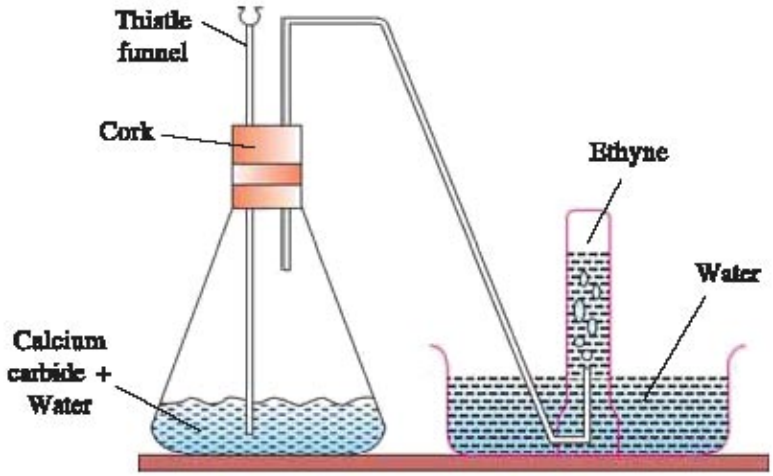


Fig. 10.5 Preparation of Ethyne

Observe the properties of ethyne gas, as follows :

Ethyne obtained by downward displacement of water proves that it is insoluble in water. It is colourless and odourless gas. It is lighter than water. It burns with non-luminous bright, flame when burns in air. If bromine water is added to a test-tube containing ethyne and shaken then the brown colour of bromine water is removed and 1, 1, 2, 2- tetrabromo ethane is formed.

$$HC \equiv CH + 2Br_2 \rightarrow H-\underset{\displaystyle Br}{\overset{\displaystyle Br}{\underset{|}{\overset{|}{C}}}}-\underset{\displaystyle Br}{\overset{\displaystyle Br}{\underset{|}{\overset{|}{C}}}}-H$$

Ethyne Bromine water 1,1,2,2, Tetrabromo ethane.

This is addition reaction of ethyne.

Ethyne and hydrogen react in presence of Raney nickel catalyst; ethane is obtained by addition reaction.

$$HC \equiv CH + 2H_2 \xrightarrow{\text{(Raney Nickel)}} H-\underset{\displaystyle H}{\overset{\displaystyle H}{\underset{|}{\overset{|}{C}}}}-\underset{\displaystyle H}{\overset{\displaystyle H}{\underset{|}{\overset{|}{C}}}}-H$$

Ethyne Dihydrogen Ethane

Ethyne also undergoes polymerization reaction.

Vinyl chloride and vinyl cyanide or acrylonitrile are formed on reaction of ethyne with HCl and HCN respectively. Polyvinyl chloride (PVC) and Polyacrylonitrile (PAN) polymers can be obtained by their polymerization.

e.g.

(1) $HC \equiv CH + HCl \xrightarrow{HgCl_2} H_2C = CHCl$

Ethyne — Vinyl chloride

$$nCH_2 = CHCl \xrightarrow{\text{Polymerisation}} \left[CH_2 - \underset{\displaystyle Cl}{\underset{|}{CH}} \right]_n$$

Vinyl chloride — Polyvinyl chloride (PVC)

(2) $HC \equiv CH + HCN \longrightarrow CH_2 = CHCN$

Ethyne — Vinyl cyanide

$$nCH_2 = CHCN \xrightarrow{\text{Polymerisation}} \left[CH_2 - \underset{\displaystyle CN}{\underset{|}{CH}} \right]_n$$

Vinyl cyanide — Polyvinyl cyanide (polyacrylonitrile) (PAN)

The industrial name of ethyne is acetylene. Ethyne is industrially very important. The substances like ethanol, acetic acid, vinyl polymer and plastic like substances can be prepared from it. Ethyne is used in oxyacetylene flame used for welding of metals. On kite flying day, acetylene gas is filled in rubber balloons and are flown high in sky.

What have you learnt ?

- The mineral coal and petroleum available from earth's crust is a very important and useful wealth.
- Mineral coal and petroleum available from nature are important sources of energy.
- Mineral coal is very useful in steel industry, thermal power stations, manufacture of steel and extraction of metals.
- At the high pressure and temperature in the crust of the earth, the vegations and their parts are decomposed and at the end of the chemical reactions, they are converted into mineral coal. This type of fuel of mineral coal is called fossil fuel.
- Types of mineral coal - peat, lignite, bituminous coal and anthracite.
- If mineral oil is heated at high temperatures in absence of air, then coal gas, coaltar, ammonia and coke are formed.
- The oil available naturally from the crust of the earth is called petroleum. The name petroleum is derived from the Greek words 'petro' means rock and 'oleum' means oil.

- The main purpose of refining of petroleum is to obtain pure chemicals in addition to obtain liquid fuels like gasolene, petrol, kerosene and to separate Liquefied Petroleum Gas (LPG), lubrication oil, wax, naptha, tar etc.
- Petroleum in the furnace when heated, carbon is obtained by decomposition of hydrocarbon. This is known as petroleum carbon. It is used in the preparation of electrodes of battery and carbon tiles. Carbon tiles resist corrosion.
- Carbon possesses tetravalency and property of catenation so that it forms innumerable organic compands.
- The compounds which contain carbon and hydrogen are called hydrocarbons.
- In organic compounds like grains, pulses, sugar, tea, coffee, paper, cotton, wool, synthetic fibres, kerosene, petrol diesel, cooking gas, drugs, dyes, soap, detergent, rubber, plastic, perfume etc. which are useful in our everyday life mainly contain organic compounds.
- On classification of hydrocarbons, alkanes are saturated hydrocarbons, alkene and alkyne compounds are unsaturated hydrocarbons - Alkenes contain double bond and alkynes contain triple bond.
- The general molecular formula of alkanes is C_nH_{2n+2} where n is the number of carbon atoms in that molecule. The suffix at the end of members of alkane series is ane viz. methane, ethane, propane etc.
- sp^3 hybridisation is there in methane which possesses tetrahedral structure- the angle between two bonds is 109° 28'
- Methane is the chief component in gobar gas obtained from animal waste, sewage gas and biogas.
- Ethene gas is obtained by cracking reaction of kerosene or wax. Unsaturated hydrocarbons are mostly obtained by cracking of petroleum.
- Ethene forms polymer polythene by polymerisation which is used in large proportion in household uses.
- The molecular formula of ethyne is C_2H_2 which is known by the name acetylene. Ethyne gas can be obtained by reaction of water with calcium carbide, which is industrially very important. In ethanol, acetic acid, vinyl chloride etc. are used in welding by oxyacetylene flame,

EXERCISE

1. Select the proper choice from the given multiple choices :

(1) Which is the primary state in transformation of coal ?

(A) Lignite (B) Bitumen (C) Anthracite (D) Peat

(2) What is the matured form of coal ?

(A) Lignite (B) Bitumen (C) Anthracite (D) Peat

(3) Which type of coal does not produce smoke or odour when burnt ?

(A) Anthracite (B) Lignite (C) Bitumen (D) Peat

(4) Which of the following components is not obtained when destructive distillation of mineral coal is carried out ?

(A) Coal gas (B) Methane (C) Coaltar (D) Coke

(5) Which of the following is used in production of water gas ?

(A) Coke (B) Coaltar (C) Coal gas (D) Ammonia

(6) Water gas is the mixture of which gases ?

(A) Carbon dioxide and hydrogen (B) Carbon and hydrogen

(C) Carbon monoxide and hydrogen (D) Ammonia and hydrogen

(7) Which gas is filled at high pressure in cylinders of household cooking gas ?

(A) Methane (B) Ethane (C) Propane (D) Butane

(8) Which component obtained from refining of petroleum is used as solvent in petrochemicals ?

(A) Naphtha (B) Kerosene (C) Tar (D) Petroleum coke

(9) Which of the following is used in petromax to obtain light ?

(A) Petrol (B) Diesel (C) Kerosene (D) Butane

(10) Which is the chief hydrocarbon in natural gas ?

(A) Methane (B) Ethane (C) Propane (D) Butane

(11) What is the molecular formula of ethene ?

(A) C_2H_6 (B) C_2H_2 (C) C_2H_4 (D) CH_4

(12) What is the general formula of alkyne series ?

(A) C_nH_{2n} (B) C_nH_{2n-2} (C) C_nH_{2n+2} (D) C_nH_n

(13) What is the commercial name of ethyne ?

(A) Acrylic acid (B) Acetylene (C) Ethane (D) Oxyacetylene

(14) C_3H_8 is the molecular formula of which compound ?

(A) Methane (B) Ethane (C) Propane (D) Butane

(15) What is the angle between any two bonds in methane molecule ?

(A) 105°54' (B) 109°28' (C) 119°28' (D) 190°28'

(16) What is called fossil fuel ?

(A) Mineral coal (B) Wood

(C) Cowdung cake (D) All the given

(17) From where mineral coal is obtained in Gujarat ?

(A) Ankleshwar (B) Cambay (Khambhat)

(C) Thangadh (D) Kalol

(18) What is used as fuel in jet planes ?

(A) Gasolene (B) Diesel oil (C) Kerosene (D) All the given

2. Answer the following questions in brief :

(1) What is called fossil fuel and write its use.

(2) How many main types of mineral coal are there and which are they ?

(3) Write a short note on coke.

(4) Explain in brief about coal tar and coal gas.

(5) What is the valency of carbon ? Why ?

(6) What is meant by hydrocarbon ? How are they classified ?

(7) Explain by drawing the shape of methane molecule.

(8) From which methane is obtained ? Write its preparation

(9) Write uses of ethyne by writing its common name and structural formula.

(10) What is isomerism ? Write isomers of butane and pentane.

(11) The everyday life is not possible without mineral coal and petroleum. Why ?

(12) Explain cracking reaction.

3. Answer the following questions :

(1) Explain the destructive distillation of mineral coal in laboratory by drawing its figure.

(2) Write the types of mineral coal, explain that the use of anthracene coal is more than the bitumen coal. Why ?

(3) Explain occurrence of methane and its preparation.

(4) Writing the common molecular formulas of alkanes, alkenes and alkynes, write the names of first compound of each.

4. Answer the following questions in detail :

(1) Explain preparation of ethene in laboratory by drawing figure.

(2) Explain preparation of ethyne in laboratory by drawing figure.

(3) What is meant by hydrocarbons ? Explain its classification in detail.

(4) Explain in detail about natural gas.

5. Answer the following question pointwise.

(1) What is meant by petroleum ? Explain in detail the refining of petroleum.

UNIT

11

ORGANIC COMPOUNDS

11.1 Introduction

The role of substances available through minerals, plants and animals existing in nature from ancient time is important. The substances available from non-living sources are called inorganic substances. The substances available from plants and animals that is substances available from living sources are called organic substances. Organic molecules are very essential for sustaining life on the earth. It was believed in the ancient time that some important force present in the living entities is necessary for the formation of organic compounds.

The basic constituent of organic compounds is carbon. Hydrocarbons are the basic organic compounds in organic chemistry. Many organic compounds are obtained by displacement of one or more than one hydrogen atom by elements like nitrogen, oxygen, sulphur and halogen. Thus, organic compounds contain the elements like nitrogen, oxygen sulphur, halogen in addition to carbon on the displacement of hydrogen. Hence, organic chemistry is made up of the several types of organic compounds obtained by displacement of hydrogen in them.

Organic compounds are very useful in everyday life of human being. The study of functional groups of organic compounds is necessary to understand easily the organic compounds. We shall obtain the preliminary information about organic functional groups.

11.2 Organic Functional Groups

The chemical reactivity of any organic substance is because of its functional group.

The reactivity of alkene or alkyne compounds corresponding to their alkane compounds is more viz. the reaction of ethene or ethyne is faster than that with its corresponding alkane.

Ethanol or ethanoic acid having same number of carbon atoms as in ethane have different physical and chemical properties which is due to the functional group present in them and the intermolecular forces associated with them.

Definition of Functional Group :

The atom or the group of atoms by which the characteristic reactions of organic compounds are determined, that atom or group of atoms is called the functional group.

Alkane hydrocarbon does not possess any functional group for causing the reaction because of its saturation in organic compound. Different organic compounds having same functional group show similar chemical reactions.

In organic compounds functional groups have atoms like oxygen(O), nitrogen(N), or sulphur(S) in addition to carbon. Common and IUPAC names of compounds having functional groups and examples of some common functional groups are given in Table 11.1

Table 11.1 Some Common Functional Groups

Formula of the functional group	Name of the functional group	Molecular Formula	Common name	IUPAC* name
–COOH	Carboxylic acid	CH_3COOH	Acetic acid	Ethanoic acid
>C = O	Ketone	CH_3COCH_3	Acetone	Propanone
–CHO	Aldehyde	HCHO	Formaldehyde	Methanal
–OH	Hydroxyl (alcohol)	CH_3CH_2OH	Ethyl alcohol	Ethanol
–COOR	Ester	CH_3COOCH_3	Methyl acetate	Methyl ethanoate
– X (Halogen)	Halide			
(F,Cl, Br,I)		CH_3Cl	Methyl chloride	Chloromethane

*(IUPAC = International Union of Pure and Applied Chemistry)

11.3 Organic Compounds Possessing Oxygen Containing Functional Group

In this section we shall have the preliminary study of organic compounds having mainly (1) Alcohol (–OH), (2) Aldehyde (–CHO), (3) Ketone (>C = O) (4) Carboxylic acid (–COOH) groups. In addition, organic compounds having ester and ether as functional groups are also included. We shall study them in the next standards.

Alcohol

If one hydrogen atom of an alkane is displaced by hydroxyl (–OH) group, then corresponding alcohol compound is obtained. The general formula of alcohol is C_nH_{2n+1} OH. Hence, it is represented as R-OH where R = alkyl group.

Nomenclature of Alcohols :

The nomenclature of alcohol corresponding to its hydrocarbon is carried out by removing last alphabate 'e' from the hydrocarbon the suffix – ol is added. Viz. After removing e from methane and by adding ol to methan, methan + ol = methanol. Similarly from ethane, ethan + ol = ethanol.

The first five alkane compounds and their corresponding alcohol compounds are given in Table 11.2.

Table : 11.2 Alkanes and their corresponding alcohols (first five members)

Alkane Name	Alkane : Molecular formula C_nH_{2n+2}	Common name	IUPAC name	Alcohol : Molecular formula ($C_nH_{2n+1}OH$)
Methane	CH_4	Methyl alcohol	Methanol	CH_3OH
Ethane	C_2H_6	Ethyl alcohol	Ethanol	CH_3CH_2OH
Propane	C_3H_8	Propyl alcohol	Propanol	$CH_3CH_2CH_2OH$
Butane	C_4H_{10}	Butyl alcohol	Butanol	$CH_3CH_2CH_2CH_2OH$
Pentane	C_5H_{12}	Pentyl alcohol	Pentanol	$CH_3CH_2CH_2CH_2CH_2OH$

Here, we shall study chemistry of well-known alcohol amongst alcohol compounds. Before this we will obtain information about fermentation process.

Process of Fermentation and its Importance :

You must have noted certain phenomena occurring in everyday life viz. formation of curd from milk, the reaction occurring in donaught (Khiru) of idli, 'handva', 'dhokla' which we call as fermentation reaction. It is anaerobic decomposition reaction. It is carried out by biological enzymes. Such biochemical catalysts are called enzymes.

Formation of curd from milk is carried out by lactase enzyme. It converts lactose of milk to lactic acid obtained in the form of curd. The formation of curd from milk by slow decomposition carried out by enzyme lactase, is known as fermentation. **Thus, reaction of formation of simple substances by slow decomposition of organic compounds through enzyme and in absence of oxygen is called fermentation.** In such reactions, presence of oxygen is not necessary, hence it is an anaerobic respiration e.g. as seen above, fermentation in donaught of idli. In the juice of grapes or fruits, ethanol is formed by decomposition in presence of enzyme yeast. During this fermentation reaction, carbon dioxide gas is produced. Hence, bubbles of gas are observed in this fermentation process.

Ethanol (CH_3CH_2OH) :

We know ethanol as alcohol. It is present in some toxic drinks like whiskey, wine, beer, as well as certain syrups. It also exists as component in dense liquid medicines for cough and for digestion. Two methods of industrial production are known.

(I) Industrial production of ethanol by fermentation reaction : First glucose and fructose are formed by fermentation reaction of sugarcane juice, juice of fruits or grapes, molasses (The waste which is without sugar after removal of sugar from sugarcane is called molasses) etc. in presence enzyme invertase.

$$\underset{\text{Sugar or molasses}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{\text{Invertase}} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

Ethanol and carbon dioxide are formed by fermentation of this glucose or fructose in presence of enzyme zymase. Both the enzymes - invertase (sucrase) and zymase are present in yeast. (which is in the skin of the grapes).

$$\underset{\text{Glucose or fructose}}{C_6H_{12}O_6} \xrightarrow{\text{Zymase}} \underset{\text{Ethanol}}{2C_2H_5OH} + 2CO_2(g)$$

Ethanol is obtained as a mixture of 95% ethanol and 5% water which cannot be further concentrated. But pure ethanol is obtained by membrane technology.

(2) Modern Method of Industrial Production of Ethanol : The industrial production of ethanol is carried out by hydration of ethene ($CH_2 = CH_2$) obtained as petrochemical. Ethanol is formed by hydration of ethene with water in presence of concentrated sulphuric acid.

$$\underset{\text{Ethene}}{CH_2 = CH_2} + H_2O \xrightarrow{\text{Conc.}H_2SO_4} \underset{\text{Ethanol}}{CH_3CH_2OH}$$

Properties of Ethanol :

(1) Pure ethanol : Pure ethanol is colourless. Its boiling point is 351 K and it is highly soluble in water.

(2) Combustibility : Ethanol is a very combustible liquid. It burns rapidly with a blue flame when combusted and produces carbon dioxide and water by combustion.

$$\underset{\text{Ethanol}}{C_2H_5OH} + 3O_2 \xrightarrow{\Delta} 2CO_2 + 3H_2O$$

(3) Reaction with sodium (Na) metal : When ethanol reacts with sodium metal sodium ethoxide (which is generally known as alcoxide) and dihydrogen gas are produced.

$$\underset{\text{Ethanol}}{2C_2H_5OH} + \underset{\text{Sodium metal}}{2Na} \rightarrow \underset{\text{Sodium ethoxide}}{2C_2H_5ONa} + H_2(g)$$

(4) Ethanol on reaction with acetic acid in presence of acid gives ethyl acetate which has sweet fruity smell. This reaction is called esterification reaction.

$$\underset{\text{Acetic acid}}{CH_3COOH(l)} + \underset{\text{Ethanol}}{C_2H_5OH(l)} \xrightarrow{[H^+]} \underset{\text{Ethyl acetate}}{CH_3COOC_2H_5(l)} + H_2O(l)$$

(5) Acetic acid is formed by oxidation of ethanol.

$$\underset{\text{Ethanol}}{CH_3CH_2OH} \xrightarrow[KMnO_4]{\text{Alkaline}} \underset{\text{Ethanoic acid or Acetic acid}}{CH_3COOH}$$

Activity : 1

Take small amount of ethanol in a dry test tube. Add a small piece of sodium metal to it. Note the observation. The bubbles of hydrogen gas will be produced around the piece of sodium metal. By bringing a lighted match stick near the open mouth of the test tube it burns with explosion, which will be combustion. The teacher should take utmost care during this activity.

Activity : 2

Take some amount of ethanol in a dry test tube. Add slowly dropwise $KMnO_4$ solution prepared in 5% aqueous solution of NaOH and keep it for some time. Afterwards, on observation, it will be found that the colour of $KMnO_4$ disappears which indicates the formation of ethanoic acid by oxidation of ethanol.

Uses of Ethanol :

(1) It is used as solvent in industry and in lacquers, varnish, and in fragrant materials like perfumes and in medicine also.

(2) As it is antiseptic, it is used for dressing and cleaning of boils.

(3) As ethanol should not be used as toxic drink, harmful substances like methanol, copper sulphate are mixed with it.

(4) Ethanol solution containing 5% water is called rectified spirit which is useful for making the outer surface of the body germ-free. 100% ethanol is called absolute alcohol.

Alcohol - harmful as drink :

Ethanol is known as toxic amongst alcohols. Those who drink ethanol containing adulterant substances like methanol known as "lathha" lose their eyesight and become blind. They lose sensitivity and lose the balance of the body. It affects the liver and causes death due to a diseases called scirrohsis of liver. Hence, the drinking of alcohol is harmful for the health.

In alcohol containing drinks, ethanol is the main constituent and so it has got toxic effect on the body. If it is taken in small amount, it works as stimulant. If alcohol containing drinks are taken, then ethanol is absorbed through mucosa of stomach and ethanol mixes with the flow of blood through the layers of liver. If an adult drinks alcohol, then it becomes 0.3% in the blood. If more concentration of alcohol is there in the blood, it is harmful and in this condition, he becomes unconscious and the heart fails also.

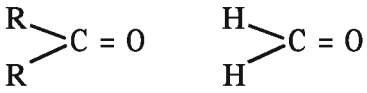
If alcohol is absorbed in the cells, then 90% of ethanol is slowly converted into acetaldehyde by oxidation. Acetic acid is formed by oxidation of acetaldehyde and finally carbon dioxide and water are formed by oxidation. All the cells are able to carry out this oxidation, even then the oxidation reaction occurs mainly in the liver. The toxic effect of alcohol is due to this acetaldehyde and so the person feels vomiting or loses balance or becomes unconscious.

In the liver of the alcohol-drinker (alcohol addict) the amount of enzyme P-450 increases very high and so one who drinks alcohol gets tempted to drink more alcohol. One who is habituated to drinking alcohol, is given medicine called disulfiram. By this medicine alcohol is oxidised only upto acetaldehyde and so by drinking acetaldehyde containing alcohol, one feels vomiting and nautia and as a result the alcohol drinker (alcohol addict) develops hatred towards alcohol.

Aldehyde and Ketone Compounds :

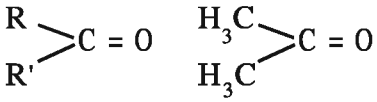
Aldehyde and Ketone are carbonyl ($>C = O$) group containing organic compounds. The

carbon atom of carbonyl compound group is attached with one alkyl (– R) group and one hydrogen atom (H) in which formaldehyde is the exception.



Aldehyde Methanal (Formaldehyde)

While in ketones carbon of carbonyl group is attached with carbon atoms of two alkyl groups (R and R').



Ketone Propanone (Acetone)

where R and R' are similar or different alkyl groups.

IUPAC Nomenclature of Aldehydes and Ketones :

For IUPAC nomenclature of aldehyde compounds having longest hydrocarbon carbon chain with aldehyde group (– CHO) corresponding to original carbon is decided and last alphabet 'e' is removed from the name of the hydrocarbon and the suffix 'al' is added.

As an example, the aldehyde corresponding to methane is known as methanal (Common name : formaldehyde) ethane known as ethanal (Common name : acetaldehyde) and propane known as propanal.

From methane, methan + al = methanal. From ethane, ethan + al = ethanal.

While in ketone compounds last alphabet 'e' is removed from the name of the hydrocarbon and the suffix 'one' is added viz. Ketone corresponding to propane is propanone, and ketone corresponding to butane as butanone.

From Propane : Propan + one = Propanone, From Butane : Butan + one = Butanone

Examples of simple aldehydes and ketones corresponding to alkanes are given in Table 11.3.

Table 11.3 Some Common Aldehydes and Ketones

Alkane		Aldehyde			Ketone		
Formula	Name	Formula	Common name	IUPAC name	Formula	Common name	IUPAC name
CH_4	Methane	HCHO	Formaldehyde	Methanal	-	-	-
C_2H_6	Ethane	CH_3CHO	Acetaldehyde	Eathanal	-	-	-
C_3H_8	Propane	CH_3CH_2CHO	Propionaldehyde	Propanal	CH_3COCH_3	Acetone	Propanone
C_4H_{10}	Butane	$CH_3CH_2CH_2CHO$	Butanaldehyde	Butanal	CH_3CH_2-$COCH_3$	Methyl ethyl ketone	Butanone

Methanal (Formaldehyde) (HCHO)

The common name of methanal is formaldehyde. Its aqueous solution containing 4 to 6% concentration is called formalin. It is antiseptic. Its molecular formula is HCHO. It is used as preservative in preserving samples of dead animals in the laboratory.

Preparation of Methanal :

Methanal (HCHO) is formed by oxidation of methanol at 873 K to 973 K temperature in presence of catalyst like oxides of silver or iron.

$$2CH_3OH + O_2 \xrightarrow[[Ag_2O]\ 873K\text{-}973K]{\text{Oxidation}} 2HCHO + 2H_2O$$

Methanol — Methanal (Formaldehyde)

Properties of Methanal :

(1) Methanal is a colourless, poisonous gas. Its boiling point is 253 K. It is soluble in water.

(2) The chemical reactions of aldehyde as analdehyde functional group are as follows :

(1) Oxidation : Methanoic acid is formed by oxidation of methanal in presence of oxidising substance.

$$HCHO \xrightarrow{[O]} HCOOH$$

Methanal (Formaldehyde) — Methanoic acid (Formic acid)

In this reaction oxidising agents like ammoniacal silver nitrate (Tollens reagent) and Fehling reagent oxidise aldehyde compound to corresponding carboxylic acid having same number of carbon atoms.

Activity : 3

In a test tube, take solution of silver nitrate. Add solution of NaOH in such a proportion that stable brown black colour precipitates are obtained. Dissolve these precipitates by adding liquor ammonia. The resulting solution is Tollens reagent. In another test tube take aldehyde and add Tollens reagent to it. Place this test tube in a beaker containing hot water. Silver metal is separated by reduction of silver ion (Ag^+) and gets deposited on the inner surface of the test tube which appears as a mirror. This test is known as silver mirror test.

Activity : 4

Glucose is a compound containing aldehyde group. When Fehling solution-A (Solution of copper sulphate) and Fehling solution –B (sodium potassium tartarate and sodium hydroxide mixture) are added to aldehyde. Copper (II) is reduced and red precipitates of copper (I) oxide are formed. This test is known as Fehling test in the laboratory.

Activity : 5

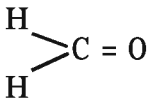
Glucose is a compound containing aldehyde group. In the urine of a diabetic patient, amount of glucose is present. When it is treated with Benedict's Solution (mixture of $CuSO_4$ + aqueous citric acid + sodium carbonate) copper (II) is converted to precipitates of copper (I) oxide. This test is known as Benedict's test in pathological laboratory.

(ii) **Reduction of methanal :** Methanol is formed by reaction of methanal with dihydrogen (H_2) gas in presence of palladium (Pd) catalyst.

$$HCHO + H_2 \xrightarrow{[Pd]} CH_3OH$$

Methanal Dihydrogen Methanol

(iii) **Addition reaction of hydrogen cyanide (HCN) with methanal**



A double bond is present between carbon and oxygen atoms in methanal. Organic compounds containing double bond give addition reaction (addition of reagent to the original substance). Methanal reacts with hydrogen cyanide and gives methanal cyanohydrin product by addition reaction.

Methanal Hydrogen cyanide Methanal cyanohydrin

Uses of Methanal :

(1) Aqueous solution of methanal (formalin) is antiseptic and so used to preserve residues of dead animals.

(2) Methanal is used as a raw material in plastic industry. Methanal is used as a monomer in preparation of bakelite, melamine plastic etc.

(3) Methanal is used for making dyes phenol and formaldehyde fibres (Polymer).

(4) The resin known as urea formaldehyde (UF) resin is prepared from urea and formaldehyde, which is used as foam.

Propanone (Acetone) (CH_3COCH_3)

The simplest compound of ketone group is propanone. Its common name is acetone which is one of the compounds of the solution to remove nail polish.

Preparation of propanone :

Fisher – Tropsch Process : When a mixture of ethene obtained during cracking of petroleum and water gas is passed over a catalyst cobalt oxide (CoO) at 150 bar pressure and 453 K temperature, acetone is obtained.

$$CH_2 = CH_2 + \underbrace{H_2 + CO}_{\text{Water gas}} \xrightarrow[453\ K;150\ bar]{[CoO]} CH_3COCH_3$$

Ethene Propanone

Properties of Propanone :

(1) **Propanone (acetone)** is a colourless liquid and possesses fragrant smell. Its boiling point is 329 K and it is very much soluble in water.

(2) **Reduction of propanone :** Propanone gives propan-2-ol on reduction with reducing agent like sodium borohydride ($NaBH_4$) or Lithium aluminium hydride ($LiAlH_4$)

$$CH_3COCH_3 \xrightarrow[\text{or } LiAlH_4]{NaBH_4} CH_3\text{-}\underset{\displaystyle OH}{\underset{|}{CH}}\text{-}CH_3$$

Propanone Propan-2-ol

(3) **Oxidation of propanone :** Ethanoic acid is obtained by oxidation of propanone, with alkaline potassium permanganate. ($KMnO_4$)

$$CH_3COCH_3 \xrightarrow[\text{Alkaline}]{[O]KMnO_4} CH_3COOH + CO_2 + H_2O$$

Propanone — Ethanoic acid or Acetic acid

(4) **Addition reaction of propanone :** Like methanal propanone contains $>C = O$ double bond. As a result of this it reacts with hydrogen cyanide (HCN) and gives additive product propanone cyanohydrin.

$$H_3C\text{-}\underset{\underset{O}{\|}}{C}\text{-}CH_3 + HCN \longrightarrow H_3C\text{-}\underset{\underset{OH}{|}}{\overset{\overset{CN}{|}}{C}}\text{-}CH_3$$

Propanone — Hydrogen cyanide — Propanone cyanohydrin

Uses of Propanone :

(1) As a solvent in laboratory and in paint industry.

(2) In preparation of artificial leather and synthetic fibres.

(3) It is used as nail paint remover.

Carboxylic Acid Compounds :

Organic compounds containing –COOH functional group are called carboxylic acid compounds. Some of them like methanoic acid and ethanoic acid have well known common name as formic acid and acetic acid respectively.

IUPAC Nomenclature :

For nomenclature of carboxylic acid compounds, the longest hydrocarbon carbon chain with carboxylic group is selected and last alphabate 'e' is removed from the corresponding hydrocarbon and 'oic' suffix is added. e.g. Methane – Methanoic acid, Ethane – Ethanoic acid.

Common and IUPAC names of some carboxylic acids are given in Table 11.4

Table 11.4 Common and IUPAC Names of Carboxylic Acids :

Alkane		Carboxylic acid		
Molecular formula	Common name	Molecular formula	Common name	IUPAC name
CH_4	Methane	HCOOH	Formic acid	Methanoic acid
C_2H_6	Ethane	CH_3COOH	Acetic acid	Ethanoic acid or Acetic acid
C_3H_8	Propane	CH_3CH_2COOH	Propanoic acid	Propanoic acid

Carboxylic acids having general formula $\begin{matrix} R' \\ HO \end{matrix}\!\!>\!C = O$ obtained by substitution of any one of the R or R' group present in general formula $\begin{matrix} R' \\ R \end{matrix}\!\!>\!C = O$ by -OH group.

Ethanoic acid (Acetic acid) CH_3COOH :

The common name of ethanoic acid is acetic acid. Its formula is CH_3COOH.

Preparation of Ethanoic Acid :

(1) Ethanoic acid (vinegar) is formed by oxidation of ethanol in air by fermentation in presence of acetobacter enzyme.

$$C_2H_5OH + O_2 \xrightarrow[\text{Enzyme}]{\text{Acetobacter}} \underset{\text{Ethanoic acid}}{CH_3COOH} + H_2O$$

The proportion of ethanoic acid obtained by this method is very less.

(2) In the modern industrial production of ethanoic acid, methanol is reacted with carbon monoxide in presence of catalyst Iodine-Rhodium (I_2 -Rh)

$$\underset{\text{Methanol}}{CH_3OH} + \underset{\text{Carbon monoxide}}{CO} \xrightarrow{[I_2-Rh]} \underset{\text{Ethanoic acid or Acetic acid}}{CH_3COOH}$$

Properties of Ethanoic Acid :

(1) Ethanoic acid is a colourless, liquid containing highly sour smell and is soluble in water. Its boiling point is 391 K.

(2) **Acidic Property :**

(a) It reacts with metals like sodium (Na) and magnesium (Mg) and forms metal ethanoate (acetate) salt and dihydrogen gas. It is a weak acid.

$$\underset{\text{Ethanoic acid}}{2CH_3COOH} + \underset{\text{Sodium}}{2Na} \longrightarrow \underset{\text{Sodium ethanoate (Sodium acetate)}}{2CH_3COONa} + \underset{\text{Dihydrogen}}{H_2\,(g)}$$

(b) Ethanoic acid forms salt like sodium acetate by reaction with base like sodium hydroxide.

$$\underset{\text{Ethanoic acid (Acetic acid)}}{CH_3COOH} + \underset{\text{Sodium hydroxide}}{NaOH} \longrightarrow \underset{\text{Sodium ethanoate (Sodium acetate)}}{CH_3COONa} + H_2O$$

These reactions indicate that hydrogen present in -COOH group possesses acidic property.

(3) **Reaction with Alcohol :** Ethanoic acid reacts with ethanol in presence of concentrated sulphuric acid and forms ethyl ethanoate (ethyl acetate).

$$\underset{\text{Ethanoic acid}}{CH_3COOH} + \underset{\text{Ethanol}}{C_2H_5OH} \xrightarrow[\Delta]{[\text{Con. } H_2SO_4]} \underset{\text{Ethyl ethanoate (Ethyl acetate)}}{CH_3COOC_2H_5} + H_2$$

Here the reaction of formation of ester by the reaction of carboxylic acid with alcohol is called esterification.

Uses of Ethanoic acid :

(1) In preparation of vinegar, to have sour taste in food stuffs and as preservative for foods.

(2) As a solvent and reagent in the laboratory.

(3) In preparation of white lead.

11.4 Polymers

The macromolecules that are formed by combination of one or more than two types of innumerable simple molecules by chemical bond formation are called **polymers.**

One or more than two types of innumerble simple organic molecules that combine with one another and form a polymer are called **monomers.**

The process (reaction) of one or more than two types of innumerable simple organic molecules that combine with each other by chemical bond formation is called **Polymerisation.**

Polythene is formed by addition reaction of innumerable molecules of ethene with one another. In this reaction, two molecules of monomer ethene combines in the first step and form a dimer. Third molecule combines with a dimer and forms a trimer. A trimer combines with fourth monomer and forms a tetramer. In the same way the chain elongates. As a result very long chain is formed which is called macromolecule or polymer.

$$CH_2 = CH_2 \xrightarrow{CH_2 = CH_2} CH_3 - CH_2 - CH = CH_2 \xrightarrow{CH_2 = CH_2}$$

Ethene monomer Dimolecular formation (Dimer)

$$CH_3 - CH_2 - CH_2 - CH_2 - CH = CH_2 \xrightarrow{CH_2 = CH_2}$$

Trimolecular formation (Trimer)

$$CH_3 - CH_2 - CH_2 - CH_2 - CH_2 - CH_2 - CH = CH_2$$

Tetramolecular formation (Tetramer)

$$\xrightarrow{n(CH_2 = CH_2)} \text{-}\!\left[CH_2 - CH_2\right]\!\text{-}_n$$

Polythene (polymer)

In every polymer chain, certain part is continuously repeated on the basis of the monomer molecule. This part is called 'repeating unit' viz. In polythene, ethene is the monomer. The number of repeating unit 'n' in a polymer is called degree of **polymerisation.**

(1) Classification of Polymers :

Polymers are classified in different types :

(i) **Naturally occurring Polymer :** Polymers are found in nature, viz, starch, protein, nucleic acid, rubber etc. are very essential for human beings.

(ii) **Semisynthetic Polymer :** Semisynthetic polymers are obtained by chemical reaction with polymers occurring in nature. The rubber with improved properties obtained by vulcanization of natural rubber, is used in the formation of tyres,

(iii) **Synthetic Polymers :** Man-made synthetic polymers are made up of polymers. This is an important big class of polymers, in which fibres, plastic and rubber are included. Synthetic polymers are used in textile industry, electrical appliances, and in lieu of wood and metal.

(2) Classification based on Polymerisation Reaction :

(i) Homopolymer and Co-polymer : When two or more types of innumerable simple organic monomers of the same type combine with one another through chemical bond formation gives polymers. They are called homopolymers viz. Polythene formed from ethene is a homopolymers. When two or more types of innumerable simple organic monomers of same type combine with one another through chemical bond formation gives polymers. They are called co-polymers viz. Styrene Butadiene Rubber (SBR) prepared from styrene and butadiene is a copolymer.

(ii) Addition and Condensation Polymer : The polymers that are formed by combination of chemical bond formation of innumerable simple organic monomers having double bond are called addition polymers viz. Polystyrene formed from styrene is an addition polymers.

Some important addition polymers, their monomers and their uses are given in Table 11.5

Table 11.5 Monomer, Polymer and their uses

Monomer	Polymer	Uses
$CH_2 = CH_2$ Ethene	$+CH_2 - CH_2+_n$ Polythene	Toys, packing bags
$CH_2 = CH\text{-}Cl$ 1-Chloroethene (Vinyl chloride)	$+[CH_2 - CH(Cl)]+_n$ Polyvinylchloride	In preparation of flooring tiles, rain coats, hand bags .
$CF_2 = CF_2$ Tetrafluoroethene	$+CF_2 - CF_2+_n$ Teflon	Preparation of non-stick cooking vessels and as insulator
$CH_2 = C(CH_3) - CH = CH_2$ 2-Methyl buta-1,3-diene (Isoprene)	$+[CH_2 - C(CH_3) = CH - CH_2]+_n$ Natural rubber	In preparation of water proof clothes, tyres of cars and bikes.
$CH_2 = CH - CH = CH_2$ Buta-1,3-diene (Butadiene)	$+CH_2 - CH = CH - CH_2+_n$ Polybutadiene	As an alternative for natural rubber
$CH_2 = C(Cl) - CH = CH_2$ 2-Chlorobuta-1,3-diene	$+[CH_2 - C(Cl) = CH - CH_2]+_n$ Neoprene	As an insulator in conveyor belts, rollers of printing

Uses : In preparation of utensils for household purposes, pipes, paints, fibres, nylon, terrylene, etc. spare parts of automobile, furniture and brush, comb, chappal, raincoat etc. Also useful in preparation of fish nets, ropes, and tyres. It is useful in textile industry. With the use of science and technology we have been able to prepare polymers having different characteristics,

Rubber : Rubber is obtained naturally and is also prepared synthetically.

There is notable elasticity in natural rubber. The reversible stress is maintained for a long time even if a small force is applied on it. Because of this characteristic property of elasticity, the natural rubber is notably used in different fields. The rubber latex available from the rubber plant, obtained by a cut in its bark, is a colloidal suspension called rubber latex. Natural rubber is obtained by physical and chemical reactions with rubber latex. The characteristic property of elasticity of natural rubber is maintained between temperatures 283 K to 333 K or higher. At the temperatures below 283 K, it remains brittle while it becomes soft at temperatures 333 K or higher. Its capacity of absorbing water is high. It is resistant to non-polar solvents and gets oxidised easily by the oxidising agent.

Vulcanised Rubber : In 1893, Charles Goodyear found out that if the mixture of rubber and sulphur is heated at 373 K to 413 K temperature, the required change in the required proportion can be carried out. This process is known as vulcanisation. This reaction is slow and so zinc oxide is added as addition substance and so the rate of reaction becomes fast.

Vulcanised rubber has very good elasticity, very low water absorbing property and resists organic solvents and oxidation reaction. By use of 5% of sulphur during vulcanisation, rubber suitable for tyres and by use of 30% of sulphur during vulcanisation, rubber suitable for cases of battery can be prepared.

Uses : The vulcanised rubber is used in rubber bands and preparation of tubes and tyres of vehicles. The high non-inflamable property of neoprene is due to large number of chlorine atoms present in it.

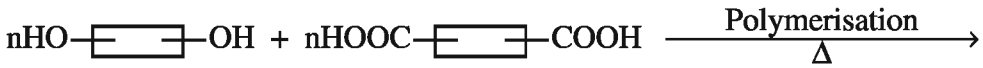
Condensation Polymers :

When two different types of innumerable simple organic monomers combine with one another by condensation polymerisation and gives polymers after removal of molecule like water, ammonia or alcohol, are called condensation polymers viz. Nylon 6,6 polymer obtained from hexamethylene diamine and adipic acid is a condensation polymer.

Uses : Nylon 6,6 is of thermoplastic type polymer. Its fibres are strong, elastic and water resistant. It is used in preparation of fishing nets, ropes and also used in tyre industry.

Polyester :

Polyester molecule possesses innumerable ester functional group containing repeating units. It is formed by combination of two hydroxyl and two carboxylic groups containing substances.



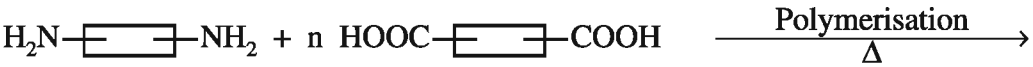
(Compound containing hydroxyl group) (Compound containing carboxylic group)

Polymer

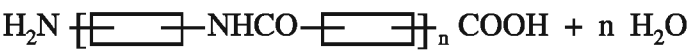
where ▭ shows hydrocarbon part.

Uses : Polyester fibres are mixed with cotton fibres and used in textile industry.

Polyamide : Polyamide is a polymer containing amide group. It can be prepared by condensation of diamine and carboxylic acid and is known as nylon :



Diamine Dicarboxyllic acid



Nylon

where ▭ shows hydrocarbon part.

Biopolymers :

Some polymers in nature, viz; polysachharide, protein and nucleic acid are very essential for human beings. They are called biopolymers.

Most of the polymers used in everyday life possess inactivity towards environmental reactions. Hence, decomposition reactions do not occur during use of polymers and substances useful to human being are not produced. Hence, a big and intense problem has emerged out for the disposal of waste collected after use of this type of non-biodegradable polymers.

In the biological systems of human being the degradation of biopolymers is mostly carried out by hydrolysis through enzymes and to some extent by oxidation.

In recent years the development of biodegradable polymers is being carried out with a view that it is suitable to human life system and taking into consideration the disposal of solid waste after use of polymers.

Uses : Biodegradable polymers are used in special types of packing, orthopaedic appliances and in capsules to fill controlled drugs. Only when controlled drug containing PHBV (Polyhydroxy butyrate Co-β hydroxy valerate) capsule is decomposed in the body, then after effect of the drug released from the capsule starts. The dextran used for taking stitches after surgical operation is a biodegradable polymers.

11.5 Soap and Synthetic Detergents

The chemical substance used to remove the dirt sticked to the surface and does not harm the surface of a thing is called detergent.

Detergents have been used for many of years, we will be familiar with the preliminary information of detergents like soap and detergents.

Soap : Soap is a sodium or potassium salt of fatty acid (stearic acid, oleic acid, palmitic acid). Sodium salt is present in washing soaps and potassium salt is present in bathing soaps. Acid gives glycerol and ester compounds which is present in animal fat (mutton tallow) and vegetable oil (fat).

Preparation of Soap : Vegetable oil (groundnut oil, castor oil etc.) or animal fat when heated with sodium hydroxide (NaOH), sodium salt of fatty acid and glycerol are formed. This process of preparing soap is called **saponification.**

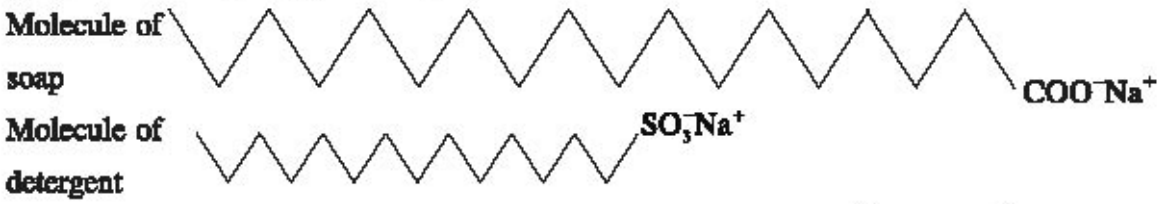
Vegetable oil or Animal fat + Sodium hydroxide $\xrightarrow[\Delta]{\text{Saponification}}$ Glycerol + Sodium salt of fatty acid (Soap)

Activity 6

In a beaker, take 20 ml. of vegetable oil and add aqueous solution of 20% NaOH. Heat it for some time and stir it. The oily and aqueous layers will mix with each other and the mixture will be viscous. Add 5 to 10 grams of common salt (NaCl). Cool the mixture so that the insoluble substance will come in the upper part of the mixture. Take it in another vessel and prepare cakes which is soap. In the preparation of this soap, fragrant substances, antiseptic drug, filler etc. are added as per the requirement of the soap.

Detergents : Chemically, detergents are the sodium salts of organic sulphonic acids.

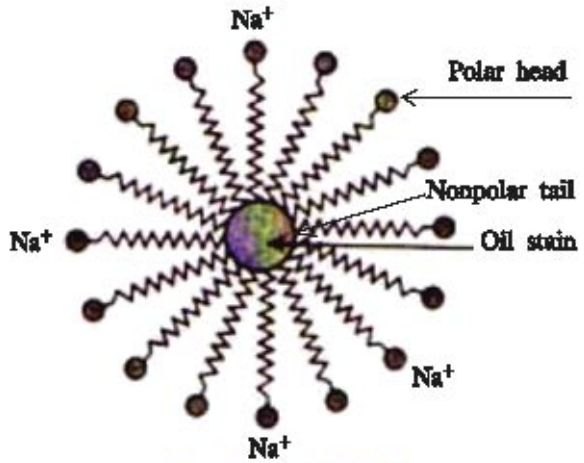
In soap - COONa functional group is attached to hydrocarbon while detergents are sulphonate ($-SO_3Na$) functional group possessing hydrocarbon chains.



The cleansing effect of the detergent is more effective because Ca^{2+} and Mg^{2+} ions present in hard water do not give precipitates with ions which are in the soluble form. They remain in the solution and so detergent in more quantity is not used. Hence, the use of detergent has increased. The cleansing process of soap and detergent is same. There are two parts in the structure of soap and detergent; one part of a long hydrocarbon chain is known as nonpolar tail. It does not possess attraction towards water but possesses attraction towards dirt or stain.

While the other negatively charged part ($-COONa$ or $-SO_3Na$) is known as head. It possesses attraction towards water molecules. Concentrated solution of soap or detergent is applied on the dirty or oily stained surface. The nonpolar part possessing attraction towards dirt is attracted by oily stain or dirt.

When polar part remains in water, it possesses attraction towards water. The spherical structure formed around the stain is called **micelle.**



Formation of micelles

The hydrocarbon part remains attached with the surface containing dirt or oil while polar part remains in water.

The part on which detergent is applied, is being dragged by water so that the water gets dirty and the surface becomes clean.

What have you learnt ?

In this unit, we have learnt about information on organic compounds and how organic compounds are very useful in our everyday life. The study of functional group is essential for the study of organic compounds.

The atom or group of atoms which carry out reactions of organic compounds is called functional group.

- Functional groups are like carboxylic acid (–COOH), ketone (> C = O), aldehyde (–CHO), alcohol (–OH), ester (–COOR) and halogen (X)

In this unit, alcohol and ethanol etc., fermentation method of obtaining alcohol, fermentation reaction and its importance are discussed.

Usage of ethanol in toxic beverages such as whisky, wine, beer and certain syrups, in medicines necessary for cough and digestion. Drinking toxic drinks and the harmful effect due to that, necessary medicine for that and properties of ethanol are studied in detail.

You have studied about aldehyde and ketone compounds, their nomenclature, methanal (formaldehyde), ethanal (acetaldehyde), etc. Preparation of methanal, properties and uses, and also studied the silver mirror test and Fehling tests as activity.

Preparation of propanone, properties, uses and study of reduction-oxidation and addition reactions are also carried out.

In carboxylic acid compounds, ethanoic acid (acetic acid), its preparation, properties and acidic properties, esterification reaction and uses - acetic acid as preservative (vinegar) have been discussed.

Also learnt about artificial polymers, classification of polymers, addition and condensation polymer, rubber, vulcanised rubber, polyester, polyamide and their uses as well as biopolymers.

Also learnt in detail about soap and synthetic detergents, preparation of soap. Detergents and their uses, method of removing dirt.

EXERCISE

1. Select the proper choice from the given multiple choices :

(1) What is called the compounds possessing (-CHO) functional group ?

(A) Amide (B) Aldehyde (C) Ketone (D) Alcohol

(2) Which functional group is possessed by carboxylic acid ?

(A) $>C = 0$ (B) -COOH (C) -CHO (D) -OH

(3) 'ol' suffix is attached with which group in nomenclature ?

(A) -CHO (B) $>C=O$ (C) -OH (D) -X

(4) Which functional group is there in methyl ethanoate ?

(A) Alcohol (B) Halide (C) Ketone (D) Ester

(5) Which of the following compounds is obtained by fermentation reaction of molasses ?

(A) Chloromethane (B) Ethanol (C) Acetone (D) All the given

(6) What is called the solution ethanol containing 5% water ?

(A) Beer (B) Varnish (C) Rectified spirit (D) Perfume

(7) What is the moleuclar formula of formalin ?

(A) HCOOH (B) $HCOOCH_3$ (C) HCHO (D) $HCOOC_2H_5$

(8) Which substance is obtained by reduction of methanal ?

(A) Ethanol (B) CO_2 and O_2 (C) Methanol (D) All the given

(9) What is prepared by Fisher-Tropsch method ?

(A) Acetic acid (B) Acetaldehyde (C) Acetone (D) Ethanol.

(10) Which of the following is the use of propanone ?

(A) To remove nail polish (B) Antiseptic

(C) Antibiotic (D) As preservative.

(11) Which of the following is the reaction occurring between alcohol and carboxylic acid in presence of concentrated H_2SO_4 ?

(A) Hydrolysis (B) Beta-elimination (C) Saponification (D) Esterification

(12) Which compound of the following functional groups is having minimum three carbon atoms ?

(A) –COOH (B) –CHO (C) $>C=O$ (D) –C–O–

(13) Which of the following monomers is in polythene ?

(A) $CH_3–CH_3$ (B) $CH_2 + CH = CH_3$

(C) $CH_2 = CH_2$ (D) CH = CH

(14) Which of the following is the use of acetic acid ?

(A) Preparation of vinegar (B) White lead

(C) As reactant (reagent) (D) All the given

(15) Which of the following is used in conveyor belts ?

(A) Polythene (C) PVC (C) Teflon (D) Neoprene

2. Answer the following questions in brief :

(1) Mention the functional groups containing oxygen.

(2) Explain the fermentation reaction and its importance.

(3) Write preparation of methanal with equation.

(4) Write properties of methanal.

(5) Write Fisher-Tropsch method with equation.

(6) Write preparation of ethanoic acid.

(7) Write the defintion of functional group and give examples of two functional groups.

(8) Explain homopolymer and co-polymers.

(9) Explain addition and condensation polymers.

(10) Write structures and uses of ethene and vinyl chloride polymer.

(11) Write uses of polymers.

(12) Write the structure and uses of teflon and polyisoprene polymers.

3. Answer the following questions :

(1) Write industrial production of ethanol.

(2) Write properties of ethanol.

(3) What is rubber ? Explain.

(4) Write uses of ethanol.

(5) Give examples of aldehyde and ketone.

(6) Write oxidation, reduction and addition reaction of methanal with hydrogen cyanide.

(7) Write uses of acetone.

(8) Write uses of ethanoic acid.

(9) What is meant by soap ? Write its preparation.

(10) What is called esterification reaction ? Explain giving examples.

4. Answer the following questions in detail :

(1) Write names and molecular formulas of first four members of alkanes and their corresponding alcohols.

(2) Write four chemical properties of ethanol.

(3) "Alcohol is harmful as drink." Explain this statement in detail.

(4) Write uses of methanal (formaldehyde).

(5) Write properties of propanone.

(6) Write properties of ethanoic acid.

(7) What is polymer ? Explain in detail.

(8) Write a short note on detergents.

5. Answer the following questions pointwise :

(1) Write in detail classification of polymers.

(2) Write short notes-polyester and polyamide.

(3) Write about vulcanised rubber and its uses.

UNIT 12

NUTRITION AND RESPIRATION

Every organism performs different types of physiological activities. For these activities organisms required energy. This energy is obtained by organisms through different methods of nutrition. Autotrophic organisms obtained nutrition by performing the process of photosynthesis. While heterotrophic organisms dependent on other organisms for food. In animals, the entire process of ingestion of food conversion into easily absorbable components and transport to the different cells is known as nutrition. The process of getting energy from nutritive substances is carried out by cells. Thus, phenomenon is generally known as cellular respiration. During this process energy is realesed which can be utilised by organisms for physiological activities.

12.1. What are Life Processes ?

All the organisms perform certain main functions to keep themselves alive. The main fundamental functions, performed by living organisms to maintain their life are called life processes. They are nutrition, growth, respiration, circulation, excretion, control and coordination, movement and reproduction. The nutrition means taking of food and converting it into smaller absorbable unit by our body. The process of respiration releases energy from the absorbed food. Transport is the process through which absorbed substance are transported to various parts of the body. Waste materials produced in various cells of the body are removed from the body by process of excretion. Control and coordination keep the living organisms to survive in the changing environment surrounding them. The process of growth involves the change in size of the living organism (small to big). In the process of movement the living organisms move from one place to another or make movement of smaller to larger parts of the body. The process of reproduction involves multiplication of existing organisms, so they can make existence of their species on the earth.

Nutrients

Nutrients mean substances which provide the two basic requirements of organisms, namely organic raw material and energy.

12.2. Nutrition

Nutrition can be defined as the process of intake of nutrients from which organisms derive energy to work. A substance which supply nutrients to the body is called diet or food. The food taken by an organism contains, carbohydrates, proteins, fats, vitamins, water and minerals. In organisms there are different ways for obtaining food. Hence in various organisms different modes of nutrition can be seen.

Modes of Nutrition :

The modes of nutrition means methods of obtaining food by organisms. All the organisms do not obtain their food in the same way. So organisms have following methods for obtaining food.

(A) Autotrophic (Holotrophic) Nutrition

(B) Heterotrophic Nutrition

[A] Autotrophic nutrition :

The word 'auto' means self and 'trophe' means nutrition. Autotrophic means 'self nutrition'. In autotrophic nutrition organisms synthesize their own food, like carbohydrate, from water and carbon dioxide with the help of chlorophyll in presence of sun light. This process is known as photosynthesis. e.g. green plants, Euglena, Volvox and Bacteria. Carbohydrates are used for providing energy to them. The carbohydrates which are not used are stored in the form of starch. We derived energy from the food which is stored in our body in the form of glycogen.

The following events are involved in the process of photosynthesis :

(i) Absorption of light energy by chlorophyll

(ii) Conversion of light energy into chemical energy

(iii) Reduction of carbon dioxide in to carbohydrates.

Let us see how sunlight, chlorophyll and CO_2 are important for photosynthesis. In leaf some cells contain green organelles viz. chloroplasts which contain chlorophyll. Let us do an activity which demonstrates that chlorophyll is important for photosynthesis.

Activity : 1

- Take a potted Croton plant whose leaves are partly green and partly white.
- The green part of the leaf possesses chlorophyll while the white part of the leaf does not have chlorophyll.
- Keep this plant in a dark place for about three days to destarch its leaves.
- Now keep the plant in sunlight for about six hours.

Fig. 12.1 Variegated leaves

- Pluck the variegated leaf from the plant and remove its "chlorophyll" by boiling it in alcohol. Thus green parts of the leaf get decolourised.
- Now dip the leaf in a dilute solution of iodine for a few minutes.
- Observe the change in colour of leaf.
- The inner part of the leaf which was originally green turns blue on dipping in iodine solution, this shows that starch is present in it.
- The outer part of the leaf which was originally white (without chlorophyll) does not turn blue while dipping in iodine solution, showing that no starch is present.
- From this observation we can conclude that chlorophyll is essential for the process of photosynthesis.

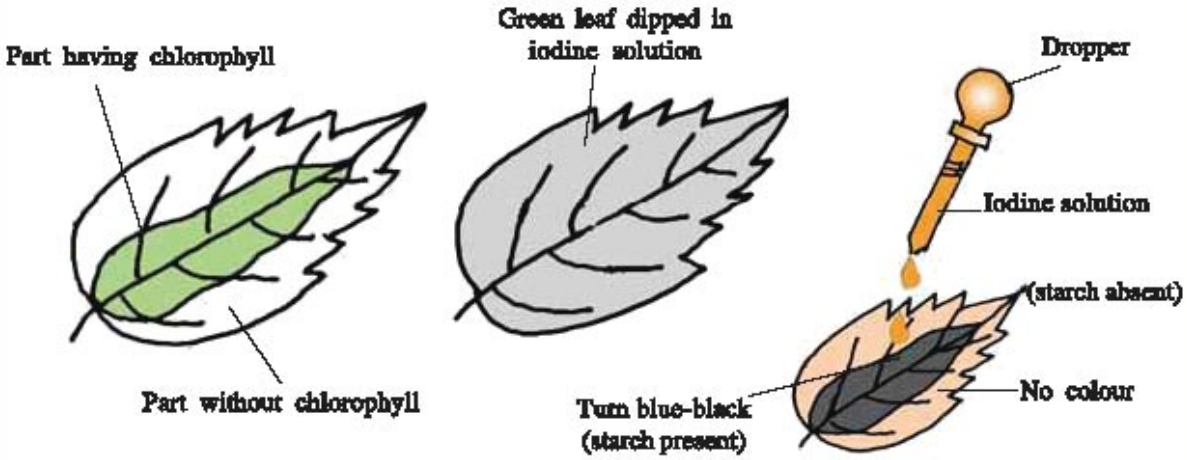


Fig. 12.2 Experiment shows necessity of chlorophyll for photosynthesis

Let us know how the plants obtain carbon dioxide. The plants take carbon dioxide from the atmosphere for photosynthesis. The carbon dioxide enters the leaves of plant through the stomata present on the surface of leaves. The stomata are also present in the green stems of plant.

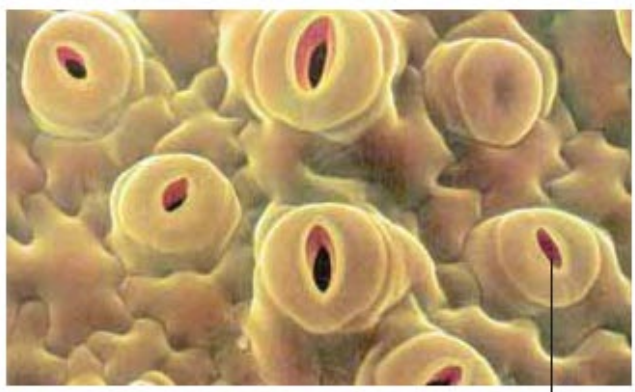


Fig. 12.3 Stomata

Each stomatum consists of minute pore surrounded by a pair of guard cells. The opening and closing of stomata are controlled by the guard cells. When water enters into the guard cells, the cells become turgid and cause the pore to open. When the guard cells lose water, they shrink and cause the pore to close. Aquatic plants obtain the carbon dioxide gas dissolved in water to carry out photosynthesis.

Activity : 2

Let us do an activity which demonstrate that carbon dioxide is necessary for photosynthesis.

- Take two potted plants which are nearly same in size.
- Keep them in a completely dark place for three days to destarch their leaves.
- Now put each potted plant on a separate glass plate.
- Put a watch glass containing potassium hydroxide by the side of one of the plants. The use of potassium hydroxide is to absorb carbon dioxide.
- Cover plants with separate bell – jars.
- Use vaseline to seal the bottom of the jars to the glass plates so that set-up is airtight.
- Keep the plants in sunlight for more than two hours.
- Pluck the leaf from both plants and check the presence of starch as in activity No. 1. This shows that carbon dioxide is necessary for photosynthesis.

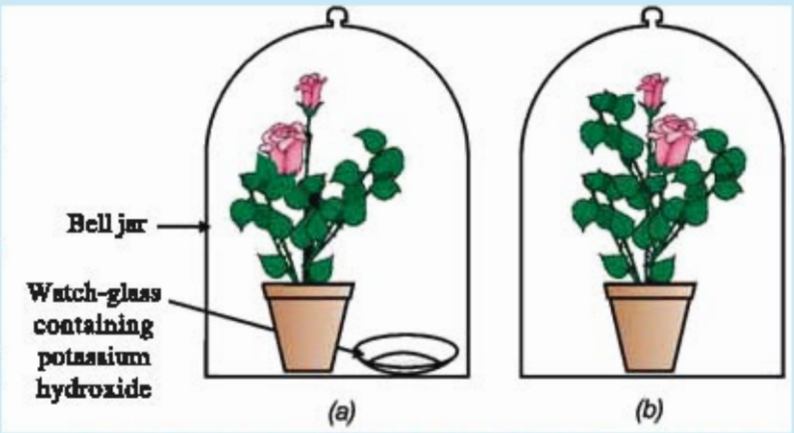


Fig. 12.4 Experimental set-up (a) with potassium hydroxide (b) without potassium hydroxide

Activity : 3

Sunlight is necessary for photosynthesis

- Take the potted plant with green leaves and place it in a dark place for about three days to destrach its leaves.
- Take a thin aluminium foil and wrap it in the centre of one leaf on both the sides, in such way that the remaining part of the leaf remain uncovered and exposed to sunlight. The covered part of leaf does not receive sunlight.
- Keep this potted plant in bright sunlight for three days.
- Pluck the partially covered leaf and remove the aluminium foil.
- This leaf is to be tested for the presence of starch.
- Before testing starch, chlorophyll from the leaf is removed.
- Put the plucked leaf in a beaker containing alcohol
- Put the beaker containing alcohol and leaf, into water bath.
- Heat the water bath, alcohol in the beaker will also get heated and start boiling. The boiling alcohol will remove chlorophyll from the green leaf completely.

- Now the leaf becomes almost colorless, remove colorless leaf from alcohol.
- Put the colorless leaf in a perti-dish and with the help of dropper put a drop of iodine solution.
- Observe the change in colour of leaf.
- Part of the leaf which was covered with aluminium foil does not turn blue-black because sunlight could not reach there. Hence this part did not perform photosynthesis to make starch.
- The uncovered part of the leaf, which was exposed to sunlight turns blue-black on adding iodine solution.
- The starch is present in this part of the leaf. This means that the part of the leaf which was exposed to sunlight make starch by the process of photosynthesis. So we can conclude that sunlight is necessary for photosynthesis to make starch.

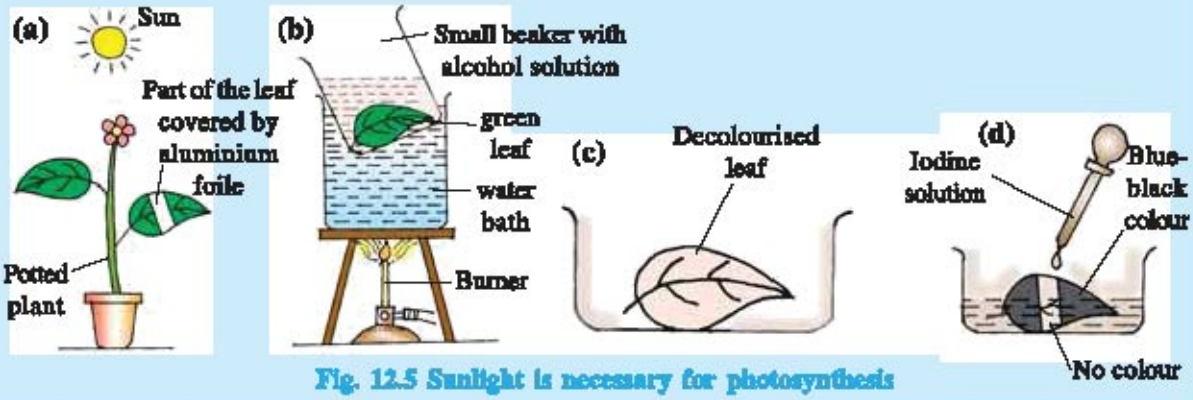


Fig. 12.5 Sunlight is necessary for photosynthesis

Now we have understood how autotrophs meet their energy requirements. We should keep in mind that plants also require other raw materials like water, nitrogen, phosphorus, iron and magnesium for building their body which are taken from soil. For the synthesis of protein, nitrogen and other compounds these are essential elements.

[B] Heterotrophic nutrition

All organisms are adapted to their environment. The heterotrophic nutrition differs depending on the availability and also how it is obtained by the organism. In heterotrophic nutrition the organisms cannot synthesize their own food by using carbon dioxide, sunlight and water. In heterotrophic nutrition energy is derived by digestion of organic substances obtained from plant and animal. In this type of nutrition, after intake, the food is digested in to simple forms and then organisms utilize it. All animals, bacteria and fungi are heterotrophic organisms.

Heterotrophic nutrition is of the following types:

[1] Saprophitic nutrition :

Here the dead and decaying organic materials are absorbed through the body wall of the organisms. The organisms depend entirely on the non-living substances. e.g. Bacteria and Fungi.

Fig. 12.6 Fungi

[2] Parasitic nutrition :

When organisms depend on another living organisms for their nutrition, then this mode of nutrition is called parasitic nutrition and the organism from which they obtain food is called 'host'. The parasite has close association with the host and obtains food from it. The host is not benefited but harmed. Several bacteria, fungi, plant like cuscuta and animal like tapeworm, ascaris etc live as parasites.

[3] Holozoic nutrition :

In this type of nutrition parts of plants or animals or whole organism are taken in as food which is then digested with the help of digestive enzymes into simple substance and then absorbed by body cells of the animals. The undigested food is thrown out of the body of animal through the process of egestion.

12.3 How do organisms obtain their nutrition ?

In different animals, food and the way how they obtained food are different. Animals cannot make their own food and hence, they obtain food either from plants or animals. All the animals can be divided into three groups on the basis of their food eating habits.

(1) Herbivores : Those animals which eat only plants are known as herbivores. eg. Goat, cow etc.

(2) Carnivores : Those animals which eat only animals are known as carnivores. eg. Lion, Tiger.

(3) Omnivores : Those animals which eat both plants and animals are known as omnivores. eg. Man, Rat

Nutrition in Amoeba :

Amoeba is unicellular animal. The mode of nutrition in Amoeba is holozoic. In Amoeba the process of obtaining food is called phagocytosis (means cell feeding). The various processes involved in nutrition are ingestion, digestion, absorption, assimilation and egestion. Amoeba ingests food particles by forming temporary finger like projections known as pseudopodia around them so the food is encaptured along with lysosomes into a bag called food vacuole.

Digestion : In Amoeba food is digested in the food vacuoles by digestive enzymes.

Absorption : The digested food found in food vacuoles is absorbed directly into cytoplasm by diffusion

Assimilation :

A part of the food absorbed in cell is used to obtain energy through respiration. The remaining part is used in the growth of Amoeba.

Egestion :

The undigested food remains in the food vacuole is thrown out of the body by rupturing cell membranes.

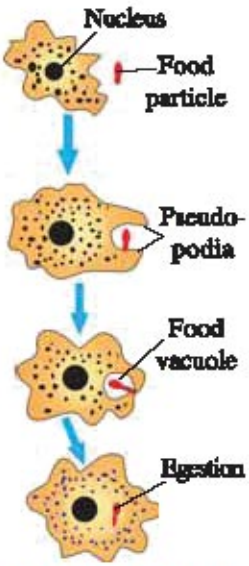


Fig. 12.7 Nutrition in Amoeba

The unicellular animal Paramoecium has thin, hair-like cilia found all over the body. Through sweeping of cilia the food particle found in water enters in the mouth of Paramoecium, this process is known as ingestion. Ingestion is followed by other steps as described in the case of Amoeba.

12.4 Human Digestive System :

The digestive system of human consists of the alimentary canal and its associated glands. The human digestive organs are mouth, oesophagus, stomach, small intestine, large intestine and associated glands like salivary gland, liver and pancreas.

The mouth is the special organ for ingestion of food. With the help of hands the food is put into mouth. The digestion of food starts as we put food in our mouth. The mouth cavity contains teeth, tongue, and salivary glands. The teeth cut the food into small pieces, chew and grind it. The salivary gland secretes the saliva in our mouth. The tongue mixes the food with saliva. Saliva is a watery liquid so it wets the food in mouth. The wetted food is swallowed easily.

The salivary gland secretes an enzyme called amylase, which digests the starch of food into maltose. Thus, the digestion of starch begins from mouth. As the food remains in the mouth for a short time, the digestion of food is incomplete in mouth. The partly digested food in the mouth goes down to oesophagus. Now the food is carried from oesophagus to stomach. The stomach is present on the left side of the abdomen. The food is churned in stomach for nearly three hours. The food breaks into small pieces and converts into semi-solid paste. The wall of stomach contains three tubular glands which secrete gastric juice. The gastric juice contains dilute hydrochloric acid, enzyme pepsinogen and mucus. The mucus protects the stomach wall from its own secretion of hydrochloric acid and pepsin. The hydrochloric acid makes the acidic medium in stomach. It also kills bacteria which enter the stomach with food. In acidic medium, the enzyme pepsin digests protein, present in the food, and converts into small molecules. Thus digestion of protein begins in the stomach. The partly digested food then goes from the stomach into small intestine. The exit of food from stomach is regulated by a sphincter muscle. The small intestine is the largest part of the alimentary canal and in adult person it is about 6.5 meter long. The length of the small intestine differs in various animals depending on the type of food they eat. Herbivorous animals, eating grass, need a longer small intestine to allow the cellulose, present in grass, to be digested completely. The meat is easy to digest, so the carnivorous animals have shorter small intestine.

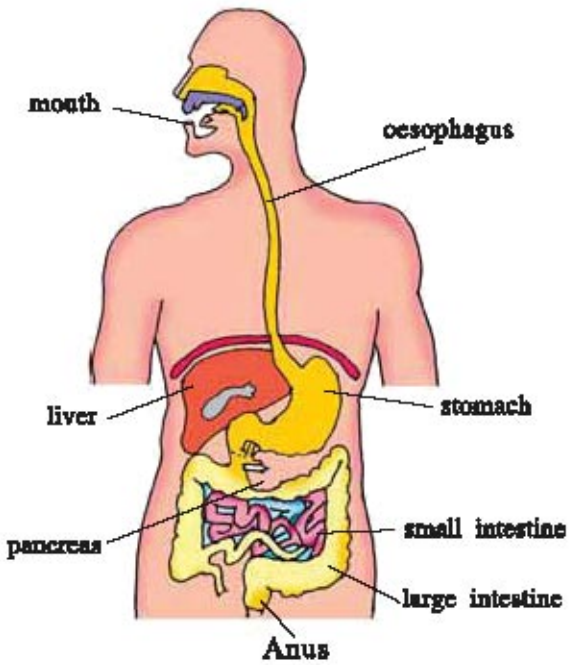


Fig. 12.8 The human digestive systems

The small intestine in man is the site of complete digestion of carbohydrates, proteins and fats. The small intestine receives the secretion from liver and pancreas. The liver secrets bile, which is a greenish yellow liquid and normally stored in the gall bladder. The bile is alkaline in nature and contains salts. It makes the acidic food coming

from the stomach alkaline, so that pancreatic enzymes can act on it. The bile salts break the fats present in the food into small globules, making it easy for the enzyme to act and digest them. The pancreas secretes pancreatic juice which contains enzyme like amylase, trypsin and lipase. The enzyme amylase digests starch, the trypsin digests proteins and lipase digests fats.

The glands of the wall of small intestine secrete intestinal juice. The intestinal juice contains various enzymes which complete the digestion of carbohydrates into glucose, proteins into amino acids and fats into fatty acids and glycerol.

After complete digestion, the small intestine becomes the main site for the absorption of digested food. The inner wall or the small intestine has millions of small, finger-like projections called villi. The presence of villi increases the surface of small intestine. This helps in the rapid absorption of digested food. The absorbed digested food passes through the wall of the small intestines, goes into our blood.

The blood carries digested food to all the parts of body where it is assimilated as part of the cells. This assimilated food is used by all the cells, where it is utilized for energy, growth and repair of the body. The undigested food passes from small intestine to large intestine, where most of water from the undigested food is absorbed. Now the undigested food becomes almost solid, and is removed from the body via anus. The exit of this waste material (faeces or stool) is regulated by the muscles of anus.

12.5 Respiration

Cells in order to perform various functions require energy. This energy is derived by the oxidation of food. The process of releasing energy from food is called respiration. The process of respiration involves intake of oxygenated air into the cell (inspiration), using it for releasing energy by burning of food, and then removal of the carbon dioxide and water from the body. During the process of respiration energy is released inside the cells. So it is known as cellular respiration. Respiration is essential for life, because it releases energy to carry out different life processes.

Types of respiration :

Respiration is of two types, aerobic and anaerobic.

Aerobic respiration :

The respiration which takes place in the presence of oxygen is called aerobic respiration. Aerobic respiration takes place in the cell, so it is also called cellular respiration. During this food (Glucose) is broken down into carbon dioxide and water in the presence of oxygen. The energy released in the process is stored in ATP.

The overall equation can be represented as follows :

$$\text{Glucose} \xrightarrow[\text{in cytoplasm}]{\text{Glycolysis}} 2\ \text{Pyruvic acid} \xrightarrow[\text{(in mitochondria)}]{\text{Oxygen(Kreb's cycle)}} 6CO_2 + 6H_2O + 38\ \text{ATP Energy}$$

Anaerobic respiration :

The respiration which takes place without oxygen is called anerobic respiration. It is seen in microorganisms like bacteria, yeast, fungi, end parasites and muscle cells. In anaerobic respiration, the microorganisms break down glucose into ethanol and carbon dioxide and release energy. CO_2

and ethanol are formed as end products in plants, while lactic acid is an end product in muscles of animals. The equations are as follows :

$$\text{Glucose} \xrightarrow[\text{in cytoplasm}]{\text{Glycolysis}} 2 \text{ Pyruvic acid} \xrightarrow[\text{Yeast}]{\text{In absence of oxygen}} 2 \text{ Ethanol} + 2CO_2 + 2ATP$$

$$\text{Glucose} \xrightarrow[\text{in cytoplasm}]{\text{Glycolysis}} 2 \text{ Pyruvic acid} \xrightarrow[\text{In muscles of animals}]{\text{In absence of Oxygen}} 2 \text{ Lactic acid} + 2 \text{ ATP}$$

Difference between aerobic and anaerobic respiration :

Aerobic respiration	Anaerobic respiration
(1) It takes place in presence of oxygen.	(1) It takes place in absence of oxygen.
(2) End products are CO_2 and water	(2) End products are ethanol or lactic acid.
(3) It takes place in cytoplasm and mitochondria	(3) It takes place only in cytoplasm.
(4) Aerobic respiration produces a considerable amount of energy.	(4) Much less energy is produced.

Respiration in plants :

Plants also need energy like animal. The plants get this energy by the process of respiration. Plants also use O_2 of air for respiration and release CO_2. The respiration in plants differs from that of animals by the following ways:

(1) All parts of a plant (like root, stem and leaf) perform respiration independently.

(2) There is a little transport of gases from one part to another in plant.

(3) Respiration in plants occurs at much slower rate than in animal.

Exchange of gases in root and stem :

The roots of a plant take oxygen for respiration from the air present in between the soil particles by the process of diffusion. The extensions of the epidermal cells of a root are known as root hair. These root hairs are in contact with air in the soil hence, oxygen diffuses into root hairs and reaches all the cells of the root for respiration. The CO_2 gas produced in the cells of the root during respiration moves out through root hairs by the process of diffusion.

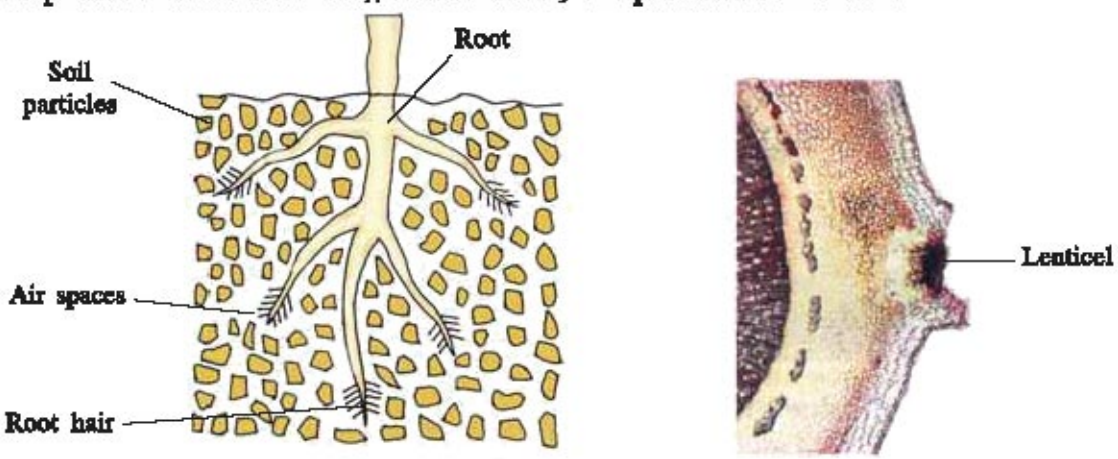


Fig. 12.9 [A] Absorption of Oxygen through root [B] Lenticel

The stems of herbs have stomata, so the exchange of gases takes place through stomata. The oxygen from air diffuses into stem through stomata and reaches all the cells of stem for respiration. The CO_2 gas produced during respiration diffuses out into air through stomata. The hard and woody stems of big plants do not have stomata. In woody stems, the bark, has lenticels for respiratory gaseous exchange. The leaves of a plant have small pores called stomata. The exchange of respiratory gases by the process of diffusion takes place through stomata. In leaves during day time when photosynthesis occurs O_2 diffuses out and CO_2 diffuses in, but at night time no photosynthesis occurs so O_2 diffuses in and CO_2 diffuses out.

Fig. 12.10 Stomata

Respiration in animals :

Various animals have different modes of respiration. In unicellular animals (eg. Amoeba) respiration takes place in cell membrane by diffusion of gases. In earthworm the respiratory organ is skin. In insects tracheae are the respiratory organs. The aquatic animals like fish, prawns, crabs and sepia have gills as respiratory organs which obtain oxygen dissolved in water. In frog, lizard, bird and human beings the lungs are the respiratory organs.

Respiration in human being :

Human respiratory system consists of nostril, nasal passage, pharynx, laropharynx, trachea, bronchi, lungs and diaphragm. Nostrils open into nasal cavities. The air for respiration is drawn into our body through nostril. This air then goes into nasal cavity. The nasal cavity is lined by fine hairs and mucus. The dust particles and microbes in the air get trapped in mucus of the nasal cavity. Nasal cavity ends in internal nostril through which air passes to pharynx. The pharynx leads to trachea, through a slit called glottis. Glottis is protected by a cartilaginous flap like epiglottis. While swallowing food, glottis is covered by the epiglottis so food cannot enter the trachea. Trachea does not collapse even when there is no air because it is supported by 'C' shaped cartilaginous ring. At the upper end trachea has a voice box known as larynx. Trachea runs down the neck and divides into two bronchi which lead into the lungs. Each bronchus divides in the lungs and form many smaller bronchioles. The smallest bronchioles terminate into alveoli. The wall of the alveoli is thin and covered by blood capillaries. In alveoli the gaseous exchange takes places.

Mechanism of breathing :

When the diaphragm pulls down and rib muscles contract, the volume inside the thoracic cavity increases and air pressure inside the chest cavity decreases hence, air from outside (being at higher pressure) rushes into the lungs. So the alveoli get filled with oxygen rich air and exchange of gases takes place. When the diaphragm moves up (relaxes) the volume inside the thoracic cavity decreases and thus pressure increases so air containing CO_2 is pushed out of the lung into atmosphere through nostril.

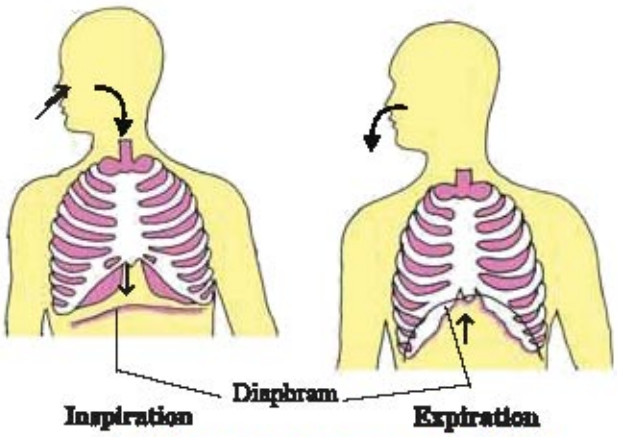


Fig. 12.11 Mechanism of Breathing

What have you learnt ?

- Various types of movements can be taken as an indication of life.
- The processes like nutrition and respiration are required for the maintenance of life.
- In autotrophic nutrition, organism make (synthesize) its own food from carbon dioxide, water and sunlight. Plants are Autotrophs.
- Animals are heterotrophs which depend on plants or other animals for their food.
- Heterotrophic nutrition is of three types, saprotrophic nutrition, parasitic nutrition and holozoic nutrition.
- All the animals can be divided into three groups on the basis of their food habit. These are herbivores, carnivores and omnivores.
- The mode of nutrition in Amoeba is holozoic. The process of obtaining food by Amoeba is called phagocytosis.
- In human beings, the food is broken down by the process of digestion and digested food is absorbed by the small intestine and is sent to all the cells in the body.
- The main purpose of respiration is the release of energy from the oxidation of organic compound like glucose.
- The energy produced during respiration is stored in the form of ATP molecules in the cell of the body.
- Respiration are of two types – aerobic respiration and anaerobic respiration.
- Plants get oxygen by diffusion, diffusion occurs in roots, stems and leaves of plants.
- Various animals have different types of respirations.
- In unicellular animals respiration takes place in cell membrane.
- In insects trachea is a respiratory organ. In prawn, crabs, sepia and fishes, gill is a respiratory organ. Frog, lizard, bird and human beings respire through lungs.

EXERCISE

1. Select the proper choice from the given multiple choices :

(1) Which of the following types has the longest small intestine ?

(a) Carnivores (b) Omnivores (c) Herbivores (d) Autotroph

(2) The process of obtaining food by Amoeba is known as .....

(a) Dialysis (b) Cytokinesis (c) Phagocytosis (d) Amoebiosis

(3) Which organism possesses parasitic mode of nutrition ?

(a) Penicillium (b) Plasmodium (c) Paramoecium (d) Euglena

(4) Which one of the following organisms has a saprophytic mode of nutrition.

(a) Mushroom (b) Malarial parasite (c) Leech (d) Lice

(5) The length of small intestine in an adult human being is about :

(a) 4.5 m (b) 1.5 m (c) 3.5 m (d) 6.5 m

(6) Where the process of digestion of food starts in human being ?

(a) Stomach (b) Food canal (c) Mouth (d) Small intestine

(7) In which organ the process of digestion in human is completed ?

(a) oesophagus (b) small intestine (c) stomach (d) large intestine

(8) By which of the following bile is secreted in human digestive system ?

(a) Pancreas (b) Liver (c) Kidney (d) Stomach

(9) The autotrophic mode of nutrition requires .....

(a) Carbon dioxide and water (b) Chlorophyll

(c) Sunlight (d) All of the above

(10) In human digestive system, the enzymes pepsin and trypsin are secreted respectively by which organs ?

(a) Pancreas and liver (b) Stomach and salivary glands

(c) Pancreas and gall bladder (d) Stomach and pancreas

(11) Which one of the following organisms can live without oxygen of air.

(a) Amoeba (b) Sheep (c) Yeast (d) Leech

(12) During respiration, the exchange of gases takes place in:

(a) Bronchi (b) Alveoli (c) Bronchioles (d) Trachea

(13) In which of the following organisms, the gaseous exchange during respiration does not take place through cell membrane or skin.

(a) Electric ray (b) Leech (c) Earthworm (d) Amoeba

2. Answer the following questions in brief :

(1) Which inorganic sustances are used as food by autotrophic organisms ?

(2) What is the mode of nutrition in fungi ?

(3) Name one organism each having saprophytic, parasitic and holozoic modes of nutrition.

(4) Name the process by which plants make food.

(5) In addition to carbon dioxide and water, state two other conditions necessary for the process of photosynthesis to take place.

(6) Name the pigment which can absorb solar energy.

(7) Where is chlorophyll mainly present in a plant?

(8) Which structure of the food vacuole in Amoeba to break down the food ?

(9) From which part of the body, undigested food is egested in Amoeba ?

(10) Name one organism which can live without oxygen.

(11) In which type of respiration more energy is released?

(12) Which part of root is involved in the exchange of respiratory gases ?

(13) Name the respiratory organ of fish.

3. Write answers of the following questions :

(1) (a) What is autotrophic nutrition ? Give one example of autotrophs.

(b) What are the conditions necessary for autotrophic nutrition ?

(2) (a) What is heterotrophic nutrition ? Give one example of heterotroph.

(b) What is the difference between autotrophic nutrition and heterotrophic nutrition ?

(3) (a) Define nutrition. Name four important nutrients present in food.

(b) What are the various types of heterotrophic nutritions ?

(4) Define (i) saprophytic nutrition (ii) parasitic nutrition, and (iii) holozoic nutrition. Give one example of each type.

Define (i) saprophyte, and (ii) parasite. Name two saprophytes and two parasites.

(5) (a) What is the role of hydrochloric acid in our stomach?

(b) What is the function of enzymes in the human digestive system?

(6) Describe the process of respiration in the following parts of a plant:

(a) Root (b) Stem (c) Leaves

4. Answer the following questions in detail :

(1) (a) Describe the process of nutrition in Amoeba. Draw labelled diagram to show various steps of the nutrition in Amoeba.

(b) What is the mode of nutrition in Amoeba known as?

(2) Draw a labelled diagram of the human digestive system. With the help of this diagram, describe the process of digestion of food in man (human).

(3) (a) Give the main points of difference between respiration in plants and respiration in animals.

(b) Describe the exchange of gases which takes place in the leaves of a plant (i) during daytime, and (ii) at night.

(c) What type of respiration takes place (i) in yeast and (ii) in human being ?

UNIT

13

Transportation, Circulation and Excretion in Organisms

The body of multicellular organism possesses complex structure. In order to survive and maintain themselves, the body cells require oxygen, water and food. Different types of substances absorbed or synthesized in one part of the body are transported to another part of the body. This process is known as transportation. In this chapter we will study how plants and animals transport substances from one part of the body to another part.

13.1 Transportation in Plants

We have studied that plants convert solar energy into chemical energy utilizing atmospheric CO_2 and water. Other substances which are also required for the building plant bodies will be taken up separately. These substances are absorbed by the roots of the plants from the soil. If the distances between the roots and leaves are small, energy and raw materials can easily diffuse to all parts of the plant body. But if distances are large, the process of diffusion will not be sufficient to provide raw materials in leaves and energy in roots. Thus a proper transportation system is required in such situation.

As plants do not move, the energy requirement of plants is low as compared to animals which move from one place to another. In plants, energy stored in the leaves, and raw materials absorbed by the roots will be transported to the different parts of the body. Xylem moves water and other substances obtained from the soil and phloem transports products of photosynthesis from leaves to other parts of plants.

Transportation of Water : Higher plants possess xylem which is associated with the transportation of water. Water absorbed by the root from the soil is transported to stem, branches, leaves and flowers. The main structural components of the xylem responsible for the transport of water are tracheids and vessels. We have studied the structure of these components in class IX. Xylem tissue of all the organs of plants are interconnected forming a continuous system for water

conduction. As the root cells are directly in contact with soil, they take up ions. Due to this, a difference is created between the concentration of these ions between the root and the soil. Water therefore, moves into the root from the soil to eliminate this difference. This water movement creates a column of water that is steadily pushed upwards. However, in higher plants this pressure is not sufficient to move water over the heights is commonly found in plants.

Plants use another strategy to move water in the xylem upwards to the highest points of the plant body. If adequate water is available then the water which lost through the stomata is replaced by the water present in xylem vessel. In fact, evaporation of water molecules from the cells of a leaf creates a suction which pulls the water from the xylem cells of roots.

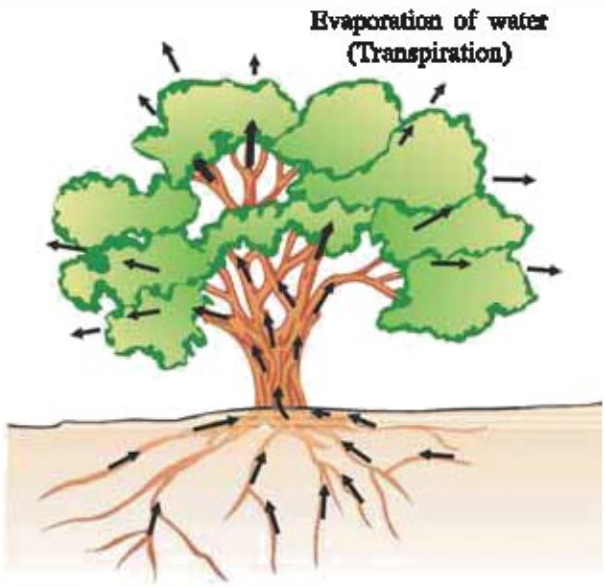


Fig. 13.1 Transport of water

The loss of water in the form of water vapor from the aerial parts of the plant is known as transpiration. Transpiration also helps in regulation of temperature. As the stomata are open during day time, the transpiration pull becomes the major driving force in the movement of water in the xylem.

Transportation of food and other substances : Carbohydrates are synthesized in the green leaves by the process of photosynthesis. From the green leaves, these photosynthetic products are transported to the various parts of the plant body. Transportation of photosynthetic products is known as translocation and it is performed by sieve tubes and sieve cells of vascular tissue known as phloem. Besides the carbohydrates, the phloem transports amino acids, several plant hormones which are synthesized at the shoot and root tips and other substances. The translocation takes place in both, upward and downward directions. Translocation of substances requires energy which is obtained from ATP. When the material like sucrose is transferred into phloem tissue, the osmotic pressure of tissue increases leading to entry of water into it. This pressure moves the material in the phloem to tissue which have less pressure. This allows the phloem to move material according to the need of plant.

13.2 Transportation in Human Beings

The system which is concerned with the transportation of various substances in animals is called circulatory system. In human being, the transport of nutrients, oxygen, carbon dioxide, hormones, enzymes and excretory substances take place through blood and lymph. As we have studied in class IX that blood is a living red colored liquid connective tissue. The liquid medium of blood is known as plasma in which blood cells are suspended. We will study the various components of circulatory system of human being.

Heart : The human heart is conical in shape and is of the size of a closed fist. It is located in the small space between two lungs and slightly towards the left side. As both carbon dioxide and oxygen are transported by blood, the heart is four chambered in order to prevent the mixing of oxygen rich blood with the blood containing carbon dioxide. The upper two chambers are called atria (singular – atrium). Of these one is left atrium and the other is right atrium. The two lower chambers are known as ventricles, of these one is left ventricle and the other is right ventricle. The walls of atria are thin while the walls of ventricles are thick. All the four chambers are separated from each other by partitions called septa. For the flow of blood from the left atrium to the left ventricle, there is a bicuspid valve. Similarly there is a tricuspid valve between right atrium and right ventricle. These valves prevent backward flow of the blood from ventricles to atria.

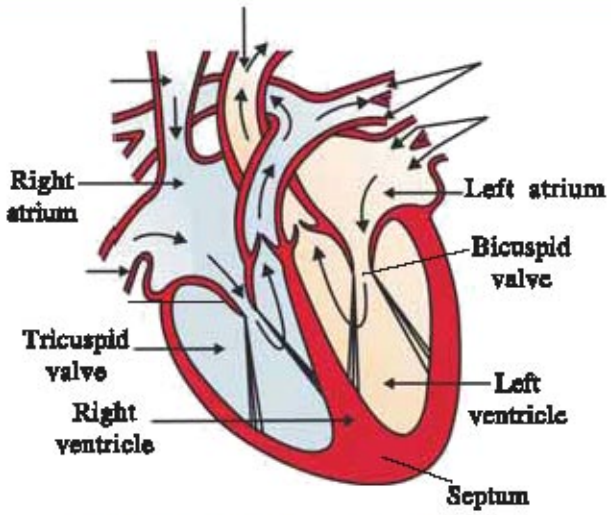


Fig. 13.2 Internal structure of heart

Entry of oxygen in the blood through lungs : Deoxygenated blood from various organs of the body is received by the right atrium through the superior and inferior vena cava. At the same time left atrium receives oxygenated blood from the lung through the pulmonary veins. Now both the atria contract and the deoxygenated blood from right atrium is poured into right ventricle and oxygenated blood from left atrium is poured into left ventricle. Now both the ventricles contract. Due to contraction of right ventricle, the blood enters into lungs through arteries. In lungs CO_2 is released from blood and O_2 diffuses into it. While due to contraction of left ventricle, oxygenated blood is distributed to all the parts of the body through the aorta.

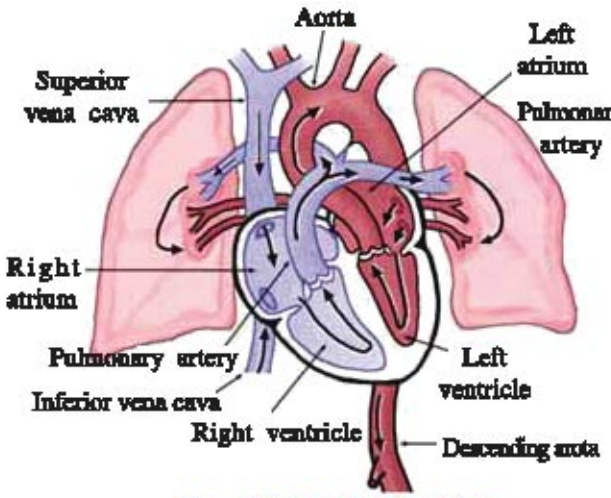


Fig. 13.3 Blood circulation

The separation of both types of the blood in the heart allows a highly efficient supply of oxygen to the body. This is useful in the animals which have high energy need, such as birds and mammals, which constantly use energy to maintain their body temperature.

Blood vessels : Blood circulates throughout the body along definite routes through blood vessels. Arteries and veins are such blood vessels. Arteries carry blood away from heart to different organs. Veins carry blood away from different organs towards heart. Since the blood is pumped in to the arteries by the heart, it is under high pressure and therefore, arteries have thick elastic walls. Veins collect the blood from different parts of the body and bring it back to heart. In the veins, blood is not under pressure and hence, wall of vein is thin. In order to prevent backward flow of blood valves are present in veins.

On reaching to the organs or tissues, the artery divides into many smaller vessels to bring the blood in contact with all the individual cells. These smaller vessels have single cell thick walls and are known as capillaries. Exchange of materials between blood and surrounding takes place through capillaries. Capillaries then join together to form veins.

Lymphatic system : Lymphatic system consists of lymph, lymph vessels, lymphatic capillaries and lymphatic nodes. Lymph is another type of fluid which is also involved in transportation. Some amount of plasma, proteins and blood cells, escape into the intercellular spaces through the pores present in the wall of capillaries, form lymph. Lymph is colorless and contains less proteins as compared to that in the blood.

Lymph drains into lymphatic capillaries form intercellular spaces. Lymphatic capillaries join to form lymph vessels that finally open into large veins. Lymphatic system performs following three important functions :

1. Collect intercellular fluid through the medium of lymph vessels and returns it to blood circulation.
2. In the villi of small intestine, lymph vessels absorb lipids and conduct them to blood circulation
3. Protects against diseases.

13.3 Excretion in Plants

Like animals, plant do not possess any excretory organs or system. In plants O_2 may be considered as waste product generated during photosynthesis and released back to the atmosphere directly. They remove excess water by the process of transpiration. Sometimes they store excretory waste in the leaves that fall off. Many plant waste products are stored in cellular vacuoles. Other waste products are stored as resins and gums.

13.4 Excretion in Human Beings

For sustaining life, body cells perform biochemical processes. During these processes useful as well as harmful toxic substances are produced. Accumulation of toxic substances in the body may harm body and hence, there will be a need to remove these substances from time to time. The harmful substances produced during biochemical reactions are known as excretory substances and a biological process involved in removal of these excretory substances in liquid form is known as excretion. Unicellular organisms remove the excretory substances by simple diffusion from the body surface into the surrounding water. This process is complex in the multicellular organisms and hence, they use special organs to perform the same function.

Excretory system of human being : Excretory system of human being includes a pair of reddish brown bean shaped kidneys located in the abdomen on the dorsal side, a pair of ureters, one from each kidney, a urinary bladder and a muscular tube called urethra. Urethra opens out by a small opening known as urinary opening. Kidney is divided into cortex and medulla. These regions consist of the excretory units called nephrons.

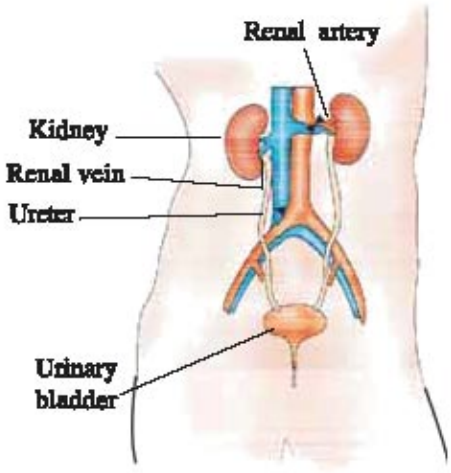


Fig. 13.4 Excretion in Human Beings

Structure of nephron : Each kidney has very minute tubular and convoluted structures known as uriniferous tubules. Nephrons in each kidney has ten lacs such tubules. Each nephron has a double walled cup shaped structure called Bowman's Capsule at its upper end. The Bowman's Capsule possesses a mass of capillaries called glomerulus. The short tubular region after the Bowman's Capsule is called neck. After this the tubule is narrow and coiled. It consists of a proximal convoluted tubule, a Henle's loop and a distal convoluted tubule. The post end of nephron is called collecting tubule. Collecting tubule opens in the renal pelvis, which opens into the ureter.

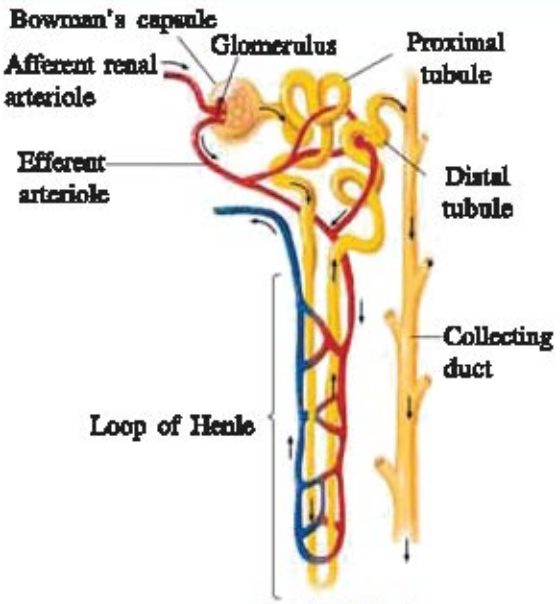


Fig. 13.5 Nephron

Process of urine formation

The waste material along with blood is brought to kidneys by the renal arteries. As the blood is under pressure in the arteries, it is filtered out from the blood capillaries into Bowman's capsule. This process is known as ultrafiltration. This filtrate passes through the lumen of tubular parts of nephron. During this useful substances like water, amino acids, minerals ions etc. are reabsorbed by blood capillaries surrounding the nephron. The remaining fluid contains excretory substances and is called urine. From the ureter urine passes into urinary bladder where it is stored. When the bladder is filled with the urine, it contracts and urine passes out of the body.

What have you learnt ?

Different types of substances absorbed or synthesized in one part of the body are transported to another part of the body. This process is known as transportation. In plants, vascular tissues like xylem moves water and other substances obtained from the soil and phloem transports product of photosynthesis from leaves to other parts of plant.

In higher plants, evaporation of water molecules from the cells of leaves creates a suction which pulls the water from the xylem cells of roots. The loss of water in the form of water vapor from the aerial parts of the plant is known as transpiration. The system which is concerned with the transportation of various substances in animals is called circulatory system. Heart, blood, lymph and vessels are the components of blood circulatory system. Arteries and veins are the blood vessels. Arteries transport blood from heart to various parts of the body while veins collect the blood from different parts of the body and supply to heart. Lymphatic system consists of lymph, lymph vessels, lymphatic capillaries and lymphatic nodes.

Like animals, plant do not possess any excretory organs or system. But animals possess various structures associated with the process of excretion. In unicellular organisms, the excretory substances are diffused out in the surrounding water. But multicellular organisms have complex mechanism of excretion. They have excretory organs and system. Excretory system of human being includes a pair of reddish brown bean shaped kidneys, located in the abdomen on the dorsal side, a pair of ureters, one from each kidney, a urinary bladder and a muscular tube called urethra. The formation of urine involves the processes like ultrafiltration and reabsorption.

EXERCISE

1. Select the proper choice from the given multiple choices :

(1) Which of the following structures is responsible for transportation of water in higher plants :

(A) Sieve tube (B) Sieve cell (C) Vessel (D) Companion cell

(2) The kidneys in human being are a part of the system for :

(A) Respiration (B) Transportation (C) Excretion (D) Nutrition

(3) How many chambers are present in human heart ?

(A) 2 (B) 3 (C) 4 (D) 6

(4) Where is tricuspid valve found in human heart ?

(A) Between two atria (B) Between two ventricles

(C) Between right atrium and right ventricle (D) Between left atrium and left ventricle.

(5) What is the excretory unit in human being ?

(A) Bowman's capsule (B) Nephron

(C) Urinary bladder (D) Kidney

(6) In which part of the body blood gets purified (Becomes oxygenated) ?

(A) Heart (B) Lungs (C) Atrium (D) Ventricle

(7) In plants, food and other substances are transported through ..... .

(A) Tracheids (B) Vessels (C) Sieve tubes (D) Companion cell

(8) During which process blood is filtered out in Bowman's capsule ?

(A) Reabsorption (B) Secretion (C) Ultrafiltration (D) None of them

2. Answer the following questions in brief :

(1) Mention the color of blood and lymph.

(2) Define Transpiration.

(3) What is transported through phloem?

(4) Define Ultrafiltration.

(5) Name the organs of excretory system in human being.

(6) Name the components of circulatory system of human being.

(7) Differentiate between arteries and veins.

(8) Why the wall of artery is thick and elastic ?

(9) What is the advantage of four chambered heart ?

(10) Define Excretion.

3. Answer the following questions pointwise :

(1) Explain the excretory system of human being.

(2) Explain the structure of human heart.

(3) Explain the process of urine formation.

(4) Describe the structure of nephron.

(5) Write a note on lymphatic system.

UNIT

14

CONTROL AND CO-ORDINATION IN ORGANISMS

Introduction

Living organisms are stimulated due to less or more changes in their environment. Due to stimulation against these changes organisms give response. As an example, if there is a change in heat, cold or noise, living organism gives response against it. This response to stimulus is generally in the form of movements of their body parts. e.g. If a man touches a very hot vessel he quickly pulls his hand away. Thus reaction to stimuli is a characteristic feature of the living organisms. Plants and animals respond to various stimuli surrounding them. But the method of reacting to stimuli is different in plants and animals. For example plants bends towards the light, but animal do not bends toward light. Thus animal can react to stimuli in different ways, while plant can react to stimuli in a limited way. Since they do not have a nervous system like the animals. From the above discussion we conclude that functioning of the various organs together in a systematic manner to produce a proper response to the stimulus is termed as co-ordination. Now we will study the control and co-ordination. First, start with plants and then with animals.

14.1 Control and Co-ordination in Plant

Like animals, plants do not have nervous system and sense organs like nose, ears and eyes. The plants can sense gravity, light, water, chemicals and touch by the action of hormones present in them. The stimuli like gravity, light, water, chemicals and touch are known as environmental changes. By using hormones the plant co-ordinates their behaviour against environmental changes. The hormones in plants do not act in the same way as in the animals. The response of plants to different stimuli like gravity, light, water, chemicals and touch is due to the effects of hormones. The plants cannot react to respond quickly as compared to animals because they are devoid of nervous system. Animals use both nervous system and hormones for the co-ordination of their activities, while plants use only hormones for co-ordination because they have no nervous system. Thus the response of plant to a stimulus cannot be quick, but it takes a considerable time to know

the effect of a stimulus on plant. The plant hormones are called as phytohormones. The auxins, gibberellins and cytokinins are phytohormones which promote growth of plants, while abscisic acid inhibits the growth.

14.2 Response to Stimulus

The sensitive plant moves in response to touch. But in this sensitive plant there is no nervous system and muscle tissue. Then how does plant detect the touch and how do the leaves move to response ? Plants respond to light, touch, water, gravitation force and other stimuli only by means of chemicals i.e. hormones. The animals can react to stimuli in different ways because they have nervous system and endocrine system. In the following section we will study the types of stimuli in plants.

14.3 Types of Stimulus

The plant movements made in response to external stimuli fall into two main categories (i) tropism and (ii) nastism.

(i) Tropism (Tropic movements) : If the movement of curvature in a plant organ is induced by an external and directional stimuli, then it is called tropism. If the growth of plant is towards the stimulus, it is called positive tropism and if it is away from the stimulus then it is called negative tropism. There are five common stimuli such as light, gravity, chemical, water and touch. The movement of the plant in response to light is called phototropism. Stem shows positive phototropism while root shows negative phototropism. The movement of a plant to gravity is called geotropism. Stem shows negative geotropism while root shows positive geotropism. The movement of a plant part in response to a chemical stimulus is called chemotropism eg. The growth of pollen tube towards ovule during the process of fertilization. The movement of a plant part in response to water is known as hydrotropism eg. The root of plant goes towards water. Movement in response to touch is called thigmotropism eg. tendrils of a plant.

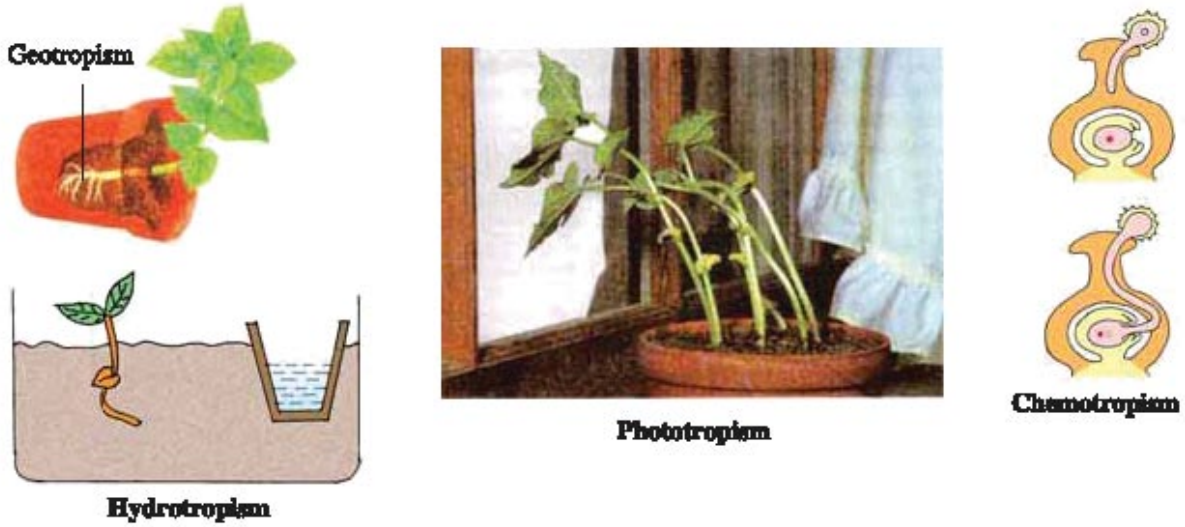


Figure : 14.1 Types of stimulus of plant

ii) Nastism (Nesctic movement) : This kind of movement depends on the presence and intensity of external stimulus. In nastic movement the direction of response is not determined by the direction of stimulus.

Thigmonesty :

The thigmonesty is the nastic movement of a plant part in response to touch, eg. The nastic movement in plants caused by touch is seen in Mimosa plant.

When we touch the leaves of Mimosa with our fingers, the leaves of plant fold up.

In this plant the 'touch' with our fingers is the stimulus and leaves respond by 'folding up'. The sensitive parts which leaves possess is a soft, cushion-like swollen structure known as 'pulvinus'. The cells of pulvini contain a lot of water. When the leaflets having pulvini at their base are touched with a finger, then an electrical impulse is generated which travels through cells. These impulses act on plant hormones which makes the water to migrate from the cells of one half of a pulvinus to the intercellular spaces in the other half of pulvinus. This loss of water from half of pulvinus causes the pulvinus to lose its firmness and leaf folds. Similarly all pulvinus of leaflets lose firmness and collapse and fold up. Like animals in plants there is no specialized nerve tissue for conduction of information. In animals some cells change their shape in order for movement to happen. The plant cells change the shape by changing the amount of water in them.

Fig. 14.2 Thigmonesty

Photonesty : – Movement of plant part in response to light. e.g. The flower of lotus and sunflower open in morning.

Thermonesty : – Movement in response to temperature. e.g. Flower of Crocus and Tulip at higher temperature.

14.4 Control and Co-ordination in Humans

There are two following systems for the co-ordination of different activities in humans :

(1) Nervous system, (2) Endocrine system

The nervous system and endocrine system of human beings work together to control and co-ordinate all our activities such as physical, emotional behaviour and thinking processes. The function of nervous system is to control and co-ordinate all the parts of our body. The nervous system co-ordinates muscles so person can do works like writing, reading and dancing. The nervous system also c-oordinates certain involuntary functions like heart beat and breathing. The human nervous system collects all the information from surroundings and interprets them, and then responds accordingly. The nervous system also passes information from one system to other system. The nerve cells are the units of nervous system. Hence nerve cell is the structural and functional unit of nervous system. The nerve cell has three components :

(i) Cell body, (ii) Dendrites and (iii) Axon

Cell body contains cytoplasm and nucleus. A number of short or long fibers are stretching out from the cell body and they are known as nerve fibers. The short fibers on the cell body are known as dendrites, while the longe fiber on the cell body is known as axon. Around the axon a protective and an insulating sheath of myelin is found, which is made up of fat and protein. The dendrites and axon both arise from the cell body of nerve cell. The messages acquired at the dendrite of nerve cell, sets off a chemical reaction that creates an electrical impulse known as nerve impulse. The dendrites pick up messages from receptors. They pass the messages to cell body and then to axon. The axon passes the message to another nerve cell through the junction. A very small gap is present between the two nerve cells. This gap is known as synapse. Thus nervous tissue is made up of organized network of nerve cells, and is very specialized for conducting messages through electrical impulses from one part of the body to another.

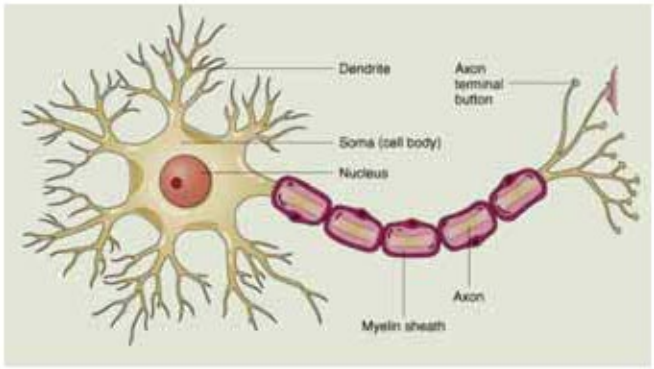


Fig. 14.3 Nerve cell

The nerve cell acquires message, which travels as an electrical impulse, This electrical when impulse is converted into a chemical signal for onward transmission.

Human brain :

The central nervous system (CNS) consists of the brain and the spinal cord. They receive messages from all parts of the body and integrate them. It is protected by the cranium and three membranes known as menings. The brain of an adult weigh about 1350 gms and it is mainly made up of nervous tissues. In the brain, grey matter is present on the outer surface while the white matter forms the inner part. The space between meanings is filled with cerebrospinal fluid which protects the brain from mechanical shock and acts as a cushion. The brain is broadly divided into three regions – Forebrain, midbrain and hind brain.

- Human brain
  - Fore-brain
    - Cerebrum (with olfactory lobe)
    - Thalamus
    - Hypothalamus
  - Mid-brain
    - Corpora quadrigemina
    - Cerebellum
  - Hind-brain
    - Pons

Cerebrum is largest and most complex part of brain. It consists of two cerebral hemispheres, joined together by a band called corpus callosum. Each cerebral hemisphere is divided into 4 lobes. The occipital lobe has specific activities of visual reception, while temporal lobe controls specific

activities of auditory reception. The parietal lobe has perception of general sensation like smell, touch and temperature. Frontal lobe controls specific muscular activities, both involuntary and voluntary, which include thought, speech and memory. The outer region of cerebral hemispheres is densely packed with nerve cells called cerebral cortex. Cerebral cortex is highly convoluted which increases its surface area. It does various kinds of activities. The cerebrum has sensory areas where information (impulse) is received from sense organs. Similarly there is a motor from where impulses are sent to muscles or effector organs. Thalamus is present at the centre of forebrain. All sensory informations that reache the cerebral hemispheres pass through thalamus and direct sensory information to the cerebral cortex. Below thalamus lies hypothalamus which controls and regulates blood pressure, hunger, body temperature and thirst. It connects the fore-brain and the hind brain and controls functioning of eyes and ears. Hind-brain consists of three regions. Cerebellum which lies on dorsal side of pons. Pons and medulla oblongata on ventral side.

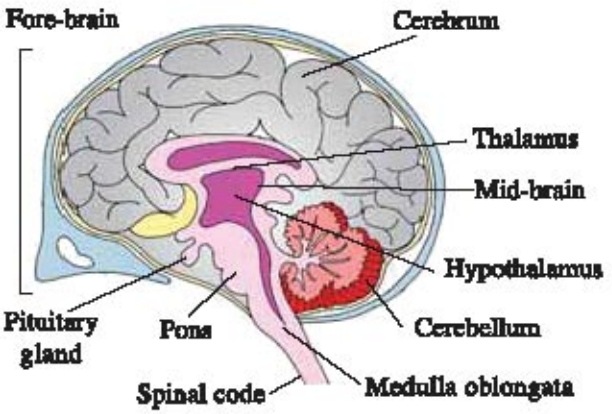


Fig 14.4 Human Brain

The pons regulates process of respiration. The cerebellum maintains balance of body and posture. The cerebellum co-ordinates body movements like dancing, walking and riding bicycle. The medulla oblongata controls various involuntary activities like breathing, heartbeats, blood pressure, peristaltic movements of alimentary canal etc. Medulla oblongata controls the centre of reflexes like coughing, sneezing, swallowing, secretion of saliva and vomiting.

Spinal Cord :

Spinal Cord is a cylindrical structure which is a posterior extension of medulla oblongata. It is enclosed within the vertebral column. Spinal cord is surrounded by three membranes known as meeninges. Grey matter forms the centre of spinal cord and the white matter is present in the periphery. In the centre canal the cerebrospinal fluid is present 31 pairs of nerves arise from spinal cord. Grey matter is arranged in the "H" shape of the Grey matter contains non-medullated nerve fibres and neurons possessing short processes. White matter contains medullated nerve fibres and neurons possessing long processes. The bundles of nerve fibers run ascending and descending in tracts, and link the spinal cord with the brain. Ascending tracts conduct sensory information from spinal cord to brain while descending tracts conduct motor information from brain to spinal cord.

14.5 Reflex Action

The reflex action is the simplest form of response in nervous system. It is a rapid automatic response without thinking or any thought like pulling our hand away on pricking a pin or unknowingly touching the hot plate. Other examples of reflex action are : a knee jerk, coughing, blinking eye, yawning, movement of diaphragm and sneezing. In bright light the pupils of our eyes

get smaller. The reflex action protects the retina from damage because of too much light. Coughing is another example of reflex action which clears our wind pipe. This reflex action can be defined as an unconscious and involuntary response of the muscles or glands to a stimulus. Reflex action is an automatic process.

Fig. 14.5 Reflection actions

Reflex arc :

The nerve impulse pathway involved in a reflex action is known as reflex arc. Rapid response allowed by reflex arc. The meaning of a reflex arc can be explained by the following example. Suppose we touch a hot plate, quickly and without thinking about it, we pull our hand away. Here the heat is sensed by thermo receptor in our hand. The thermo receptor triggers an impulse in a sensory neuron, which transmits the information to spinal cord. The impulse passes it to a motor neuron. The motor neuron transmits the impulse to a muscle of hand. Now the muscle then contracts and pulls the hand away from the hot plate. The muscle of hand is effector because it responds to stimulus. This pathway along which the impulse transmits is known as reflex arc.

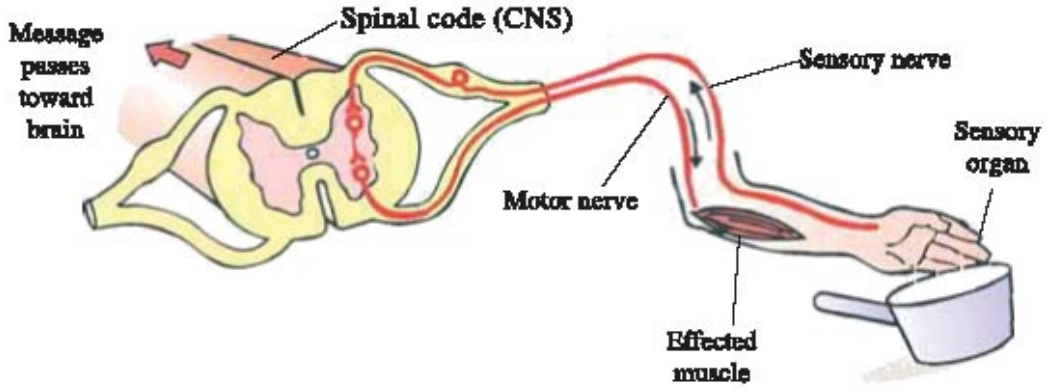


Fig. 14.6 Reflex action

14.6 The Autonomous Nervous System :

The term autonomous is derived from the term 'autos' means 'self' and 'nomos' means 'governing'. Thus 'autonomous nervous system' means 'self governing nervous system'. The system which is responsible for the control of the activities of the organs located in the body automatically even without our thinking involuntarily. This system has a specific network of nerves in the body which controls and regulates the processes like, digestion, sweating, breathing, heart beat etc. The nerves of autonomous nervous system are connected to the smooth muscles of head, heart, blood vessels, lungs, alimentary canal, kidneys, glands and skin. Autonomous nervous

system is of two types (i) sympathetic (ii) parasympathetic. By the co-ordination of these two systems, the involuntary functions of the body are controlled and regulated. The effects of sympathetic and parasympathetic nervous systems are complimentary and contradictory to each other. Sympathetic nervous system increases heart beats while parasympathetic system decreases them and brings them back to normal.

14.7 Endocrine Glands

A gland which does not have a duct and secretes its product directly into blood stream is known as endocrine gland. So endocrine glands are ductless glands. A hormone is produced in one part of the body but it acts on other part of the body. Thus hormones are a kind of chemical measengers.

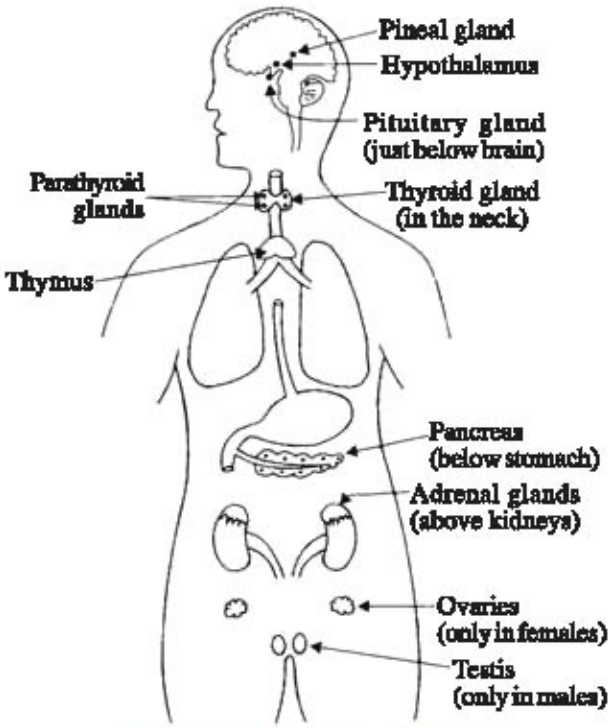


Fig 14.7 The position of endocrine glands in human

The endocrine glands in human : The human endocrine system made up of various endocrine glands, is situated in different parts of the body. The main endocrine glands in the body are hypothalamus, pituitary, thyroid, parathyroid, pancreas, adrenal, testis and ovary.

Hypothalamus is a part of fore brain present below the thalamus and above the pituitary gland. It contains many neurosecretory cells which produce releasing hormone (RH) that stimulates the anterior pituitary gland to secrete specific hormones. Releasing hormones and their effects on anterior pituitary gland are given below:

(1) TSH releasing hormone : Release Thyroid Stimulating Hormones (TSH) from pituitary gland.

(2) GH releasing hormones : Release Growth Hormones (GH) from pituitary.

(3) ACTH releasing hormones : Release Adreno Cortico Tropic Hormone (ACTH)

(4) Ganadotropic releasing hormones : Release Follicle Stimulating Hormones (FSH) and Leutenizing hormone (LH) from pituitary gland.

Two inhibitory hormones are also released from hypothalamus (1) GH inhibitor factor inhibit the release of GH. (2) Prolactin Inhibitor Factor (PIF) inhibits the release of Prolactin from pituitary.

Pituitary gland :

It is known as the master gland. It is located just below the hypothalamus. The pituitary gland is divided into three lobes: anterior lobe, intermediate lobe and posterior lobe. Anterior pituitary lobe secretes TSH, ACTH, FSH, LH, Prolectin and GH hormones.

Intermediate pituitary lobe secrets melanocyte stimulating hormone (MSH). Posterior pituitary lobe secretes two hormones vasopressin and oxytocin. Vasopressin or Anti-diuretic hormone (ADH) stimulates re-absorption of water, and controls the loss of water through urine. It increases the arterial blood pressure by acting as vasoconstrictor. Oxytocin in female causes contraction of uterine muscles during child birth and ejection of milk from mammary gland.

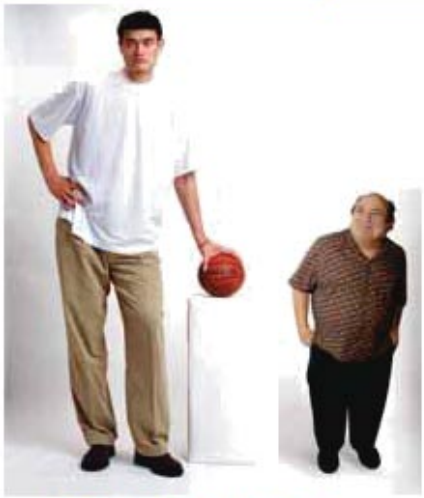


Fig. 14.8 Giantism and Dwarfism

Disorders due to GH :

Dwarfism :

Hypo or under secretion of GH from childhood leads to dwarfism.

Gigantism :

Hyper or over secretion of GH from childhood leads giantism. i.e. giant height of more than 7ft.

Acromegaly :

Too much secretion of growth hormones after adolescence causes the enlargement of certain parts like hand, feet and jaws giving appearance of body like gorilla.

Pancreas :

Fig 14.9 Goiter

The pancreas lies just below the stomach in the body. Pancreas secretes the hormone insulin, which lowers the blood sugar level. Deficiency of insulin in the body causes diabetes. Diabetes causes large amount of sugar in the blood and also in urine. The high sugar level in the blood can cause many harmful effects to a person. Diabetic persons should take less amount of sugar. Diabetes can be controlled by controlling diet, doing physical exercise, reducing body weight taking medicines and injection of insulin regularly.

Thyroid gland :

Thyroid gland is attached to the wind pipe in our body. Thyroid gland secretes thyroxine hormone, which contains iodine. Hormone thyroxine controls the rate of metabolism of carbohydrate, protein and fat. The deficiency of iodine in our diet can cause a deficiency of thyroxine. Thus deficiency of iodine in our diet results in hypothyroidism and enlargement of thyroid gland. It resultes into a disease called goitre. Iodised salt provides appropriate amount of iodine to make sufficient thyroxine by thyroid gland. Condition of hyperthyroidism of thyroid gland is known as exophthalmic goiter. (Bulging of the eyeball)

Parathyroid gland :

Parathyroid glands are four small glands which are embedded in the thyroid gland. This glands secrete a hormone known as parahormone, which regulates calcium and phosphate levels in the blood.

Adrenal gland :

Adrenal glands are two in number. They are small, conical in shape, and composed of two distinct regions: an outer cortex and an inner medulla. The adrenal cortex secretes three types of steroid hormones. Mineral ocorticoids regulate balance of water and ions like Na^+, Cl^- and K^+ in our body. Glucocorticoids stimulate metabolism of carbohydrate, proteins and fat. While sex corticoids are responsible for secondary sexual characters.

Adrenal medulla secretes adrenaline and non-adrenaline. Adrenalin hormone is called fight or flight (run away). Hence adrenal glands are also known as glands of 'emergency'.

Testis :

Testis secretes the male sex hormone testosterone. The main function of testosterone is to control the development of sex organs, secondary sexual characters like deeper voice, beard and moustache. The testes also produce sperms.

Ovary :

Ovaries produce two female sex hormones known as estrogen and progesterone. The main functions of estrogen is to control development of female sex organs. Secondary sexual characters like feminine voice, soft skin and mammary gland are under the control of estrogen. The function of progesterone is to control the changes in uterus during menstrual cycle. It also regulates the production of ova in the ovaries.

14.8 Properties of Hormone

Hormones show the following main properties :

- Each hormone is produced by a specific kind of cells.
- Hormones are not effective at their site of synthesis.
- Hormones are poured directly into blood. They are transported through blood to a specific organ and influence specific processes occurring there. This influence may be stimulatory or inhibitory. Thus, hormones are "regulator chemicals".
- Hormones are used up in producing their regulatory effect.
- Chemically hormones are peptides and steroids. Some are biogenic amines.

What have you learnt ?

- Like animals the plants do not have nervous system and sense organs.
- In our bodies control and co-ordination are the functions of the nervous system and hormones.
- Nervous tissue is made up of a network of nerve cell and is specialized for conducting information through electrical impulses to different parts of body.
- A reflex action can be defined as an unconscious and involuntary response of the body to a stimulus.
- The nerve pathway involved in a reflex action is called a reflex arc.
- Human brain is highly specialized organs. It is the highest co-ordinating centre of the body.

- External stimuli are of two types : tropism and nastism.
- Hormones produced by endocrine glands act as messengers between the nervous system and organs of our body.
- In addition to nervous systems the endocrine system also helps in co-ordinating the activities of our body.

EXERCISE

1. Select the proper choice from the given multiple choices.

1. What is called the movement of plant toward the gravity ?

   (A) hydrotropism (B) geotropism (C) chemotropism (D) phototropism

2. The plant part which exhibits negative geotropism is:

   (A) root (B) stem (C) branch (D) leaves

3. The growth of a pollen tube towards the ovule is caused by.....

   (A) phototropism (B) hydrotropism (C) gravitropism (D) chemotropism

4. Bending of the shoot of a plant in response to light is known as.....

   (A) geotropism (B) phototropism (C) thigmotropism (D) photonasty

5. The stimulus in the process of thigmotropism is:

   (A) touch (B) gravity (C) light (D) chemical

6. Which of the following helps in maintaining posture and balance of the human body?

   (A) cerebellum (B) cerebrum

   (C) medulla oblongata (D) pons

7. How many pairs of nerves arise from the spinal cord ?

   (A) 21 (B) 31 (C) 41 (D) 51

8. Cerebellum, medulla oblongata and pons are the parts of:

   (A) mid-brain (B) hind-brain (C) fore-brain (D) spinal cord

9. For the synthesis of which of the following hormone iodine is necessary ?

   (A) adrenaline (B) auxin (C) thyroxine (D) insulin

10. Which of the following is a mismatched pair?

    (A) adrenaline : pituitary gland (B) estrogen : ovary

    (C) pancreas : insulin (D) progesterone : ovary

11. The spinal cord originates from:

    (A) cerebrum (B) cerebellum

    (C) medulla oblongata (D) pons

12. Which of the following hormone prepares our body for action in emergency situations ?

(A) testosterone (B) growth hormone (C) adrenaline (D) insulin

13. Which is male sex hormone ?

(A) estrogen (B) adrenaline (C) testosterone (D) progesterone

14. Which of the following endocrine gland does not occur as a pair in the human body ?

(A) adrenal (B) pituitary (C) testis (D) ovary

2. Answer the following questions in brief :

1. Name the plant which shows thigmonesty.
2. Give the scientific terms used to represent the following:

(A) Bending of a shoot towards light.

(B) Growing of roots towards the earth.

(C) Growing of a pollen tube towards ovule.

(D) Bending of roots towards water.

(E) Winding of tendril around a support.

3. Give example of the movement of a plant part which is caused by the loss of water.
4. Name the two systems of control and co-ordination in higher animals.
5. Name the three components of a nerve cell.
6. Name the most important part of the human brain.
7. State one function each of cerebellum and pons.
8. Name one hormone secreted by the pituitary gland.
9. Where are hormones synthesised in the human body?
10. Which gland secretes the growth hormone?
11. Name the disease caused by the deficiency of insulin hormone in the body.

3. Write answers of the following questions :

1. (A) What does a root do in response to gravity ? What is this phenomenon known as?

(B) What does a stem do in response to light? What is this phenomenon known as?

2. (A) What does a stem do in response to gravity? What is this phenomenon known as?

(B) What does a root do in response to light? What is this phenomenon known as?

3. (A) What is spinal cord ? What is its main function?

(B) Give the functions of medulla oblongata.

4. (A) Name the hormones secreted by the following endocrine glands :

(i) Thyroid gland (ii) Parathyroid glands (iii) Pancreas (iv) Adrenal glands

(B) Write the functions of testosterone and estrogen hormones.

5. (A) Write the names of the regions of hind-brain. Give functions of each region.

(B) Mention the functions of cerebrum.

6. What does CNS stand for ?

4. Answer the following questions in detail :

1. (A) What is meant by 'tropisms' ? Explain with an example.
   (B) Mention types of tropisms. Define each type of tropism. Write the name of stimulus in each case.
   (C) How do tropism differ from nastism ?
2. (A) Define phototropism and give one example of it.
   (B) How does phototropism occur in a plant stem ? Explain with the help of labelled diagrams.
   (C) What is meant by positive phototropism and negative phototropism? Give one example of each type.
3. (A) Name the structural and functional unit of nervous system.
   (B) What is autonomus nervous system? What is its function?
   (C) What is voluntary nervous system? Explain the working of voluntary nervous system with an example.
4. (A) What is a reflex action ? Explain with the help of an example.
   (B) How involuntary actions and reflex actions differ from each other?
5. (A) Write the names of five endocrine glands found in the human body. Name the hormones secreted by each gland.
   (B) Name the gland which controls the secretion of hormones of pituitary gland.
   (C) How does our body respond when adrenaline is secreted in large amounts into the blood?
   (D) Name the disease which occurs in adults due to the deficiency of iodine in the diet. What is the main symptom of this disease ?

UNIT

15

REPRODUCTION IN ORGANISMS

It is fact that all living organisms grow old with time and ultimately die. Every living organism remains alive on this earth for limited period of time and then dies. So new organisms have to produce in place of those who die. This can be acheived by the process of reproduction in which new organisms are produced from the existing organisms in order to maintain the life of their species on this earth.

15.1 What is Reproduction?

In the previous chapters, we have learnt about the life processes which help animals to keep 'alive'. Every organism remains alive for a certain limited time and then dies. The production of new organisms from the existing organisms of the same species is known as reproduction. Thus reproduction is the production of new living organisms. So reproduction is one of the very important features of living organisms and it is their ability to reproduce more members of the same species. Thus reproduction is indispensable for the survival of the species. The process of reproduction makes thing safe against continuity of life.

15.2 How Organisms Create Exact Copies of Themselves?

Organisms of a species show similarity because their body designs are similar. In order to maintain similarity in body designs the blue print of the design should be similar. Reproduction is a process which makes copies of the blue prints of the design. In class-IX we learnt that the chromosomes in the nucleus of the cell contain information of protein synthesis which is stored in DNA. If the information is changed, there will be a change in protein which eventully leads to an altered body design. The creation of another copy of the cell is the basic event in the reproduction. The cells are duplicated by duplicating DNA, hence, two progeny cells are produced.

Thus two cells formed, are similar but are they absolutely identical ? This depends upon how accurately the sequence information has been copied. Although copy error is rare event, but when

happens it brings about change in the characteristic. When the changes are not compatible with the cellular system halting important function, cell cannot survive. The natural process of evolution is the outcome of slow but definite changes that have taken place over a year of evolutionary era. The next topic described how this inbuilt tendency for variation is the basis for evolution.

15.3 The Importance of Variation

The population of organisms in niches or ecosystems is also reproduced. During reproduction the consistency of DNA copying is important for the maintenance of body design feature. Thus reproduction is linked to the stability of populations of species.

The niches can change because the causes for their change are not under the control of the organisms. Such changes are temperature of the earth which can go up or down, variation in water level, or they could be metecrite hits. We will see some examples. Suppose population of reproducing organisms was suited to particular niche and if there was a drastic change in niche, the population can be wiped out. In a few individuals of this population if there were some variations present, then there would be few chances for them to survive. Thus, if there was a population of bacteria living in water with moderate temperature and because of global warming the water temperatures were to be increased, many bacteria would die, but few temperature resistant bacteria would survive and grow further. Thus variation is useful for the survival of species.

15.4 Types of Reproduction in Organisms

Types of asexual reproduction :

(A) Fission : Fission is the simplest method of asexual reproduction in unicellular organisms like protozoa and bacteria. In the process of fission, a unicellular organism divides to form two new organisms. Fission is of two types-binary fission and multiple fission. In binary fission the nucleus lengthens and divides into two parts. After that the cytoplasm divides into two parts, one part around each nucleus. This results into two daughter cells. Each one of them grows into an adult organism. e.g. *Amoeba, Paramoecium.*

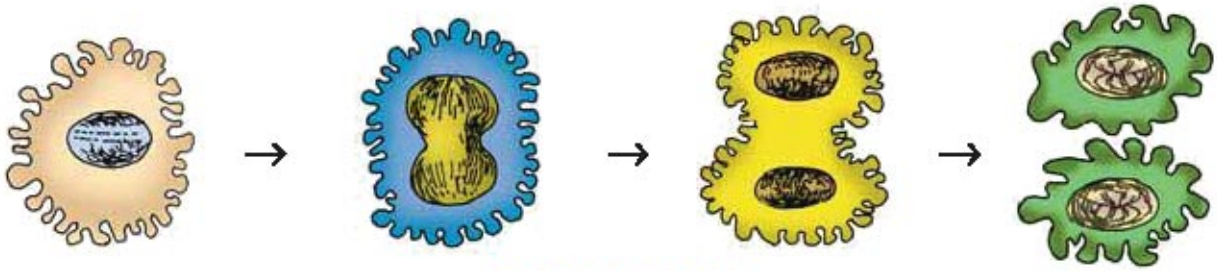


Fig. 15.1 Binary fission

In multiple fission, the parent organism divides to form many new organisms at the same time. Particularly during unfavorable conditions, a cyst is formed around the single cell organisms. Inside the cyst, the nucleus divides several times to form many smaller daughter nuclei, small amount of cytoplasm collects around each daughter nuclei and thin membranes are formed around them. Thus many daughter cells are formed from a single parent cell within cyst. When the favourable condition arrives, the cyst breaks up and many daughter cells are released, each forming a new organisms e.g. *Plasmodium, Amoeba*

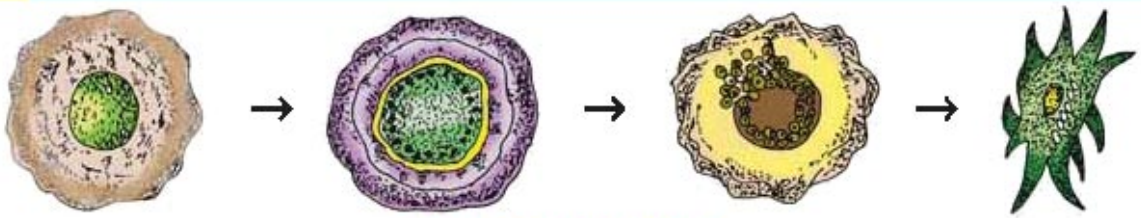


Fig. 15.2 Multiple fission

[B] Fragmentation : The breaking up of the body of a multicellular organism into two or many pieces and on maturing, each piece grows to form a complete new organism is known as fragmentation e.g. *Spirogyra*

Fig. 15.3 Fragmentation

Fig. 15.4 Regeneration

[C] Regeneration : In some plants and animals small cut parts of their body can regenerate to form a complete new organism. e.g. *Hydra* and *Planaria*

[D] Budding : In budding, a small part of the body of the parent organism grows out as a 'bud' then it detaches from parent and becomes a new organism. e.g. *Hydra* and *Planarian.*

Fig. 15.5 Budding

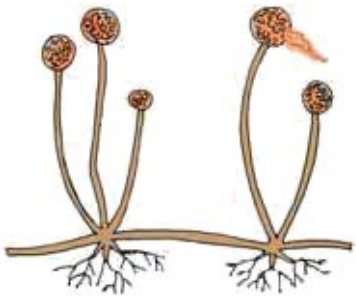
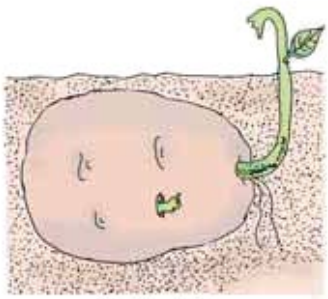


Fig. 15.6 Spore formation in mycor

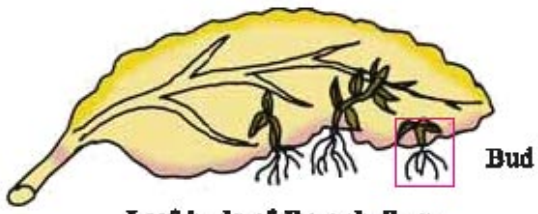
[E] Spore formation : Spores are the microscopic reproductive units of plants which are covered by a protective coat. When the protective coat bursts, the spores spread into air. These air-borne spores settle on food and under favourable condition they germinate to produce new plants, e.g. *Rhizopus, Mucor*

15.5 Vegetative Propagation

Vegetative propagation is an asexual method of reproduction, which occurs only in plants. In vegetative propagation, new plants are obtained from the plant parts like roots, stem and leaves of old plants, without taking help of any reproductive organs. Vegetative propagation involves the development and growth of dormant state of buds present in old part of the plant. When suitable moisture and temperature are provided to dormant state of bud then these buds grow to form new plants. Buds are found on the leaves of Bryophyllum. A potato tuber has a number of buds on its body, which act as organs for vegetative reproduction. When a potato tuber is planted in the ground, then buds start growing and form new plants.



Potato tuber



Leaf buds of Bryophyllum

Fig. 15.7 Vegetative propagation

15.6 Artificial Propagation in Plant :

By using artificial methods to produce many plants from a single plant is known as artificial propagation of plants. The three common methods for artificial propagation of plants are (1) Cutting, (2) Layering and (3) Grafting. A cutting of stem or shoot or leaf having some buds on it is taken and its lower part is buried in the moist soil. After few days, the cutting develops roots and grows into plant exactly similar to that of the parent plant. An advantage of this method is that we can grow many new plants from just one plant quickly, without seeds. e.g. Rose, Bougainvillea.

Fig. 15.8 Cutting

Layering : A part of stem is pulled towards the ground and covered by the soil. Once the covered part develops its own roots, it behaves independently and is detached from the parent plant and develops into matured plant e.g. Lemon, Bougainvillea, Crysenthemum

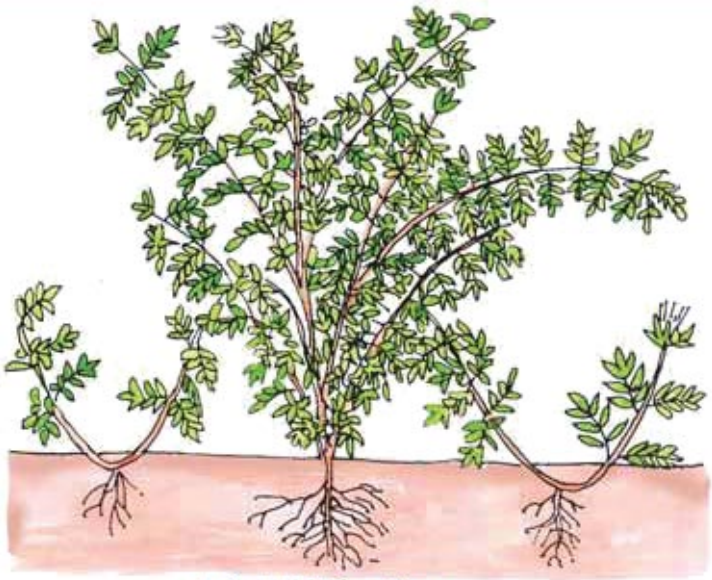


Fig. 15.9 Layering

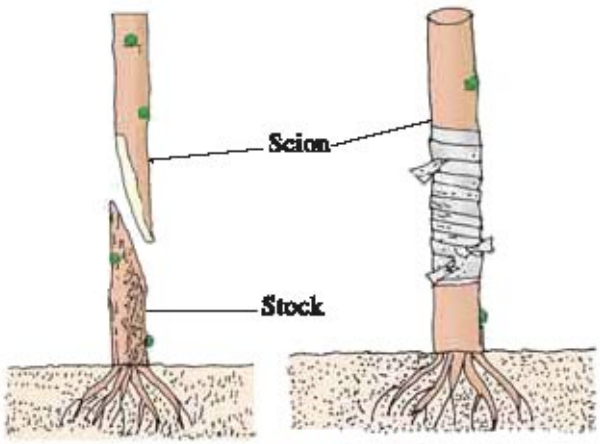


Fig. 15.10 Grafting

Grafting : In this method the cut stems of two different plants, one with roots and other without roots are joined together in such a way that they unite and grow as one plant. The stem having roots is called stock. The stem without root of another plant is called scion. Scion is the upper part which possesses leaves on it but no roots. On stock of citrus, scion of orange or lemon can be grafted. By grafting, most desirable characters of the plants can be brought together. Grafting method is always good in the plants where seeds are having long dormancy period, poor germination capacity and to produce varieties of seedless fruit.

15.7 Sexual Reproduction

Sexual reproduction takes place by union of two types of sex cells, i.e. male sex cells and female sex cells. The sex cells involved in sexual reproduction are known as gametes. In sexual reproduction, a male gamete unite with a female gamete to produce 'zygote'. This zygote then develops into new organism in course of time.

The importance of sexual reproduction:

The sexual reproduction has many advantages. In sexual reproduction the offsprings have genetic variations. In population sexual reproduction leads to greater variety. The species of plants and animals can adapt quickly to the changing environment. Those individuals which are more adapted to changes will survive and reproduce sexually. In the offspring, thus, sexual reproduction shows diversity of characters by providing genetic variations. In origin of new species the sexual

reproduction plays an important role. This genetic variation leads to the important role. These genetic variations lead to the evolution in various species to form better organisms. In sexual reproduction, the genetic material DNA from male and female gametes combine to form zygote but the amount of DNA in zygote does not get doubled. The male and female gametes contain only half the number of chromosome as compared to that of in the normal body cells of an organism. During sexual reproduction when male gamete fuses with the female gamete, then zygote achieves normal amount of DNA or normal number of chromosomes in it. e.g. The human ovum has 23 chromosomes and sperm has also 23 chromosomes. Thus when a sperm and an ova combined during fertilization the zygote, formed will have 23 + 23 = 46 chromosomes which is the normal number of chromosomes in human.

15.8 Sexual Reproduction in Flowering Plants :

The sex organs of a plant are located within the flowers. In most of the plants, the same flowers contain both male and female reproductive organs. These plants are known as bisexual. Thus, the reproductive part in higher groups of plant is flower. The function of a flower is to produce male and female gametes and to ensure fertilization which makes new seeds for the plants. The stamen is the male organ in flower which produces male gametes. The carpel is the female organ in flower which produces female gametes. Female gametes are present in ovules, and are known as ova or egg cells. The male gametes present in pollen grains which fertilize the egg cells found in ovules. The fertilized egg cell develops within ovule which later on produces embryo and entire ovule is converted into seed. Under the suitable condition the seeds germinate to produce new plants.

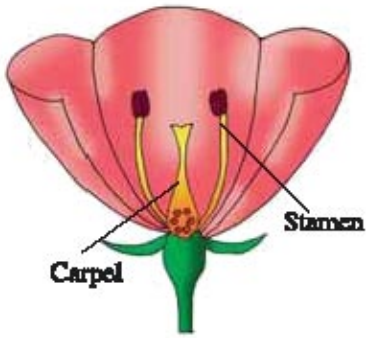


Fig.15.11 Flower of plant

15.9 Reproduction in Human Being

Human have a sexual mode of reproduction. All of us know that our body changes as we become older. Our height and weight also increase as we grow further. First we acquire milk teeth then permanent teeth. Some of these changes are common to girls and boys. In small child, it is difficult to know from the appearance whether he is boy or girl because small girls and boys have same body shape. In the early teenage, rapid growth starts and body changes. Some of these changes are common in both girls and boys. We begin to notice thick hairs growing in armpits and the genital area between the thighs. Hair can also appear on legs, arms and face. The skin some time becomes oily and pimples begin to develop. The ovary in girl and testis in boy produce different hormones, and thus girl and boy become sexually mature.

The age at which gametes start to be produced and girl and boy able to reproduce is known as puberty. Generally girls attain puberty at the age of 12 years, while boys reach puberty at the age of 13 to 14 years. On attaining puberty, testis start producing sperm and ovaries start producing eggs. In addition to these sex hormones also start secreting with the onset of puberty. Thus the time

between childhood and adulthood is known as 'adolescence'. Many changes take place during puberty, such as new hair growth, body becomes more muscular, the voice deepens, shoulders and chest broaden. The penis becomes larger and it is capable of becoming erect. In humans, the baby is carried in mother's body for a long period and will be breast fed after birth. The female breast and reproductive organs develop to accommodate these possibilities. Let us look at the reproductive system which is involved in the process of sexual reproduction.

The male reproductive system :

The male reproductive system consists of part which produce the male gametes and other part that transfer the gametes to the site of fertilization. The human male reproductive system consists of the following organs like testis, scrotum, epididymis, vas deference, seminal vesicles, prostate gland and penis. Testis are paired, oval shaped gland which produce the male gametes and secrete sex hormones, the testosterone. The testes are lying in muscular pouch scrotum present outside the abdominal cavity. The temperature of testis remains 2-3°C below the body temperature which is essential for the formation of sperms. The sperms in testis come out and carried into coiled tube known as epididymis. From epididymis the sperms come out into a long tube called vas deference, which joins with urinary duct coming from urinary bladder. Now it is known as urethra. The seminal vesicle and prostate gland join with vasdeference. The secretion of seminal vesicle increases the mobility and viability of sperms, while prostate gland secretion increases mobility of sperms. Urethra transfers the sperms to an organ called penis which opens outside through a male genital pore. From male genital pore sperms pass into vagina in the woman's body during mating.

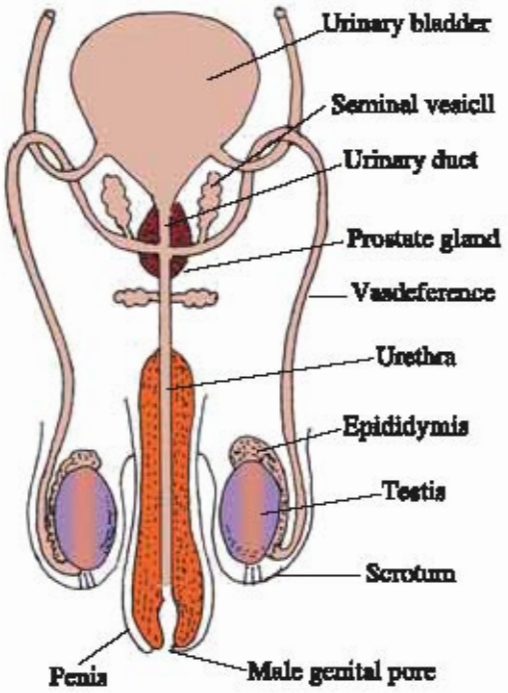


Fig. 15.12 Male reproductive system

Female reproductive system :

Female reproductive system consists of ovaries, oviduct, uterus and vagina. The female reproductive system is more complicated than male, because in it fertilization and the development of embryo till birth, occur.

Two ovaries are oval in shape and lie inside the abdominal cavity. The function of the ovary is to produce ova or eggs, and also to secrete the female sex hormones, estrogen and progesterone. There are two fallopian tubes (oviducts). These are not

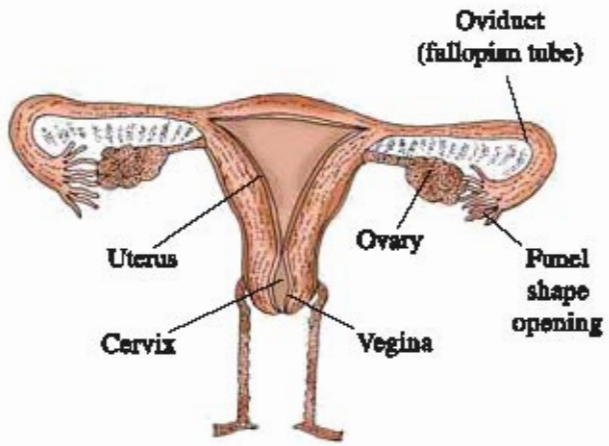


Fig. 15.13 Female reproductive system

attached to ovaries and have a funnel shaped opening to receive mature ova. Oviducts carry the ova from ovary to the uterus. The fertilization of ovum by a sperm takes place in the upper part of the oviduct. The oviduct unites to form a thick walled muscular bag like organ called uterus. Fertilized ovum further develops and grows into the uterus. The lower tip of the uterus is known as cervix. Uterus opens into tubular structure vagina, which receives sperms by the penis.

When a girl is born, the ovaries contain thousands of immature ovarian follicles. When a girl reaching puberty these immature ovarian follicles start maturing. One of the ovaries produces one ovum every month. The mature ovum finally carried to fallopian tube. During sexual inter course the sperms enter vagina. The fertilized ovum, gets implanted in the lining of the uterus and starts dividing and forms a hollow ball of hundreds of cells known as embryo. The embryo gets nutrition from the mother's blood with the help of a disc-like special tissue, develops between embryo and the uterus wall, known as placenta. The exchange of oxygen, nutrients and waste products takes place through the placenta. The development of the child inside uterus takes about nine months. The child is born as a result of rhythmic contractions of the muscles in the uterus.

15.10 Menstrual Cycle in Female

When girl reaches the age of about 10 to 12 year (puberty), the sex hormones cause the ova to become mature. Every 28 day one matured ovum is released from the ovary into the oviduct and this is known as ovulation. Before ovulation, the inner wall of uterus becomes thick, and with full

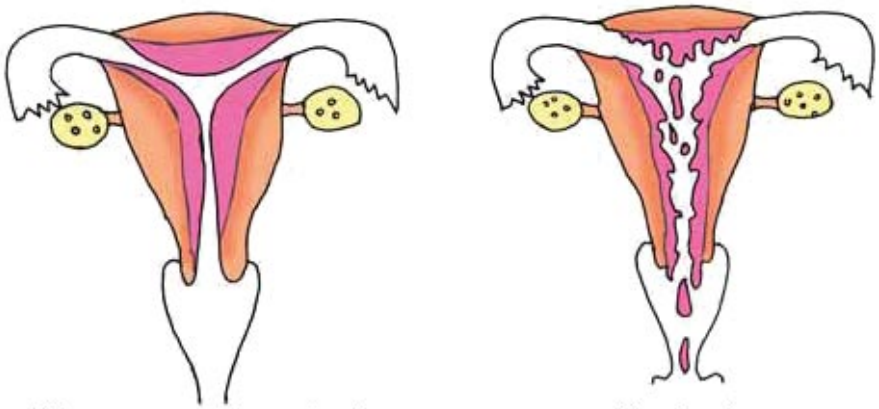


Fig. 15.14 Menstruation

of blood capillaries. Now at this stage uterus prepares to receive the fertilized ovum. If the ovum does not get fertilized, then the thick wall of uterus along with the blood vessels and dead ovum comes out of the vagina in the form of a bleeding known as menstruation. Menstruation lasts for 3 to 5 days. When menstruation is over, the inner wall of uterus starts building up again so that it may receive the next fertilized ovum. If the ovum does not get fertilized even now, then menstruation takes place again. The menstruation cycle is repeated in women every 28 days. Menstruation stops when woman gets pregnant and when woman reaches the age of about 50 years, menstruation stops permanently. This is known as menopause and in this stage woman lose the capacity of carrying embryo.

15.11 Reproductive Health

The process of sexual maturation is slow and gradual, and it continues with general growth of body. How do we decide that for this major responsibility our body or mind is ready? About this issue all of us are under different types of pressures. There can be pressure from the family members to get married and start having children. The pressure can be from government to avoid more children. Making choice becomes very difficult under this situation. We have studied in class IX that disease can be spread from person to person in a various ways. The diseases which are transmitted by sexual intimate contact with an infected person are called sexually transmitted diseases (STD). These include bacterial infections like syphilis and gonorrhea. Syphilis is caused by bacteria *Treponema palidium*. There are lesions in mucus membrane of urinogenital track and ulser in general. Gonorrhea caused by *Neisseria gonorrhea*. It is the inflammation of urinogenital tract. Both are curable diseases. The causative for AIDS is Human Immuno-deficiencey Virus (HIV). AIDS means Acquired Immuno Deficiency Syndrome. AIDS is a fetal disease, because it damages the body's immune system so that the body becomes weak and cannot protect against infection. Using condom during sex helps to prevent spread of many of these diseases to some extent. To find out medicines to cure AIDS, research work is in progress. To protect human from AIDS, the programme under guidance of WHO is in practice. In India also NACO (National AIDS Control Organization) has taken steps to create awareness and provide relevant information about reproductive health.

The continuous sexual act has the potential to lead to pregnancy. During pregnancy women's health will be adversely affected. Therefore, many ways have been devised to avoid pregnancy. These contraceptive methods can be broadly classified into the following three categories. One category is the creation of mechanical barrier that prevent the entry of sperm in the genital track. So fertilization cannot take place. Condoms on the penis or Diaphragm worn in the vagina by female can serve this purpose. In other category of contraceptives chemical methods, the female

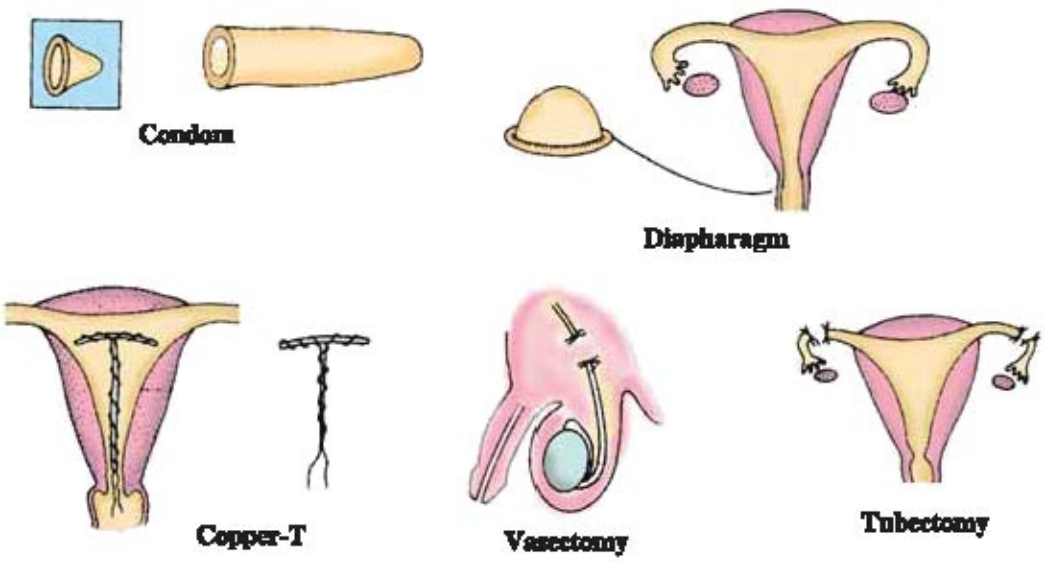


Fig. 15.15 Contraceptive devices and surgery

uses two types of pills. The oral pills contain a combination of hormones which stop the production of ova and fertilization cannot occur. The vaginal pills contain the chemical known as spermicide which kills the sperms. Another Intrauterine Contraceptive Devices (IUCDs) like copper-T are placed in uterus to prevent pregnancy. In surgical methods, in males small portion of vas deference is surgically removed and both the cut ends are tied properly. This prevents the sperms from entering the urethra. This process is known as vasectomy. In female, a small portion of oviduct is removed and tied up. This process is known as tubectomy. This process prevents the ovum from entering the oviduct. Surgical methods can be used to create such blocks. Surgery can be used to remove unwanted pregnancies. People who do not want a female child this facility may misuse. Some people are interested to have a son or to know the sex of their unborn child by ultrasound technique (sonography) illegally. In case of female child, they get it removed by surgery. The killing of the unborn girl child is known as female foeticide. By female foeticide, child sex ratio is reducing at an alarming rate in society. The reproduction is the process by which organisms increase their population. The rates of birth and death in a given population will determine its size. Human population is increasing at an enormous rate.

What have you learnt ?

- The production of new organisms from the existing organisms of the same species is known as reproduction
- Organisms look similar because their body designs are similar
- Variation is useful for the survival of species over time.
- There are two main methods of reproduction in living organisms. (1) asexual reproduction (2) sexual reproduction. Asexual reproduction takes place by six different methods. These are (1) fission (2) fragmentation (3) regeneration (4) budding (5) vegetative propagation (6) spore formation.
- Sexual reproduction has many advantages. The offspring have genetic variations, greater variety, adapt quickly to changes in environment
- The main reproduction parts of flower are stamens and carpels which contain the germ cells.
- Male reproductive system consists of testis, vasdeference, seminal vesicle, prostate gland, urethra, penis.
- Female reproductive system consists of ovary, oviduct, uterus, cervix, and vagina
- The break down and removal of the inner, thick lining of the uterus along with blood vessel gets slashed off and discharged from vagina is called menstruation
- Process of menstruation occurs every 28 day is known as menstruction.
- Birth control methods are

  (1) Barrier method (2) Chemical methods (3) Surgical method
- Gonorrhea, Syphilis and AIDS are common sexually transmitted disease.

EXERCISE

1. Select the proper choice from the given multiple choices.

1. Asexual reproduction is:

   (A) a fusion of specialized cells

   (B) a method by which all types of organisms reproduce

   (C) a method producing genetically identical offsprings.

   (D) a method in which more than one parent are involved

2. One of the following organisms does not reproduce by binary fission. This is:

   (A) Amoeba (B) Plasmodium (C) Euglena (D) Paramoecium

3. Reproduction is essential for living organisms in order to:

   (A) keep the individual organ alive (B) fulfil their energy requirements

   (C) maintain growth (D) continue the species for ever

4. A multicellular organism which reproduces by budding is:

   (A) Amoeba (B) Yeast (C) Paramoecium (D) Hydra

5. A simple multicellular animal having tentacles and lives in freshwater reproduces by the asexual method of :

   (A) binary fission (B) spore formation (C) budding (D) fragmentation

6. In which of the following living organisms spore formation takes place ?

   (A) Mucor (B) Planaria (C) Spirogyra (D) Potato

7. Method of a sexual reproduction in Spirogyra.

   (A) division of a cell into two cells (B) breaking up of filaments into smaller bits

   (C) division of a cell into many cells (D) formation of a large number of buds

8. An alga which reproduces by the asexual reproduction method called fragmentation is:

   (A) Rhizopus (B) Salmonella (C) Plasmodium (D) Spirogyra

9. The cut part of plant stem (having roots and fixed to ground) which is used in the process of grafting is .....

   (A) stock (B) scion (C) cutting (D) bud

10. In asexual reproduction, two offsprings having the same genetic material and the same body features are called:

    (A) callus (B) twins (C) clones (D) chromosomes

2. Answer the following questions in brief :

1. (A) Name two animals which reproduce sexually.

   (B) Name two animals which reproduce asexually.

2. Name the method by which Paramoecium reproduces. Is this method sexual or asexual?

3. Name the asexual method of reproduction in yeast.

4. Name the asexual method of reproduction in (a) Hydra, and (b) Plasmodium.
5. Name the artificial propagation of the rose plant for reproduction.
6. Which artificial propagation method is used for the production of citrus plants?
7. Name two plants which are propagated by layering method.
8. Name any two plants which are propagated by cutting method.
9. Write down the name of different methods of asexual reproduction.

3. Write answers of the following questions.

1. (a) What is the basic difference between asexual reproduction and sexual reproduction?
   (b) Which of the following organisms reproduce by sexual method and which by asexual method? Amoeba, Cats, Humans, Hydra, Birds
2. What do you mean by regeneration ? Name two animals which can regenerate fully from their cut body parts.
3. Explain vegetative propagation with the help of two examples. List two advantages of vegetative propagation.
4. Describe the layering method for the artificial propagation of plants. Ilustrate your answer with the help of a labelled diagram. Name any two plants which are propagated by the layering method.
5. (a) What is a tuber ? give example.
   (b) Name one commonly used vegetable which is propagated by using tubers.
6. What is meant by vegetative propagation ?
7. Explain how, new Bryophyllum plants can be produced from the leaves of the old plant ? Ilustrate your answer with the help of a labelled diagram.

4. Answer the following questions in detail.

1. Name one organism which reproduces by fission and another by fragmentation. Describe these processes with example.
2. What is the meaning of multiple fission : Describe.
3. Describe the method of reproduction in fungus.

UNIT 16

HEREDITY AND EVOLUTION

We know that the living organisms reproduce either by asexual or sexual method. Due to this capacity every organism reproduces new generation of offsprings that resembles the parental generation. Though the offsprings of a species may resemble very closely to their parents, they never exactly resemble them. In other words, we can say that each species has individuality, i.e. each species is recognizable by certain specific characteristics. By the process of gradual and continuous change, living organisms have evolved to exhibit a wide diversity. In this chapter you will learn about heredity, variation, sex determination and also about evidences of evolution.

16.1 Accumulation of Variation During Reproduction :

The occurrence of differences among the individuals of the same species is known as variation. Very little variations can be seen in the organisms which are reproduced vegetatively or asexually while distinct variations are observed in the organisms which reproduce sexually. We know that sexual reproduction involves the process of meiosis for gamete formation. During meiosis, crossing over takes place between the genes and hence, new combinations are formed, which ultimately results in producing variations among the characteristics of individuals of species. However, all these variations in a species do not have equal chances of surviving in the environment in which they find themselves. Depending on the nature of variations, different individuals would have different kinds of advantages. Selection of variants by environmental factors forms the basis of evolutionary processes.

16.2 Heredity :

Heredity means continuity of features from one generation to another. For example, eggs laid by a sparrow hatch into sparrows only. A dog gives birth to pups only. This is the essence of heredity.

Hereditary information is present in the fertilized egg or zygote. The zygote develops into an organism of a particular type only. Thus heredity can be defined as "the transmission of characters from parents to the offspring" or the tendency of every individual to resemble their parents.

Heredity and variation are important aspects of science, which are studied under Genetics. And so Genetics is also known as the science of heredity and variation.

16.3 Inherited Characters :

How do organisms follow the characters of their own species ? We can say that it is their inheritance. It is through inheritance that each species maintains the structure of characters generation after generation. At the same time, it is also equally true, that offsprings are not exact copies of their parents. This aspect of differing from parents is called variation. Human populations show a great deal of variations. In the following part we will study how characters are transmitted generation to generation.

16.4 Mendel's Contribution :

We know that complete inheritance from mother and father is received by offsprings through a single ovum and a single sperm respectively. It is through their fertilization, that the first cell, called zygote, comes into existence as a new offspring. This means that each character in offspring will be influenced by both the parents. What will, the character then be seen in the offspring ? Mendel performed experiments on *Pisum sativum* (Garden pea) and worked out the main rules of such inheritance. After selecting Garden pea as an experimental material, Mendel performed experiments to study the inheritance of some of the pairs of contrasting characters like tall and short plants, white and violet flowers, round and wrinkled seeds, axial and terminal flower positions and so on.

When Mendel crossed a tall plant (with TT traits on DNA) with a dwarf plant (with tt traits on DNA), the F_1 generation was found to be tall. There were no dwarf or medium height plants in F_1 generation. This means that only one of the parental characters was seen. But when F_1 generation plants were self-fertilized, it was found that some plants were dwarf (25%) some were tall (75%) in F_2 generation. This indicates that both tallness and dwarfness characters were inherited in F_1 generation from the parents, but only the character for tallness was expressed. Thus two copies of each character are inherited in each sexually reproducing organisms which may be either identical or different.

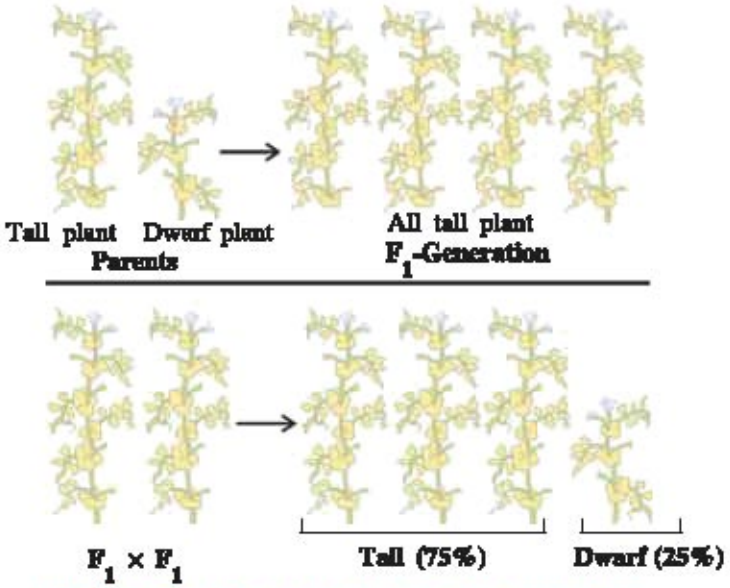


Fig. 16.1 Inheritance of traits over two generations

The experiment indicated that plants having either TT or Tt traits for height were tall while with tt traits were dwarf. In other words we can say that a single trait "T" is enough for making plant tall but for dwarfness traits "tt" are required. Thus "T" is called dominant trait while "t" is a recessive trait.

In other experiment, Mendel selected two different characteristics in a plant. He crossed a plant having yellow and round seeds with a plant having green and wrinkled seeds. In F_1 generation all the plants were with yellow and round seeds indicating that yellow and round seeds are dominated characteristics (Traits). When the plants of F_1 generations are self pollinated, plants along with the parental combinations (i.e. yellow and round seeds, green and wrinkled seeds) new combinations (i.e. yellow and round seeds, green and round seeds) are also formed. This indicates that the yellow seeds/green seeds characteristics (traits) and the round seeds/wrinkled seeds characteristics are independently inherited.

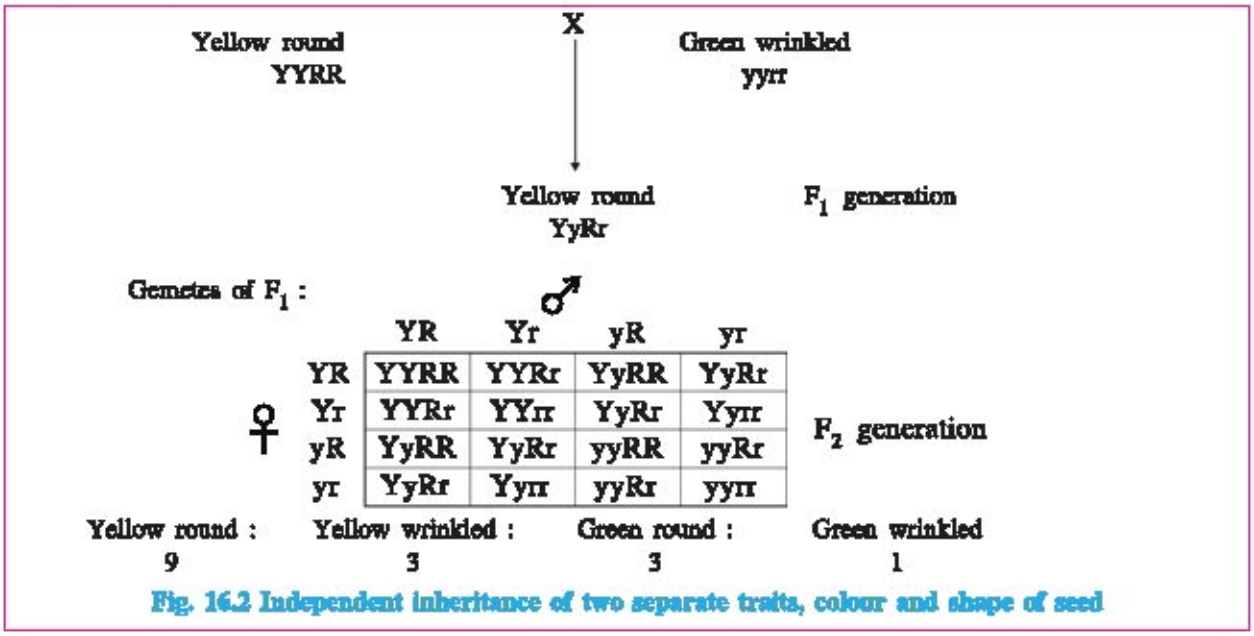


Fig. 16.2 Independent inheritance of two separate traits, colour and shape of seed

16.5 Expression of Inherited characters

The gene is a unit of heredity. Genes are located on DNA in a linear order. Each gene exercises its function by synthesizing specific protein which is responsible for the expression of characteristic. How do proteins control the characteristics ? Let us consider the height as a characteristic of the plant. We know that plants have hormones that can trigger growth. So height of plants depend upon the amount of particular hormone. The synthesis of hormones is catalysed by particular type of enzymes and the synthesis of enzymes is regulated by genes located on DNA. It means if enzyme is synthesized in required amount and is working efficiently, a lot of hormones will be made and the plant will be tall. However, if the gene has alteration that makes the enzyme less efficient, the amount of the hormone will be less and plant will be dwarf. This clearly indicates that characteristics or traits are under the control of genes.

16.6 Sex Determination in Human

How is the sex of a newborn individual determined ? Different species use different mechanism for this. Some rely on the environmental factor like temperature. The temperature at which fertilized

eggs are kept determines whether the animal developing in the eggs will be male or female. In other animals such as snails, individuals can change sex, indicating that sex is not genetically determined. However in human beings, the sex of the individual is genetically determined. Thus, the mechanism to determine the sex of an individual is known as sex determination.

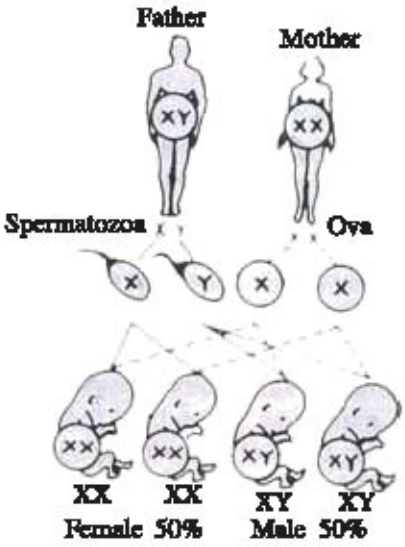


Fig. 16.3 Sex determination in Human

In human beings, the sex will be determined by the genes, located on the chromosomes, which are inherited from parents to offsprings. In humans, 23 pairs of chromosomes occur. Of these, 22 pairs are of autosomes. They are similar in male and female. In female 23rd pair consists of two similar X sex chromosomes. In male one chromosome in 23rd pair is like X chromosome in women. Its homologous chromosome is smaller in size and is called Y chromosome .

All eggs of a female are similar. Each egg contains 22 autosomes and one X sex chromosome. Male produces two types of sperms. 50% sperms carry X sex chromosome while other 50% carry Y sex chromosome.

When a sperm carrying X chromosome fertilizes an egg, the zygote develops into a female, while a sperm carrying Y chromosome fertilizes an egg, the zygote develops into a male.

In human, presence of Y chromosome is obligatory for maleness. When the zygote is formed and embryo development occurs, the gonads which are formed are undifferentiated. They can develop either into testes or into ovaries. If the zygote contains the Y sex chromosome, the gonads differentiate into testes. Testes produce male sex hormones and stimulate development of a male individual.

16.7 Evolution

On this earth an enormous number of different types of plants and animals are present. Besides these the remnant of the dead organisms which lived in the past are also present which are known as fossils. On this earth a great variety of living plants and animals exist. All these things are studied in the branch of biology known as 'evolution'. The word evolution has been derived from the Latin word 'evolvere' which means to 'unfold' or 'unroll'.

Primary Explanation of Evolution

Evolution is a kind of gradual formation of new organisms from the pre-existing primitive plants or animals by constant and relatively long time changes. Thus evolution is the sequence of gradual changes which have taken place over millions of years in the primitive plants and animals from which new species are formed. The evolution is a constant process which is taking place in the primitive organisms since life is originated. All the enormous varieties of organisms which we see around us have evolved from some ancestors that lived on this earth long time ago.

Acquired and Inherited Traits (Characteristics) :

Acquired trait means a Trait of an organism that is not inherited but developed in response to the environment. For example reduction in weight due to starvation. The reduced weight due to starvation would not change the DNA of germ cells. Thus reduced weight is not a trait that can be inherited by the future generation of starving organisms. Another examples of acquired trait are cut tail of mouse or a man who knows how to swim, or speak German or roller skate, or may have scar on the face due to accident. Thus the man is not born with these acquired traits and he cannot pass on these traits to his progeny. The reason for this because only those traits inherited to their progeny where change has occurred in the genes in gametes of organisms during the process of reproduction. Thus the changes in the non-reproductive body cells of an organism cannot be transmitted to its progeny.

A trait of organisms which is caused by a change in its DNA is known as inherited trait. For example there is a population of red beetles which live in bushes with green leaves. Suppose a color variation arises during reproduction in the gene of reproductive cells, one green color beetle arises instead of red color. Here the green color of this beetle is an inherited trait which can be transmitted to the next generations. This is the essence of the idea of evolution.

16.8 Speciation :

The process by which new species develops from the existing species is known as speciation. Thus speciation means, the formation of new species. When population of same species splits into two groups which then get separated from each other geographically by the certain barriers like rivers, seas or mountain ranges then new species are formed. Thus geographical isolation leads to reproductive isolation due to which there is no gene flow between two separated groups of population. Variation arises in individuals due to natural selection. Due to processes of random change in gene frequency (genetic drift), after thousands of years the individuals become so different that they cannot reproduce with each other. Thus new species are formed. There can be more ways like DNA changes, the change in the number of chromosomes, the green cells of two isolated groups of populations which cannot fuse with each others etc. which can lead to speciation. Thus new species are formed.

16.9 Evolution and Classification :

Among organisms we find similarities that will allow us to classify them in to groups and study in detail. The main characteristic of plants is that they can do photosynthesis while animals cannot do. The cell is the basic fundamental unit of life. The next characteristic of classification is that not all the organisms possess cells. Among various organisms the basic characteristic of cell design is also different. Some organisms like bacterial cell do not have nucleus. Organisms with nucleated cells are of two types, unicellular and multi-cellular. And there is a basic difference in body design, because of specialization of cells and tissues. Among the multicellular organisms the skeleton around the body or inside the body will mark another basic design difference. The more closely related two species have a common ancestor. For example a brother and sister are closely related, and they have a common ancestor.

16.10 Evidences for Evolution :

Some of the very significant sources which provide evidences for evolution are as follows:

Homologous organs :

Those organs which have the same internal structure but different functions are called homologous organs. For example the basic design of bones of forelimbs of a frog, a lizard, a bird, a bat and a man is similar in their internal structures but they perform different types of functions. These indicate that all these forelimbs have evolved from a common ancestral animal which had a same basic internal structure.

Forelimb of Human | Forelimb of Lizard | Forelimb of Frog

Fig. 16.4 Homologous organs

Analogous Organs :

Organs which have different basic design but have similar appearance and carry out similar functions are called analogous organs. For example the wings of insect and bird have different structures but perform similar functions. Thus the presence of analogous organs in different animals provide evidence that they are not evolved from the common ancestors, but they perform similar functions to survive in prevailing environment.

Fig. 16.5 Birds feathers (Analogous organs)

Fossils Provide Evidence for Evolution :

The impressions of dead plants or animals that lived in the past are known as fossils. When plants or animals die, the micro-organisms in the presence of moisture and oxygen, decompose their bodies but sometime due to environment conditions their bodies do not decompose

completely. Such body parts of the plants on animals become fossil and are available on digging the earth. If the dead leaf gets caught in the mud, leaf will not decompose completely. The mud around the leaf will set around it as a mould which slowly harden to form rock and retain the impression of the leaf. Thus fossil of leaf is formed. The age of the fossils can be estimated by carbon dating method. When living organisms changed in to fossil, their ^{14}C radioactivity decrease slowly. Thus the age of fossil is determined with the help of the ^{14}C radioactive. Ammonite, Trilobite and Dinosaur are the examples of fossils which are determined by this process.

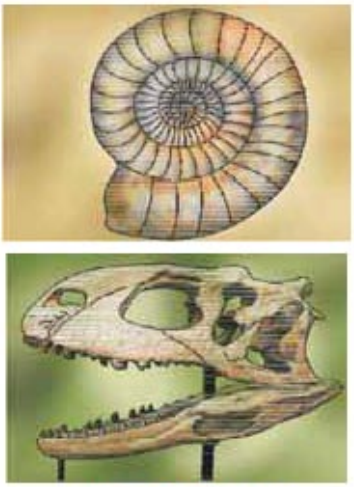


Fig. 16.6 Fossils

Wild cabbage

Cabbage

Broccoli

Cauliflower

Kohlrabi

Kale

Fig. 16.7 Varieties of wild cabbage

16.11 Evolution by stages

For animals the eye is a very important and it is a complicated organ which cannot be generated by a single DNA change. The eyes of animals have been created in stages after many generations. First of all, eye was formed in Planaria. The eyes of Planaria (flat worm) are very simple and are just like 'eye-spots' which detect light. These simple eyes provide a survival advantage to Planaria. Thus eye seems to be very popular adaptation. Most of the animals like insects, octopus, invertebrates and vertebrates have eyes. The structure of eye in above organisms is different which suggests the evolution of eye and is an example of evolution by stages.

Feathers : For example, in some dinosaurs feathers could not be used for flying but provided insulation in cold weather. But later, they might become useful for flight. Birds, however later adapted to flight. Thus presence of feathers in world tell us that birds are very closely related to reptiles, since dinosaurs which had feathers were reptiles.

Analogus organ

We have learnt that very dissimilar looking structures evolved from common ancestral body design. But those are all guesses about what happened in history long time ago. Are there any present time examples of such a process ? The wild cabbage plant is a good example. It provides evidence that completely dissimilar looking plant can evolve from the wild cabbage by the process of evolution. The only difference here is that we are using artificial selection evolution, rather than natural selection. Over more than two thousand years the farmers cultivated wild cabbage as food plant and have bred the cabbage (very short distance between leaves) which we eat, some farmers obtained for arrested flower development of wild cabbage, and have bred broccoli or some farmers went in for sterile flowers and have

developed cauliflowers. Farmers selected swollen parts of wild cabbage, and developed another variety known as 'kohlrabi'. Some farmers have developed slightly large leaves of wild cabbage and their leafy vegetable is called 'kale'. Now wild cabbage is the ancestor of cabbage, broccoli, cauliflower, kohlrabi and kale varieties obtained by artificial selection by farmers and they look different from wild cabbage which is their ancestor.

16.12 Human Evolution:

Human evolution has been studied by using same tools like digging earth, time-dating, studying fossils and determining DNA sequence for tracing evolutionary relationship. Across the earth there is a great diversity of human firms and future. Man thought for a long time about different 'races' of human. The human race was identified on commonest way of their skin colour and named as yellow, black, white or brown. It is now known that the human races have not evolved differently. In the recent years, the evidence has become very clear that all human beings are a single species called *Homo Sapiens*. By research it has been established that we lived for past few thousands years. We all came from Africa. Our genetic foot prints can be traced back to our African roots. A couple of hundred thousand years ago some of our ancestors left Africa while others stayed back. Those who left Africa slowly spread over the planet – from Africa to West Asia to Central Asia, Eurasia, South Asia and East Asia. They migrate down the island of Indonesia and Philippines to Australia and reached to America. They went with groups, sometimes separating from each other and mixing with each other, even moving in and out of Africa. Like all other species on the earth, they had come into being as accident of evolution.

What have you learnt ?

Due to reproduction capacity every organism reproduces new generation of offsprings that resembles the parental generation. However, by the process of gradual and continuous change, living organisms have evolved to exhibit a wide diversity. During meiosis, crossing over takes place between the genes and hence, new combinations are formed, which ultimately result in producing variations among the characteristics of individuals of a species. Heredity means continuity of features from one generation to another. Heredity and variation are important aspects of science, which are studied under Genetics .

Mendel performed experiments on *Pisum sativum* (Garden pea) and worked out the main rules of such inheritance. Mendel performed experiments to study the inheritance of some of the pairs of contrasting characters like tall and short plants, white and violet flowers, round and wrinkled seeds, axial and terminal flower positions and so on. The gene is a unit of heredity. Genes are located on DNA in a linear order. Each gene exercises its function by synthesizing specific protein which is responsible for the expression of characteristic. The mechanism to determine the sex of an individual is known as sex determination. In human beings, the sex will be determined by the genes, located on the chromosomes, which are inherited from parents to offsprings.

Evolution is the sequence of gradual changes which have taken place from primitive organism over millions of years in which new species are produced. A characteristic of an organism which is not inherited but develops in response to the environment is known as acquired trait. The

process by which new species develop from the existing species is known as speciation. The important factors which could form new species are (1) Geographical isolation of a population (2) Genetic drift and (3) Variation. Some important sources which provide evidences for evolution are (1) homologous organs (2) analogous organs and (3) fossils. For evolution by stages possible explanations are, Evolution of feathers and Farmers have evolved different looking vegetables like cabbage, broccoli, cauliflower, kohlrabi and kale by evolution by artificial selection.

EXERCISE

1. Select the proper choice from the given multiple choices :

1. The occurrence of differences among the individuals of the same species is due to :
   (A) Transition (B) Variations (C) Development (D) Evolution
2. The continuity of features from one generation to another is known as :
   (A) Evolution (B) Mutation (C) Heredity (D) Generation
3. On which of the following plant species Mendel has worked:
   (A) Zea mays (B) Pisum sativum (C) Cassia tora (D) Phaseolus mungo
4. When Mendel crossed Tall plant with Dwarf plant what was the ratio of dwarf plants in F_2 generation ?
   (A) 75 % (B) 25 % (C) 60 % (D) 40 %
5. In human being sex is determined by ;
   (A) Cell (B) Tissues (C) Genes (D) Organelles
6. The Human Species have genetic roots in:
   (A) India (B) America (C) Africa (D) Australia
7. The organs which perform different functions but have the same basic structure are known as:
   (A) Homologous organs (B) Analogous organs
   (C) Homolytic organ (D) Analytic organs
8. If the fossil of an organism is found in the deeper layers of earth, then we can predict that :
   i. the extinction of organism has occurred recently
   ii. the extinction of organism has occurred thousands of years ago
   iii. the fossil position in the layers of earth is not related to its time of extinction
   iv. time of extinction cannot be determined.
9. New species may be formed if :
   i. DNA undergoes significant changes in germ cells
   ii. there is no change in the genetic material
   iii. mating does not take place
   (A) (i) and (ii) (B) (i) and (iii) (C) (ii) and (iii) (D) (i), (ii) and (iii)

10. The presence of which of the following types of organs in two animals indicates that they are not derived from a common ancestor?

(A) Homologous organs (B) Excretory organs

(C) Analogous organs (D) Reproductive organs

11. Which one of the following is not homologous ?

(A) forelimbs in humans and lizard (B) forelimbs in lizard and frog

(C) wings in butterfly and bat (D) wings in bat and bird

2. Answer the following questions in brief :

1. Define sex determination
2. What are the mechanisms or methods of sex determination in different organisms?
3. Name the ancestor of the following:

   Broccoli, Kohlrabi, Kale
4. Name two organisms which are now extinct and are studied from their fossils.
5. Name five verities of vegetables which have been produced from 'wild cabbage' by the process of artificial selection
6. Choose the one term from the following which includes the other three : broccoli , wild cabbage, cauliflower, cabbage

3. Write answers to the following questions :

1. What are fossils ?
2. In what way homologous organs give evidence for evolution?
3. Will geographical isolation be a major factor in the speciation of an organism that reproduces asexually? Give reason for your answer.
4. Does geographical isolation of individuals of a species lead to the formation of a new species? Provide a suitable explanation for your answer.
5. How characters are inherited ?
6. Write a note on heredity.

4. Answer the following questions in detail :

1. (A) Explain the terms 'analogous organs' and 'homologous organs' with examples.

   (B) In what way analogous organs give evidence for evolution ?
2. (A) Define 'speciation'. Explain how speciation occurs.

   (B) Will geographical isolation be a major factor in the speciation of a self-pollinating plant species? Give reason for your answer.
3. Explain Mendel's contribution.
4. Describe the sex determination in human beings

UNIT 17

Our Environment

All organisms including plants, animals and human beings and their physical surroundings with which they interact is called environment. All biotic and abiotic components of the environment are dependent on each other for maintaining balance. Therefore, we can say that the different components of the environment are inter-linked and interdependent. The environment varies from place to place due to variation in climate, soil type and topography. All plants and animals adjust to the environment in which they are born and live. A change in any component of environment may cause discomfort and affect normal life of living organisms. In this chapter, we shall be study how various factors in the environment interact with each other and how they impact the environment.

17.1 What Happens When we Add Our Waste to the Environment ?

Wastes are unwanted, unusable items, remains or household garbage. Wastes are generated in our homes on daily basis. These wastes are classified into two major forms namely solids and liquids. The liquid forms are easy to handle and manage as compared to those of solid forms. The solid wastes include kitchen wastes such as vegetables and fruits, peels, scales, bones, etc., metal wastes, glasses, plastics and polythenes. The waste materials which are broken down by biological processes are called biodegradable, for example vegetables and fruits while glass, plastics and polythenes which are not broken down by biological processes are said to be non-biodegradable.

Activity

- Collect waste materials from your homes. This waste include boiled food, vegetable peels, used tea leaves, plastic bags, milk bags, empty bottles, torn clothes, waste papers and empty cartons.
- Bury these materials in a pit in the school garden.

- Keep these materials moist and observe after a month.
- You will find that shape and structure of some of the materials like boiled food, vegetable peels, used tea leaves, torn clothes, waste papers and empty cartons have been changed due to degradation processes.
- No change can be seen in the shape and structure of some of the materials like plastic bags, milk bags and empty bottles since they are non biodegradable.
- The non biodegradable materials may be inert and simply persist in the environment for long time or may harm various members of the ecosystem. These materials take up precious land and may be major sources of diseases. Even a few kilos of putrid garbage or waste can cause a dangerous epidemic disease.

17.2 Ecosystem

In an ecosystem all organisms such as plants, animals, microorganisms and human beings as well as the physical surroundings interact with each other and maintain a balance in nature. In other words, the biotic community, together with the physical environment forms an interacting system which is called the ecosystem. An ecosystem may be of a small or a large size. Based on the kind of habitat, an ecosystem may be aquatic or terrestrial. Terrestrial ecosystems include forests, grasslands and deserts. Aquatic ecosystems include freshwater ecosystems like river, springs, lakes and ponds as well as marine ecosystems of oceans. Every ecosystem gradually merges into another one. Each ecosystem possesses a specific structure and performs definite functions.

Components of Ecosystem : Each ecosystem consists of two main components – a biotic component and an abiotic component. Biotic component includes all living organisms e.g. producers, consumers and decomposers while abiotic component includes all non-living factors such as soil, water, light, temperature, wind, humidity, rain, inorganic nutrients and dead organic matter containing proteins, lipids, carbohydrates etc.

(1) Biotic components : All organisms living in an ecosystem can be divided into two types - producer organisms and consumer organisms.

(i) Producers : These organisms are autotropic. They possess chlorophyll and prepare food through photosynthesis for themselves as well as for other organisms. In terrestrial ecosystem green plants are producers. In aquatic ecosystems various kinds of algae act as producers.

(ii) Consumers : These organisms cannot synthesize their food by themselves and so, they consume other organisms or their products for their food. They are heterotrophic. Consumers can be divided into the following four categories.

(a) Herbivores or first order consumers : They utilize green plants and obtain their food.

(b) Carnivores or secondary and following level consumers : They predate upon herbivores and other carnivorous animals to obtain food. Carnivores which consume herbivores are the second order consumers. Carnivores which consume other carnivorous animals constitute third and higher order consumers.

(c) Omnivorous organisms : They utilize plants as well as animals as their food.

(d) Decomposers : They fulfill their nutritional requirements by decomposing dead bodies of plants and animals. They convert complex organic matter into simple organic constituents and then transform these into inorganic constituents.

(2) Abiotic components :

All the non-living constituents of an ecosystem are included in the abiotic components. The most important abiotic components are divided into two categories : i) Climatic factors and ii) Edaphic factors.

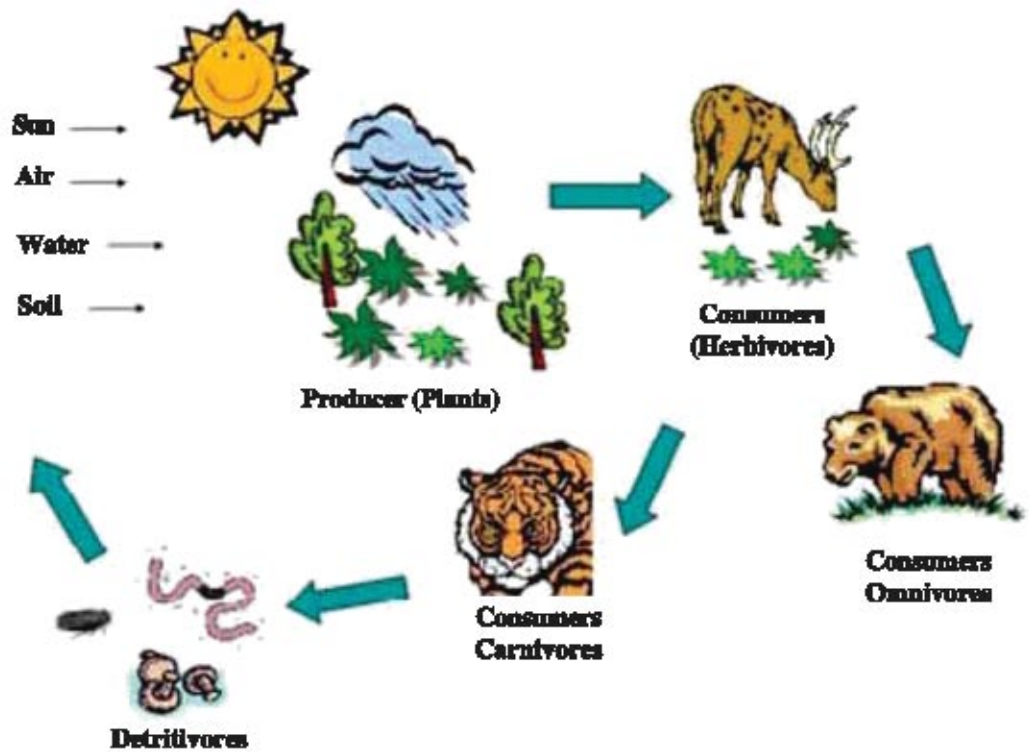


Fig. 17.1 Components of ecosystem

Climatic factors include temperature, water, light, wind, pH, mineral elements, topography and habitat while edaphic factors include soil structure and composition.

Food Chains and Food Webs : Living organisms depend on each other for their food requirement and form a chain. This is termed as food chain. Each step or level of food chain forms a trophic level. Thus, producers form first trophic level, herbivores the second and carnivores the third. As an example, a food chain might consist of grasses, fed upon by grasshoppers which, in turn are fed upon by rats which in turn are fed upon by kites or hawks. Thus food chain usually starts with primary producers and ends with carnivores.

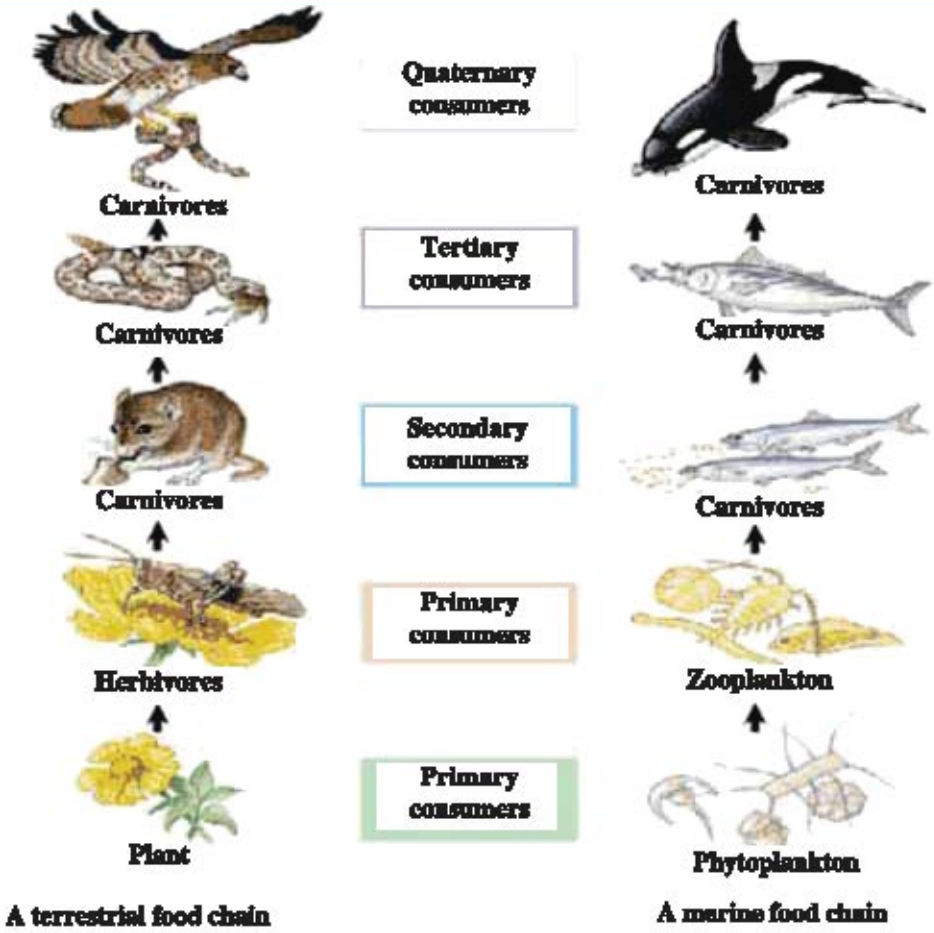


Fig. 17.2 Trophic level of food chain

Food chains : Food chains are of two types – grazing food chain and detritus food chain. A grazing food chain begins with chlorophyllous producers and extends through herbivores, carnivores and decomposers. A detritus food chain begins with decomposers which live on dead organic matter and passes through detritus feeding organisms in soil to organisms feeding on detritus feeders.

A food chain describes how energy and nutrients move through an ecosystem. The autotrophs or the producers are at the first trophic level that produce the energy. The energy then moves up to higher level organisms like herbivores. After that when carnivores eat herbivores, energy is transfered from one to the other. Thus green plants are the only source of energy which capture the energy present in sunlight and convert it into chemical energy. This energy supports all the activities of living world. The flow of energy in an ecosystem is always unidirectional. The energy that is captured by green plants does not revert back to the sun and the energy which passes to the herbivores does not come back to the autotrophs. As it moves progressively through the various trophic levels it is no longer available to the previous level.

Due to uncontrolled use of pesticides and other chemicals in order to protect the crops from diseases or pests, the amount of these chemicals increases in the soil or water bodies. From soil or water they enter in the body of plants and then in the bodies of herbivores and carnivores. As

these chemicals are not degradable, they get accumulated progressively at each trophic level. This phenomenon is known as Biological magnification.

The trophic inter-relationship between animals in nature cannot be explained as simple food chains only. Among the various ecosystems, each one is having definite food chain. The individuals involved are also linked with food chains of other ecosystems. In this way, the animals are inter-dependent for food and they form a net which is termed as a food web.

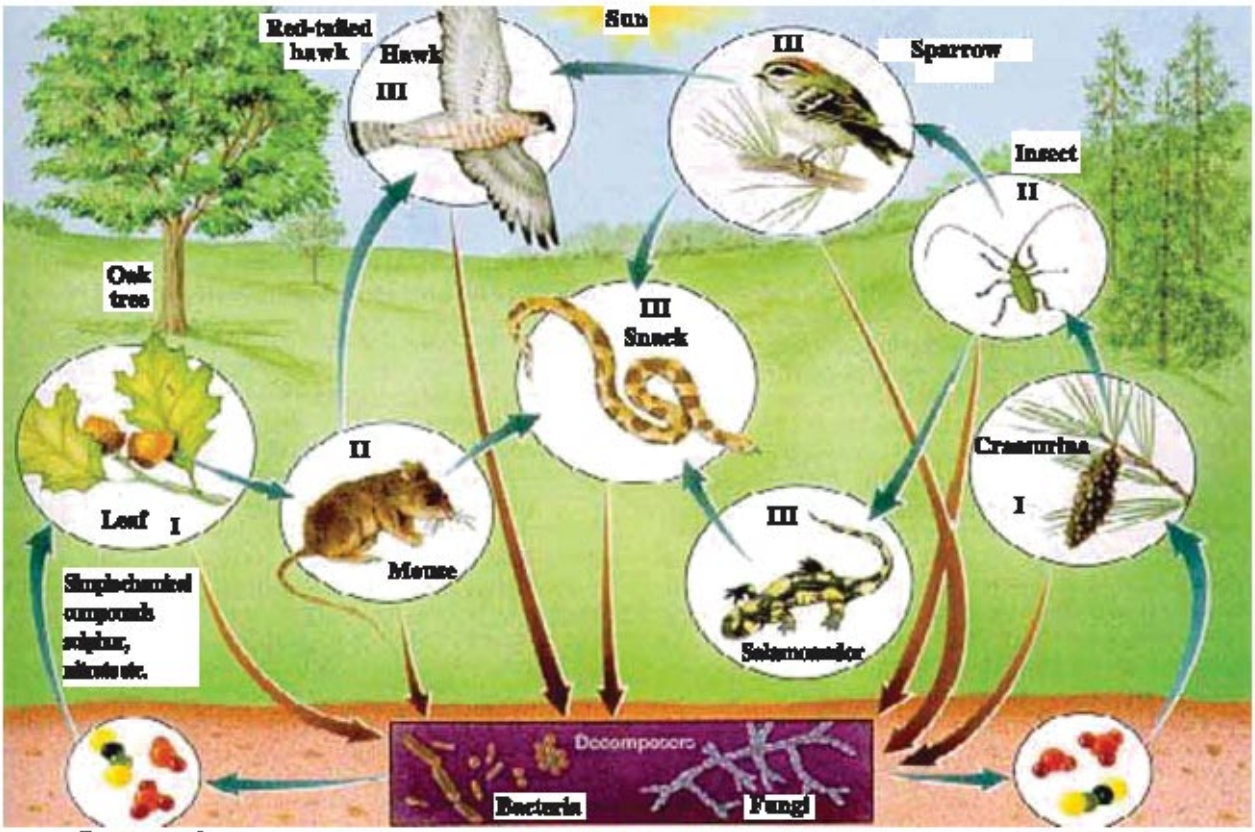


Fig. 17.3 Food web

17.3 Global Problems

Global problems are not just important problems that affect directly to individual man, but they are those problems that affect the whole planet and potentially all the people who live on it.

Climate change is one of the best examples. It is a result of human generated change. Some of the global problems faced by the living organisms are : global warming and depletion of the ozone layer, biodiversity and ecosystem losses, fisheries, depletion, deforestation, water deficits, waste disposal and maritime safety and pollution. In this chapter we shall be looking at two of the environmental problems in detail which are depletion of the ozone layer and waste disposal.

17.4 Ozone Layer and Its Depletion

The atmosphere of the earth is stratified. The nearest to our earth is troposphere. At a height of about 50 km in the stratosphere, the ozone layer is located. This layer absorbs UV-radiation from the sunlight and prevent it from reaching the earth.

Ozone is formed when oxygen molecules absorb ultraviolet photons and undergo a chemical reaction known as photodissociation or photolysis, where a single molecule of oxygen breaks down two oxygen atoms. The free oxygen atom (O), then combines with an oxygen molecule and forms a molecule of ozone (O_3).

$$O_2 \longrightarrow O + O$$

$$O + O_2 \longrightarrow O_3$$

(Ozone)

The ozone molecules, in turn absorb ultraviolet rays between 310 to 200 nm wavelength and thereby, prevent these harmful radiations from entering the Earth's atmosphere.

The depletion of the ozone layer in the stratosphere is turning out to be serious problem. This fact was first noticed in the year 1980. Depletion of ozone layer is noticed all over the earth. It is observed that around 40 to 50% depletion in ozone layer occurs in the south polar region. Such a large reduction is called ozone hole. Such ozone holes were later noticed in North polar region also. The probability of development of ozone holes also exists in other regions where human inhabitation is present. Where this will occur or not depends on the prevalent wind, climatic conditions and suspended particulate matter in the atmosphere.

The main factor responsible for the depletion of ozone layer is the addition of Cl in the atmosphere. The chlorine atom reacts with ozone and removes an atom of O one by one. One atom of chlorine can decompose 100,000 molecules of ozone in this fashion. The most important compound which accounts almost 80% of the total depletion of ozone in the stratosphere is chlorofluorocarbon (CFC). One such substance, Freon, is used in refrigerator and airconditioners.

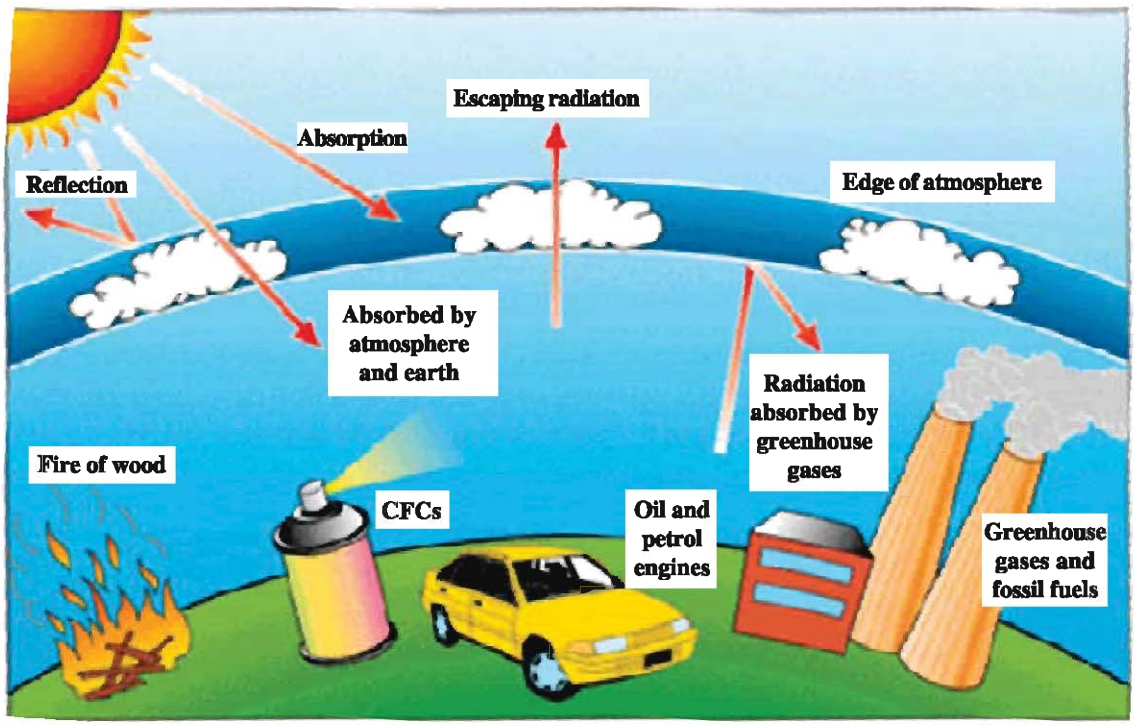


Fig. 17.4 Depletion of ozone layer

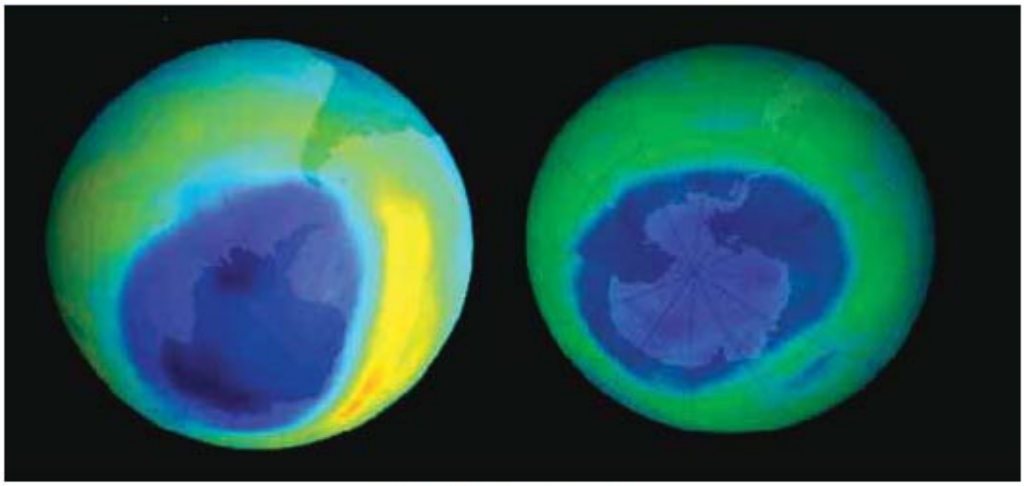


Fig. 17.5 Ozone holes

17.5 Household Waste Management

Wastes are unwanted, unusable items, remains or byproduct of household garbage. The waste generated in our homes are classified into two major forms namely solid and liquid. The liquid forms are easy to handle and manage. They can be connected from their sources to septic and soak away pits. The solid wastes are relatively different in their management.

Studies indicate that on an average, each person in urban areas produces half a kilogram of garbage everyday. This garbage takes up precious land and is a major source of disease. Just a few kilos of putrid garbage can cause a dangerous epidemic disease. If we continue to accumulate garbage at the current rate, our children and grandchildren will have no hope for a quality life in future. Therefore, it is important to reduce the amount of waste we produce. This can be done in the following ways :

- Buy loose fruits and vegetables in order to avoid packaging
- Do not buy disposable items such as razors and pens
- Use reusable nappies
- Buy reusable carry bags from supermarkets
- Use rechargeable batteries
- Do not throw old clothes and shoes but donate them
- Reuse the back of papers as scrap paper
- Put kitchen waste inside the bags or container as soon as they are generated and as soon as they are filled dispose them at the designated place.

Waste in our homes, though unwanted, can be a source of extra income when properly managed.

What have you learnt ?

All organisms including plants, animals and human beings and their physical surroundings with which they interact is called environment. A change in any component of environment may cause discomfort and affect normal life of living organisms.

Unwanted, unusable items, remains and biproduct of household garbage are called waste. Wastes are classified into two forms : solid and liquid. The waste materials which are broken

by biological processes are called biodegradable and those which are not broken down by biological processes are called non-biodegradable.

The biotic community, together with physical environment forms an interacting system called as ecosystem. Based on the kind of habitat, an ecosystem may be aquatic and terrestrial. Aquatic ecosystem may be fresh water or marine. Each ecosystem consists of biotic and abiotic components. Biotic components may be producers or consumers while abiotic components include soil, water, light, air, temperature, wind, rain, humidity inorganic nutrients and dead organic matter.

Living organisms depend on each other for their food requirement and form a chain which is termed as food chain. A food chain describes how energy and nutrients move through an ecosystem. However, the trophic inter-relationship between animals in nature cannot be explained as simple food chains only. Among the various ecosystems, each one is having definite food chain. The individuals involved are also linked with food chains of other ecosystem. In this way, the animals are inter-dependent for food and they form a net which is termed as a food web.

Global warming and depletion of ozone layer, biodiversity and ecosystem losses, fisheries' depletion, deforestation, water deficits, waste disposal and pollution are global problems faced by the living organisms.

The ozone layer is located in the stratosphere. This layer absorbs UV radiations from the sunlight and prevents it from reaching the earth. However, the depletion of the ozone layer is reported all over the earth. The main factor responsible for the depletion of ozone layer is the addition of Cl in the atmosphere.

It is essential to reduce the amount of waste we produce. This can be done in the following ways :

Buy loose fruits and vegetables in order to avoid packaging, do not buy disposable items such as razors and pens, use reusable nappies, buy reusable carry bags from supermarkets, use rechargeable batteries, donate old cloths and shoes, reuse the back of papers as a scrap paper and put kitchen waste inside the bags or container as soon as they are generated and as soon as they are filled up dispose them at the designated place.

EXERCISE

1. Select the proper choice from the given multiple choices :

(1) Which of the following is an example of biodegradable waste :

(A) Vegetables (B) Glass (C) Plastic (D) Metal

(2) Which of the following is an example of non-biodegradable waste :

(A) Fruits (B) Vegetables (C) Paper (D) Polythene

(3) Ecosystem is an interacting system made up of :

(A) Organisms and their physical surroundings

(B) Producers and consumers

(C) Producers and their physical surroundings

(D) Consumers and their physical surroundings

(4) The structural and functional unit of the environment is known as :

(A) Food chain (B) Food web (C) Ecosystem (D) None of them

(5) First order consumers are :

(A) Carnivores (B) Herbivores (C) Decomposers (D) Omnivores

(6) Omnivorous organisms consume :

(A) Only plants (B) Only animals

(C) Plants and aminals both (D) Microorganisms

(7) Edaphic factors are included in :

(A) Abiotic components (B) Biotic components

(C) Producers (D) Consumers

(8) How many molecules of ozone can be decomposed by one atom of chlorine ?

(A) 10,000 (B) 1,00,000 (C) 1,000,000 (D) 1000

(9) The most important compound which accounts for almost 80% of the total depletion of ozone layer is :

(A) Chloride ion (B) Sulphur ion

(C) Chlorofluoro carbon (D) Magnesium ion

2. Answer the following questions in brief :

(1) What is an environment.

(2) Define ecosystem.

(3) Define food chain and food web.

(4) Give examples of solid waste.

(5) What do you mean by biodegradable waste ?

(6) Give examples of non-biodegradable waste.

(7) How ozone is formed ?

(8) Name compounds responsible for depletion of ozone layer.

3. Write answers of the following questions :

(1) Describe the types of waste.

(2) Explain the components of an ecosystem.

(3) Explain food chain giving suitable example.

(4) Explain food web giving suitable example.

(5) What are the global problems ?

(6) How amount of household waste can be reduced ?

4. Answer the following questions in detail :

(1) Explain Food Chain (with figure)

(2) Explain Food web (with figure)

UNIT

18

MANAGEMENT OF NATURAL RESOURCES

Man depends on the nature for his requirements. For thousands of years the earth has been fulfilling our basic requirements like air, water, light, habitat, food and clothes. Our increasing demand of energy, as a result of our cultural evolution, development of agriculture and technological advances is also fulfilled by the earth.

The naturally occurring resources, which cannot be created by man, are termed our natural wealth. Those components of the atmosphere, hydrosphere and lithosphere which can be used for the maintenance of life are called natural resources e.g., water, land, forest, minerals, plants and animals.

In Std. IX, we have studied some of the natural resources and how various components are cycled over and over again in nature. In this chapter we shall study some of the natural resources like forest, wild life, coal and petroleum and how these resources are to be managed for sustainable development.

18.1 How We Should Make Use of Natural Resources

On this earth, man is the most developed organism. He is able to speak fluently, can write legibly and has curiosity to know new things. For making life luxurious and comfortable, man started adopting industrialization and started building roads, canals, dams, houses, satellites, cars, motors, ships, aeroplanes, submarines, missiles, rockets etc. To achieve his goal, man has destroyed nature to a great extent, so much so that even the natural products, environment etc, are also destroyed. Man has cut forests and ground plants for agriculture, shelter and factories and developed villages and cities. In natural surroundings, he has built his own social and cultural environment using various instruments, skills and intelligence. All these activities have caused an imbalance in the environment.

It will be a huge error if man continues to believe that all his essential natural resources are unlimited and he can exploit them in any way or in any amount as per his wishes. An indiscriminate

and rampant use of natural resources are creating serious danger for existence of humans and their culture.

The amount of water, trees, minerals and other natural resources on the earth is limited while the number of people using these resources is growing rapidly. But the number of people is not the real problem. The problem is how these natural resources are used. Whenever one person or group of people uses more than their fair share of resources, or causes an excess of pollution, this imbalance can lead to environmental health problems for others. Hence there is a need to use natural resources rationally and judiciously.

18.2 Applications to Save Environment

You must have come across three R's to save the environment. These are Reduce, Recycle and Reuse.

(A) Reduce : This indicates minimization of use of natural resources. One can save electricity by switching off unnecessary lights and fans. Water can be saved by avoiding misuse and wastage of water, by repairing the leaking taps or even by developing a proper distribution system of available water. We can reduce the use of LPG by making use of solar cooker for cooking food. If the mineral resources are used sensibly and repeatedly, mining and dredging for their search can be reduced.

(B) Recycle : Plastic, papers, glass, metals and scraps produced by the industries can be melted at appropriate temperature and new materials can be produced. This process is known as recycling. In order to recycle, we first need to segregate our wastes so that the material that can be recycled is not dumped along with other wastes.

(C) Reuse : As the process of recycling uses some energy, the method of reuse is always considered better. Pieces of colored glass, cups and plates made of china clay, ceramic tiles, etc. can be used to make decorative wall pieces. The plastic bottles in which you buy various food items like jam or pickle can be used for storing things like salt, sugar, tea leaves, pulses etc. in the kitchen.

18.3 Why do We Need to Manage Our Resources

All the things like food, clothes, furniture, fuels, vehicles, water etc. which we use are obtained from the resources on this earth. As the resources on the earth are limited while the human population is increasing at a tremendous rate, the demand of resources is also increasing day by day. Hence, proper management is required to ensure that the natural resources are used judiciously.

The proper management can ensure equitable distribution of natural resources so that all the people can benefit from the development of these resources.

The proper management will take into consideration the damage caused to the environment during extraction or use of the natural resources and find ways and means to minimize this damage. For example, if some trees have to be cut for some reason, then the damage to the environment can be minimized by planting new saplings in place of cut out trees.

18.4 Forest and Wild Life

(1) Forests : We all know that forests are our most valuable resources. We get food, fodder, fibres, timber, fuel wood, medicines, gum, resins and bamboo from the forest. Bamboos are mostly used to make slats for huts and baskets for storing things. However, with the increasing population of human being, forests have been cut down. At present forest area and its quality have remarkably decreased. In our country only 768436 sq. km. area is under the forest which covers 23.38 percent of the total land area. In Gujarat total 18999 sq. km. area is covered by the forest which constitutes 9.69 percent of the total land area.

Forest cover of the world is rapidly depleting. It is more rapid in developing countries. The reasons are : rapidly increasing population, industrialization and urbanization. Destruction of the forest is very rapid, particularly in the tropical region. Deforestation has serious effects. Deforestation induces changes in the regional and global climate. Due to the destruction of forests, the rain fall decreases. Loss of forest cover causes increase in soil erosion, decrease in the fertility of land, increase in the amount of CO_2 and temperature in the atmosphere. This leads to green house effects.

In our country the rate of deforestation is very high. If deforestation continues at the same rate, the day is not far off when we may be deprived of all these things which we get from forest. Therefore, we must conserve forest in the following ways:

- Scientific methods should be adopted for harvesting the forests.
- Scientific methods should be adopted to monitor proper rate of forestation and deforestation.
- Forest should be protected from fire.
- Unauthorised felling of trees should be prevented.
- Fast growing tree should be planted.
- Social forestry should be adopted. People should plant fast-growing trees on available land such as boundaries of fields, along the road sides and railway tracts, along canals etc. to get fire wood, fodder, timber, fruits etc.

In our country there are instances where local people working traditionally for conservation of forests. For example, the case of Bishnoi community in Rajasthan, for whom conservation of forest and wild life has been a religious tenet. The Government of India has recently instituted an Amrita Devi Bishnoi National Award for wild life conservation in memory of Amrita Devi Bishnoi who in 1731 sacrificed her life along with 363 others for the protection of Khejri trees in Khejrali village near Jodhpur in Rajasthan.

(2) Wild life : Normally we imagine dangerous animals such as elephant, tiger, lion, python, crocodile as wild life. But when put in the definition of wild life, those animals that are not domestic, those plants that cannot grow by agriculture and microorganisms are also included.

Wild life is not only economically beneficial but it is also an important component of the food web of ecosystem. Therefore, it is helpful in maintaining the balance of the ecosystem. The main importance of wild life is success of the gene bank. Men use them for developing many varieties of plants and animals in agriculture, animal husbandry, fishery etc.

Those plants and animals that are on the threshold of getting destroyed or extinct are called endangered wild species. Bear, elephant, tiger, lion, rhinoceros, snow leopard, gudkhar, dugong, Kashmiri stag, a deer called Baresingha and Deer of Manipur, several birds like Pheasant, Great Indian bustards, Florican, Hornbill etc. are endangered species. While reptiles like Python, Wall lizard, Crocodile, and many types of Tortoise are endangered species. Many plant species are also endangered. Endangered plant species are published in the book called Red Data Book.

The importance of wild life has been recognized by all the countries of the world. In our country several laws are framed for the protection of environment and wild life of which the main act is Wild Life Conservation Act of 1972. Many areas have been declared as sanctuaries and many are declared as national parks in order to protect wild life and to increase their number. In national parks wild lives are allowed to survive without interference with human activities. In sanctuaries also wild life is protected but many necessary human activities are allowed. As per the current report of 2010, in our country a total of 88 national parks and 441 wild life sanctuaries are there. While in Gujarat, there are 4 national parks and 21 wild life sanctuaries.

Lion

Barehsinga

Fig. 18.1 Endangered wild species

18.5 Stalkeholders of Forest

When we consider the conservation of the forest, following are the stalkeholders who take part in the management of forest.

(1) The people who live in or around forests are dependent on forest produce for various aspects of their life. These people get firewood from the forest tree. They cut the branches and pluck leaves but do not cut down the whole tree. They cut bamboo for making their huts and baskets. They make use of wood for making agricultural implements and collect fruits, fodder, medicines from the plants. In fact people living near or in the forest had developed practices to ensure that the forest resources should be used in a sustainable manner.

(2) The forest department of the government which owns the land and control the resources from the forest. The forest is a good source of revenue for the government. Most of the revenue comes from the sale of cut down trees for the timber. In order to plant trees for timber such as pine, teak and eucalyptus, huge area of the forest is cleared of all vegetation. This destroys a large amount of biodiversity in the area which harms the environment. The forests are also damaged by constructing the dams in the forest as well as building the roads through the forest.

(3) The industrialists who use various forest products and consider the forests as merely a source of raw materials for their industry. Timber industry, paper manufacturing industry, lac

industry and sports equipment industry are mostly dependent on forests. For making bidies, tendu leaves are used. The main source of tendu leaves is forest.

(4) The wild life and nature enthusiasts who want to conserve nature in pristine form (original form). These people are not dependent on the forests, but they want that forest and wild life should be conserved to prevent the damage to the environment. The example of the naturalists towards the conservation of forest is Chipko Andolan (Hug the trees movement). The Andolan was originated from an incident in a remote village called "Reni" in Garhwal in the early 1970s. There was a dispute between local villagers and a logging contractor who had been allowed to fell trees in a forest near the village. One day the contractor's workers appeared in the forest to cut the trees but the men folk were absent. However, the women from the village reached the forest quickly and clasped the tree trunks preventing the workers from felling the trees. Thus the forest trees were saved.

Fig. 18.2 Chipko Andolan

18.6 Water

Life is impossible without water. Water plays a key role in a control of climatic conditions. The water in the seas absorbs or releases heat and helps to maintain the atmospheric temperature by keeping it cool or warm. Water is used in agriculture, industries and in the production of electricity. Usually man depends upon fresh water. The earth depends mainly on rain to maintain the quantity of fresh water. Irregularities in rainfall leads to either floods or drought causing disaster. Fresh water is a key factor in the lives of man and other living organisms.

(1) Water for all : Some parts of our country have good resources of water while in other parts there is a shortage of water. The regions having good availability of water are flourishing because they have good crops but the regions having shortage of water are facing poverty because of poor crop growth. It is therefore, necessary to have a proper management system so that there is a uniform distribution of water to all the regions.

There are three sources of fresh water – the rainfall, the riverstreams and the ground water.

Rainwater is available in monsoon only. As monsoon lasts for a few months, most of the rain water lasts for a few months only. This rain water fills lakes and ponds and also flows into rivers. Some rain water also percolates into ground and become available as ground water. Rain water is stored in lakes for use over a long period of time. There are many natural lakes in our country but in order to meet the increasing demand of fresh water many artificial lakes are made.

Rivers are another important sources of water. In our country, rivers flow across diverse regions. Some of these rivers are large and are perennially filled with water. Rivers get their water supply from the melting of snow lying on the peaks of snow mountains.

The water inside the soil is called groundwater. This water which has percolated deep into the ground is clean. We are at present, utilizing nearly 25% ground water. Most of it is used in agriculture. The availability of this water is decreasing due to its overuse and deposition of salts and pollutants in it.

(2) Water related problems : More than 40 % of the world population lives in arid or semi-arid regions. Regions of Saurashtra and North Gujarat in our state are also semi-arid. Arid desert occurs in Kachchh. People living in such regions spent a major part of life in gathering water. A huge amount of wealth and manpower are used in other regions also in obtaining potable water, water for agriculture and water for industries. Due to over-exploitation, water levels are going down in rivers, lakes and ponds. This also affects the surrounding wetlands, which then dry up. Large amount is also sucked out from the ground water to meet the increasing demand. Looking to this, it is obvious that water conservation and water management require immediate attention.

(3) Water Management : Water management means a program to provide an adequate supply of good quality of water for different purposes without causing any harm to the source of water. Some of the approaches to water management are as under :

1. In hilly areas or flood prone areas, big water reservoir, ponds or dams should be constructed so that rain water and used water may be stored. This water percolates gradually and becomes ground water.
2. Canals should be constructed from the areas of excess water to the desert areas.
3. Domestic used water or municipal water should be recycled and should be used for irrigation.
4. By distillation, salt contents of sea water should be removed so that it may become drinkable. This is being adopted in Bhavnagar.
5. Excess use of water and wastage should be prevented as far as possible.

Fig : 18.3 Narmada Canal

(4) Dams : For the storage of water smaller or larger dams can be constructed across the flow of water in rivers. In our country dams have been constructed across many rivers. The large reservoir of a dam stores a huge amount of water. This stored water is then allowed to flow downstream at the desired rate . In Gujarat state such two dams have been constructed.

(1) Dharoi dam has been built across the Sabarmati river in Dharoi village.

(2) Sardar Sarovar dam has been built across the Narmada river in Kevadia village.

Dams are useful to the society in the following ways :

(1) Water from a dam is used for irrigation in fields through a network of canals. Dams ensure round the year water supply to the crop fileds.

(2) Water from a dam is supplied to the people in towns and cities through pipelines after suitable treatment.

(3) The falling water from the dams is used for generating electricity.

Fig : 18.4 Sardar Sarovar Dam

18.7 Coal and Petroleum

Coal and petroleum are fossile fuels. They are important sources of energy for us. Since the industrial revolution, we have been using increasing amounts of energy to meet our basic needs and for the manufacture of a large number of goods upon which our lives depend. These energy needs have been largely met by the reserves of coal and petroleum. The use of coal and petroleum and their products in the world economy is immense. Coal is an important fuel source as its energy is converted into other forms of energy such as electricity, steam and coal gas. It is used as a fuel as such in homes and in industry or it is used to generate electricity at thermal power plants.

Petroleum is often referred to as liquid gold due to its importance as a fuel in transport to run scooter, motorcycles, cars, buses, trucks, trains, ships and aeroplanes. It is used in forms of petrol, diesel, kerosene, gas oil, fuel oil etc. Kerosene and LPG (Liquefied Petroleum Gas) obtained from

petroleum are used as domestic fuel for cooking food. Petroleum is a source of over hundred and fifty petrochemicals used in industrial and consumer applications. The prosperity of any country depends upon petroleum reserves.

18.8 Management of Coal and Petroleum

The management of these non-renewable energy sources involves slightly different perspective from those resources discussed earlier in the term of policy and technology issues. One way of conservation and managing of these resources is to substitute existing technology so that hydrocarbon fuels are more efficiently used or used less. For example, the use of vehicles with more efficient mileage and exhaust characteristics is a substitution of fuel. Some technologies in cars now use alternate fuel in combination with petrol (alcohol mixed petroleum) or completely use biofuel. Biogas can replace liquid petroleum fuel for cooking in rural areas.

Finding non conventional and renewable sources can also conserve these resources. Power generation technologies can be developed by using wind energy through windmills, hydro energy and nuclear energy for generating electricity. Steam turbines and solar energy based technologies can be used to reduce the dependence on hydrocarbon fuels. Following steps can be taken to conserve energy resources :

- Switch off the lights, fans, television and other electrical appliances when not needed.
- Make use of stairs instead of lift at least upto two to three floors in a building.
- Pressure cookers should be used to save the fuels.
- Public transport system (local buses and trains) in the cities should be made available so people do not use their own vehicles to commute.
- Bicycles can be used to cover short distances.

What have you learnt ?

Man depends on nature for his requirement. The naturally occurring resources, which cannot be created by man, are termed our natural wealth. e.g., water, land, forest, minerals, plants and animals.

It will be a huge error if man continues to believe that all the essential natural resources are unlimited and he can exploit them in any way or in any amount as per his wishes. An indiscriminate and rampant use of natural resources are creating serious danger for existence of humans and their culture. Three R's namely reduce, recycle and reuse, have been suggested to save the environment.

We all know that forests are our most valuable resources. At present forest area and its quality have remarkably decreased. In our country only 768436 sq. km. area is under the forest which covers 23.38% of the total land area. In Gujarat total 18999 sq. km. area is covered by the forest which constitutes 9.69 % of the total land area. Due to the destruction of forests, the rain fall decreases. Loss of forest cover causes increase in soil erosion, decrease in the fertility of land, increase in the amount of CO_2 and temperature in the atmosphere. This leads to green house effects.

Those animals that are not domestic, those plants that cannot grow by agriculture and microorganisms are considered as wild life. Those plants and animals that are on the threshold of getting destroyed or extinct are called endangered wild species. The importance of wild life has been recognized by all the countries of the world. In our country, several laws are framed for the protection of environment and wild life of which the main act is Wild Life Conservation Act of 1972. Many areas have been declared as sanctuaries and many are declared as national parks in order to protect wild life. The stalkeholders of forest are : (1) The people who live in or around forest, (2) The government Forest Department (3) The industrialists (4) The wild life and nature enthusiasts.

Water plays a key role in control of climatic condition. The earth depends mainly on rain to maintain the quantity of fresh water. Irregularities in rainfall leads to either floods or drought causing disaster. Fresh water is a key factor in the lives of man and other living organisms. There are three sources of fresh water - the rainfall, the riverstreams and the ground water.

More than 40 % of the world population lives in arid or semi-arid regions. A huge amount of wealth and manpower are used in other regions also in obtaining potable water, water for agriculture and water for industries. Due to over-exploitation, water levels are going down in rivers, lakes and ponds. This also affects the surrounding wetlands, which then dry up. Large amount of water is also sucked out from the ground water to meet the increasing demand. Looking to this it is obvious that water conservation and water management require immediate attention.

The use of coal and petroleum and their products in the world economy is immense. Coal is an important fuel source as its energy is converted into other forms of energy such as electricity, steam and coal gas. It is used as a fuel as such in homes and in industry or it is used to generate electricity at thermal power plants. As these resources are limited, there is a need to conserve and manage them properly.

EXERCISE

1. Select the proper choice from the given multiple choices :

(1) To reduce the use of LPG by making use of solar energy is an example of :

(A) Recycle (B) Reduce (C) Reuse (D) none of them

(2) How much area is under the forest cover in our country ?

(A) 758330 sq. km. (B) 768436 sq. km.

(C) 750093 sq. km. (D) 749832 sq.km.

(3) In Gujarat how much area is covered by forest ?

(A) 9.32 % (B) 9. 86 % (C) 9.69 % (D) 9.99 %

(4) In which year Amrita Devi Bisnoi sacrificed her life for the protection of khejri trees ?

(A) 1731 (B) 1763 (C) 1783 (D) 1873

(5) Names of endangered plant species are published in :

(A) Green Data Book (B) Red Data Book

(C) Endangered species book (D) Yellow Data Book

(6) How many National Parks are there in Gujarat ?

(A) 5 (B) 4 (C) 21 (D) 24

(7) Which of the following dams is constructed in Gujarat ?

(A) Narmada Dam (B) Sardar Dam

(C) Sardar Sarovar Dam (D) Tapi River Dam

(8) Which one of the following is considered as liquid gold

(A) Kerosene (B) Diesel (C) Petroleum (D) Fuel oil

2. Answer the following questions in brief :

(1) What creates serious danger for existence of humans and their culture ?

(2) Mention three R's which can save the environment.

(3) Define natural resources.

(4) Define wild life.

(5) What are the reasons for depletion of forests ?

(6) What leads to green house effect ?

(7) What do you mean by social forestry ?

(8) Name bird species which are considered as endangered species.

(9) Name reptiles which are considered as endangered species.

(10) In our country how many sanctuaries and national parks are there ?

(11) Mention the sources of fresh water.

(12) How dams are useful to the society ?

3. Write answers of following questions :

(1) Why we need to manage our resources ?

(2) It will be a huge error if man continues to believe that all natural resources are unlimited : Explain

(3) How recycle can save the environment ?

(4) How can we conserve the forest ?

(5) Give an example indicating local people working traditionally for conservation of forest.

(6) What are the consequences of loss of forest cover ?

(7) What are the differences between sanctuaries and national parks ?

(8) Who are the stakeholders of forest?

(9) Give the importance of Chipko Andolan.

(10) Explain water related problems .

(11) Explain approaches to the water management.

(12) What steps could be taken to conserve energy resources ?