4 AIR AND ITS CONSTITUENTS

In This Chapter You Will Learn :

- constituents of air ; air as a mixture ; the importance of the gases present in air ; air pollution and acid rain
- occurrence of oxygen
- preparation of oxygen ; properties of oxygen : burning (formation of oxides) and rusting; tests and uses of oxygen ; regeneration of oxygen in the atmosphere
- occurrence of carbon dioxide ; preparation of carbon dioxide ; properties of carbon dioxide; importance of carbon dioxide ; green house effect and global warming.

INTRODUCTION

- You know that, among food, water and air the most essential substance for the survival of life is ***air***. It is used for respiration by all kinds of living beings.
- Air helps in burning and producing heat energy.
- Air is invisible and transparent because it is a mixture of colourless gases..
- Although we cannot see air, we can feel its presence.

OCCURRENCE

- Air occurs in the atmosphere which surrounds the earth and extends to about 320 km above its surface.
- Air also occurs in water in dissolved state which helps aquatic plants and animals to survive.

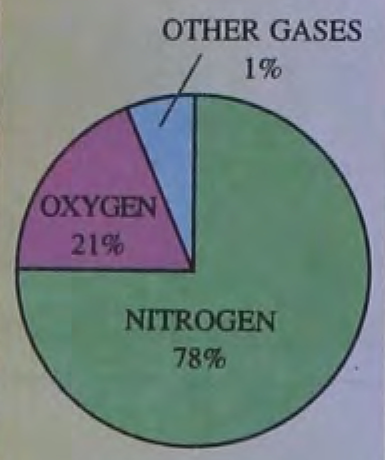
A. AIR : A Mixture of Gases

4.1 CONSTITUENTS OF AIR

The main constituents of air are nitrogen and oxygen. It also contains carbon dioxide and water vapour in small amounts. Inert gases and ozone are also present in trace amounts in air.

Apart from these gases, air also contains some impurities, like sulphur dioxide, hydrogen sulphide, nitrogen dioxide, dust particles, *etc.*

Table 4.1 Percentage proportions of gases in air by volume

Gases	*% proportion*	*Diagram*
Nitrogen	78%	
Oxygen	21%	
Carbon dioxide	0·03% - 0·04%	
Inert gases	0·9%	
Water vapour	Variable	
Dust particles (aerosols)	Variable	
Impurities	Variable	

In ancient times air was considered as an element but now it has been proved that air is a mixture of gases. This was proved by Antoine Lavoisier in 1774 with the help of an experiment.

Lavoisier's Experiment to show that nitrogen and oxygen are the main constituents of air :

Lavoisier took some mercury in a retort and heated it. The other end of the retort was connected to a bell jar containing air. The bell jar was kept in an inverted position over mercury contained in a trough as shown in the figure below.

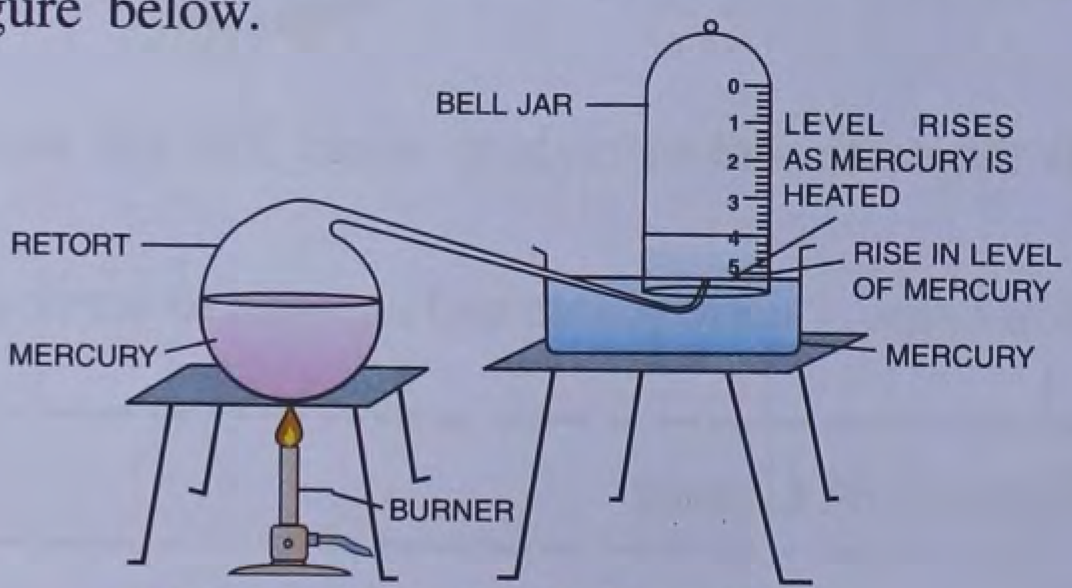


Fig. 4.1 : Lavoisier's Experiment

The following were his observations :

1. A red layer of mercuric oxide was formed on the hot surface of mercury in the retort.
2. The level of mercury in the trough rose by $\frac{1}{5}$th of the total volume of the bell jar.

The following were his conclusions :

1. The $\frac{1}{5}$th portion of air in the bell jar was used up by mercury in the retort to form the red substance. This air was ***active air***. This could be re-obtained when the red substance was heated. This gas supported burning better than air and also supported life. Lavoisier named this active air as ***"oxygen"***.

$$\text{Mercury} + \text{Oxygen} \xrightarrow{\text{heat}} \text{Mercury (II) oxide (Red powder)}$$

$$2\,Hg + O_2 \xrightarrow{\text{heat}} 2\,HgO$$

$$\text{Mercury (II) oxide} \xrightarrow{\text{heat}} \text{Mercury} + \text{Oxygen}$$

$$2\,HgO \xrightarrow{\text{heat}} 2\,Hg + O_2$$

2. The remaining $\frac{4}{5}$th portion of air in the bell jar was ***inactive air*** as it did not support burning of air. It was found that this inactive air neither supports combustion (burning) nor life. The $\frac{4}{5}$th air in the bell jar was tested by putting a burning candle into the gas. The flame was extinguished. It did not support life. The gas was named as **azote** meaning unsuitable for life. Later on Lavoisier named it as ***"nitrogen"***.

From above it is clear that air contains $\frac{1}{5}$th by volume of oxygen and $\frac{4}{5}$th by volume of nitrogen, *i.e.*, nitrogen and oxygen are present in air in the ratio of 4 : 1 by volume. The rest of the gases are in very small amounts.

Activity 1

To show that air contains carbon dioxide

Take a test tube fitted with a two-holed rubber-cork. Fit a long bent tube through one hole and fit a short bent tube through the other hole. Pour some lime water (calcium hydroxide solution) into the test tube.

Blow air by air pump through the long tube. You will observe that air bubbles through lime water and after some time the lime water turns milky.

This shows that *air contains carbon-dioxide*.

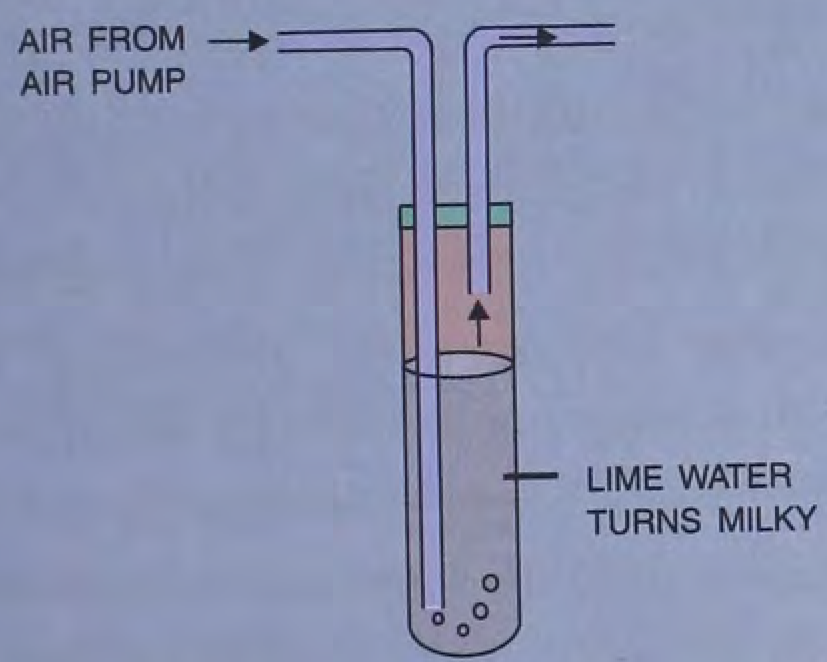


Fig. 4.2 : Air contains carbon dioxide

Note : Lime water is used as a chemical test to identify carbon-dioxide gas because the two substances react to form an insoluble white solid calcium carbonate which turns the lime water milky.

Lime-water + Carbon dioxide → Calcium carbonate + Water

$$\underset{(aq)}{Ca(OH)_2} + CO_2(g) \rightarrow \underset{\text{(white precipitate)*}}{CaCO_3\downarrow} + H_2O$$

[*Precipitate : An insoluble solid formed in water (solvent) is called a precipitate.]

Activity 2

To show that water vapour is present in air

Take a glass tumbler. Fill it half with ice cold water. You will observe that fine water droplets get deposited on the outer wall of the glass tumbler. These droplets have certainly not passed through the material of the glass tumbler from inside.

These water droplets have come from air. Due to the cold surface of the glass tumbler, the water vapours present in air get condensed into droplets.

This proves that *air contains water vapours*.

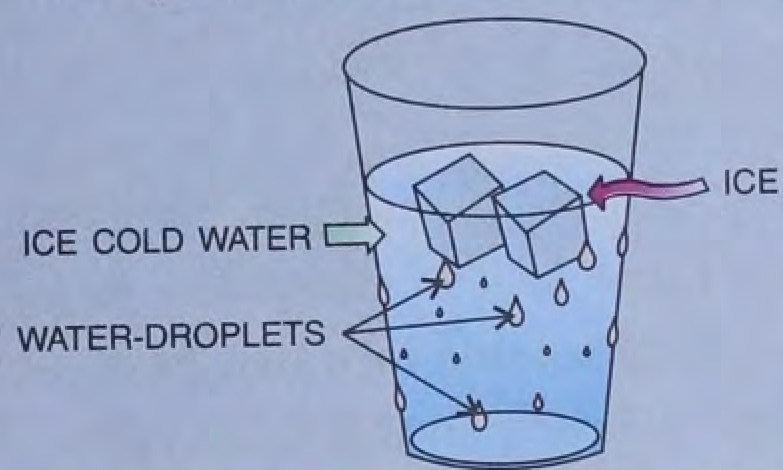


Fig. 4.3 : Air contains water vapours

There are enough evidences to show that air is a mixture and not a compound.

1. The composition of air varies from place to place and from time to time.
2. The components of air retain their individual properties.
3. Liquid air has no definite boiling point.
4. No energy exchange occurs when the components of air are mixed with each other.
5. Components of air can be separated by simple physical methods.
6. Air is not represented by a chemical formula as it is a mixture.

4.2 THE IMPORTANCE OF THE VARIOUS COMPONENTS OF AIR

4.2.1 Nitrogen

Nitrogen constitutes about 78% of air by volume. It is the main constituent of air. It does not support burning but controls it. If nitrogen is not present in the atmosphere then even small sparks would become large fires.

Physical properties of nitrogen

1. It is a colourless, odourless and tasteless gas.
2. It is slightly lighter than air as a whole. (Vapour density of air is 14.4 and that of nitrogen is 14).
3. It is both non-combustible and a non-supporter of combustion.
4. It is non-poisonous but animals die because of suffocation created by nitrogen and lack of oxygen.
5. It is slightly soluble in water. Its solubility in water is less than that of oxygen.

Uses of nitrogen

1. It dilutes the effect of oxygen present in air and thus controls the rate of combustion.
2. It is an important constituent of proteins, which is necessary for the growth of animals, plants and human beings. Plants convert nitrogen into proteins.
3. It is used in the manufacture of nitrogenous compounds like ammonia and nitric acid.

> During a thunderstorm, when lightning occurs, nitrogen and oxygen (present in the air) combine to form oxides of nitrogen, which are washed away by rain into the soil in the form of **nitric acid.**

4. It is used to make fertilizers like potassium nitrate, ammonium sulphate, urea, *etc*.
5. It is used to prepare explosives, which are unstable substances that release huge volume of gases quickly with lots of energy. *e.g. :* trinitrotoluene (T.N.T.), nitroglycerine, etc.

Do You Know ?

- Most of the chemical explosives contain nitrogen.
- Explosives are used to make bombs.

6. It is used for the preservation of foods, since it does not easily react. The containers used for storing foodstuffs are flushed with nitrogen to remove oxygen before they are sealed. The absence of oxygen does not allow bacterial growth. Thus, food remains fresh for a long time.

Nitrogen-cycle : Nitrogen is of vital importance to plants, animals and human beings as it forms a part of proteins in every living being. A constant life cycle keeps nitrogen balance. Plants get nitrogen from the soil, animals and human beings get it from plants or other animals. When plants and animals die, they decay and nitrogen is returned to the soil.

Do You Know ?

The circulation of nitrogen through the living and non-living compounds of the biosphere (air, water, soil, plants and animals) is called nitrogen cycle.

Nitrogen fixation : Nitrogen cannot be absorbed directly in its free form by plants. It

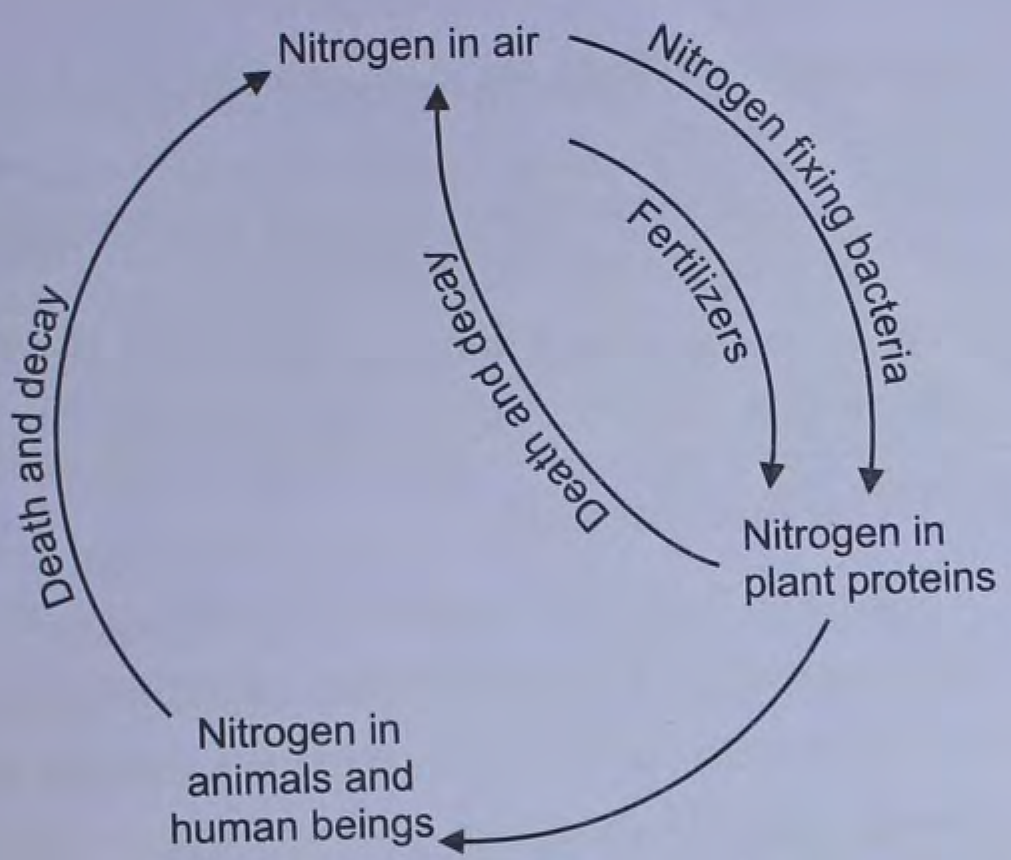


Fig. : 4.4 A nitrogen cycle.

is first converted into its compounds (nitrates and nitrites) and then absorbed by the plants.

Following are the processes by which nitrogen is converted into its compounds and vice versa.

1. Biological fixation :

(A) Symbiotic bacteria (Rhizobium) living in the root nodules of leguminous plants (plants that have nodules on their roots) like peas, grams, beans, *etc*., absorb nitrogen directly from the air and convert it into nitrates. Thereafter, the plants convert it into proteins. Some non-leguminous plants like senus and Ginkgo can also fix nitrogen.

Fig. 4.5 : Root nodules in leguminous plants

Leguminous plants

1. Root nodules (containing symbiotic bacteria) $\xrightarrow{\text{convert}}$ 2. Free nitrogen (in air and soil) $\downarrow$ to 3. Soluble nitrates [in soil] $\xrightarrow{\text{converted by plants into}}$ 4. Proteins

(B) Nitrogen is returned to the soil when plant and animal matter decays. This decomposition work is done by organisms called denitrifying bacteria, which re-convert dead organic tissue into its constituent nitrogen.

2. Non-biological fixation :

During lightning, temperatures often reach as high as 3000°C. At such high temperatures, nitrogen and oxygen present in the air combine to form nitric oxide, which further reacts with oxygen to form nitrogen dioxide.

$$\underset{\text{(nitrogen)}}{N_2} + \underset{\text{(oxygen)}}{O_2} \xrightarrow[\text{discharge (temp. > 2500°C)}]{\text{electric}} \underset{\text{(nitric oxide)}}{2NO}$$

$$\underset{\text{(nitric oxide)}}{2NO} + \underset{\text{(oxygen)}}{O_2} \longrightarrow \underset{\text{(nitrogen dioxide)}}{2NO_2}$$

Nitrogen dioxide then reacts with the water vapours present in the air to form nitrous and nitric acids.

$$2NO_2 + H_2O \longrightarrow \underset{\text{(nitrous acid)}}{HNO_2} + \underset{\text{(nitric acid)}}{HNO_3}$$

Nitric acid, so formed, reaches the earth along with rainwater, and reacts with metal carbonates to form metal nitrates, which help in the growth and development of plants.

$$\underset{\text{(calcium carbonate)}}{CaCO_3} + \underset{\text{(nitric acid)}}{2HNO_3} \longrightarrow \underset{\text{(calcium nitrate)}}{Ca(NO_3)_2} + \underset{\text{(water)}}{H_2O} + \underset{\text{(carbon dioxide)}}{CO_2}$$

Lightning discharge

Nitrogen + O_2 (air) $\xrightarrow[\text{spark}]{\text{electric}}$ Nitric oxide $\xrightarrow[\text{(air)}]{O_2}$ Nitrogen dioxide

Nitrogen dioxide $\xrightarrow[\text{(air)}]{H_2O}$ Nitric acid

Soluble nitrate $\xleftarrow[\text{Soil}]{\text{Mineral}}$ Nitric acid

Note : Acid rain is a bad effect of this natural process.

4.2.2 Oxygen

Oxygen constitutes about 21% of air by volume. It is the active part of air.

Uses :

1. It supports life on the earth. All living beings need oxygen for respiration*.
2. It is essential for the process of combustion. Fuels burn in oxygen to produce carbon dioxide, water, and energy in the form of heat and light. This energy is used by human beings for multiple purposes.
3. Oxygen dissolved in water supports aquatic life.

(For details, see Section B of this chapter).

Fuels : They are the substances which burn in air to produce a large amount of energy in the form of heat and light.

Fuel + Oxygen $\xrightarrow{\text{heat}}$ Carbon dioxide + Water + Energy

$2C_4H_{10} + 13O_2 \xrightarrow{\text{heat}} 8CO_2 + 10H_2O$ + Heat energy
(Butane)

* Respiration is a chemical process in which oxygen in the air is used by all living things to oxidise their food and gain energy.

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + Energy
(glucose)

Some common fuels are coal, wood, LPG, CNG, petrol, diesel, *etc*.

LPG is liquefied petroleum gas used as a household fuel (contains butane and isobutane)

CNG is compressed natural gas. It contains methane gas.

4.2.3 Carbon dioxide

Carbon dioxide is present in air in a very small quantity. The percentage proportion of this gas varies from 0·03 to 0·04, but it has gone up slightly because of man's activities.

Uses :

1. It is essential for the process of photosynthesis, by which green plants prepare food.
2. Carbon dioxide minimizes heat loss by radiation, by reflecting heat back to the earth's surface, particularly at night. Thus, it balances the temperature of the earth.
3. Carbon dioxide dissolved in water helps in photosynthesis of aquatic plants. Its salts (bicarbonates) add taste to water.
4. Carbon dioxide gas is used in fire extinguishers as it does not support burning.

   (Further details are given in Section C of this chapter).

4.2.4 Water vapours

Water vapours in air is also known as moisture. When water evaporates as vapours from oceans, lakes, rivers, and moist soil, it mixes with the air. Plants also give off water vapours. The amount of moisture present in the air is known as **humidity.** But the percentage proportion of water in air varies. The more is the amount of water vapours present in the air, the higher is the humidity.

Uses :

1. It determines the earth's climatic conditions. The presence of water vapours in air causes rain. At low temperatures, water vapours condense to form snow, sleet, mist, frost, hail, dew, fog, *etc*.
2. It controls the rate of evaporation from the bodies of plants and animals.
3. It is essential for the growth of plants and for the good health of animals and human beings.

4.2.5 Inert (noble) gases

Inert gases are six in number : helium, neon, argon, krypton, xenon and radon. These gases do not react with any substance. About 0·96% of air, by volume, is made up of inert gases. Argon is the most abundant inert gas.

Uses :

1. Helium is a very light gas. Therefore, it is used for filling up weather observation balloons.
2. Neon is used for making advertisement signs and tubelights. It emits a coloured light when a high voltage current is passed through it.
3. Argon is filled into electric bulbs to prevent the oxidation of their filaments.
4. Radon is used for treatment of cancer, because it is of radioactive nature.
5. Krypton and xenon are used in photography.

4.2.6 Dust particles

These are solid, minute soil particles present in the air. Water vapours condense around dust particles to form clouds. An excess of dust particles in the air might cause serious respiratory problems. Dust particles also trap heat and help in its scattering.

Do You Know ?

The smell of cooking food in the kitchen spreads out because the molecules of gases present in air are in constant motion.

4.3 AIR POLLUTION

Air is important for the survival of human beings but it should be free from impurities.

When air contains undesirable substances that are harmful to plants and animals, it is said to be polluted and the harmful substances in air are called *pollutants*. Air pollution is a major problem created by modern man.

Some common pollutants in air are smoke, dust, coal, oxides of carbon, sulphur and nitrogen. Other pollutants are chlorofluorocarbon (CFCs) and ammonia (which is evolved by decaying dead plants and animals).

Though air also gets polluted by natural processes like volcanic eruptions, crop pollination, *etc*., but mostly it is polluted by human activities like,

- burning of fuels and fibres,
- cutting of forests,
- emission of harmful gases from vehicles,
- use of chemicals like fertilizers, insecticides and pesticides in agricultural activities,

- an increase in number of industries,
- use of chemical weapons in wars (tear gas, bombs, etc.).

TYPES OF POLLUTANTS IN AIR AND THEIR HARMFUL EFFECTS :

1. Suspended particles (in smoke) : Smoke is present in the air in a large quantity, due to the burning of fossil fuels. It carries minute solid particles that cause serious respiratory problems, like *asthma* and *bronchitis*. Smoke makes the atmosphere dense and reduces the visibility leading to serious accidents.

Particulate matter : Particulate matter in the air causes many respiratory problems in human beings.

— Particles of lead oxide present in the automobile exhaust can cause brain damage in children.

— Particles of mercury cause a disease called minamata, can lead to brain damage, paralysis and mental problems.

— Particles of dust, cement and carbon particles in smoke may cause bronchitis, while asbestos fibre can cause a disease called silicosis.

Pollen grains too are suspended particles in air which act as a pollutant. They can cause allergic reactions in human beings.

Do You Know ?

Burning of coal in insufficient (or limited) supply of air (oxygen) produces carbon monoxide. That is why one should not sleep in a room with all windows and doors closed with a burning coal stove (angithi or sigri).

2. Oxides of carbon : Most fossil fuels contain carbon. When they are burnt, carbon combines with oxygen to form carbon dioxide. When there is insufficient oxygen, carbon-monoxide is produced.

Carbon monoxide is a highly poisonous gas which combines with the haemoglobin present in the blood to form a stable compound *carboxyhaemoglobin*. Thus it prevents the blood to carry oxygen for respiration. Breathing in carbon monoxide rich air can cause headache, dizziness and might even lead to death.

Carbon dioxide is non-poisonous but excess of it in the atmosphere may add to global warming.

3. Oxides of sulphur and nitrogen : Fossil fuels like coal, petrol, *etc.*, contain sulphur and nitrogen as impurities. Therefore, when these fuels are burnt, gases like sulphur dioxide, sulphur trioxide, hydrogen sulphide, nitrogen dioxide, are produced. These gases are present in variable amounts in the air around big cities and industries. They are highly poisonous and cause serious respiratory problems. Oxides of nitrogen form a mixture of smoke and fog known as **smog** which affects our eyes too. They also cause acid rain which damages crops and buildings and natural resources like water bodies and patches of land. They can even destroy ozone layer in air which protects us from ultraviolet (UV) radiation of the sun.

Acid rain : Poisonous gases like sulphur dioxide, nitrogen dioxide, *etc.*, emitted by power stations and vehicles are the major source of air pollution. These gases react with water in the clouds to form sulphuric acid and nitric acid respectively increasing the acidity of the rain. They fall as acid rain and become part of the water cycle.

"A rain which is acidic in nature is called acid rain."

Acid rain has many harmful effects.

- It can damage wildlife in ecosystem where it falls, *i.e.*, it can kill fishes and other aquatic animals and plants.
- It makes the soil more acidic and less fertile and thus seriously damaging the growth of plants, *i.e.* leads to the loss of soil fertility.
- It corrodes metals and damages buildings and historical monuments especially those made of marble and lime stone (calcium carbonate) because acids can easily breakdown carbonates.
- Acid rain promotes corrosion of metallic structures, such as railway bridges, etc.
- Acid rain damages the nutrition level of leaves of the plants.

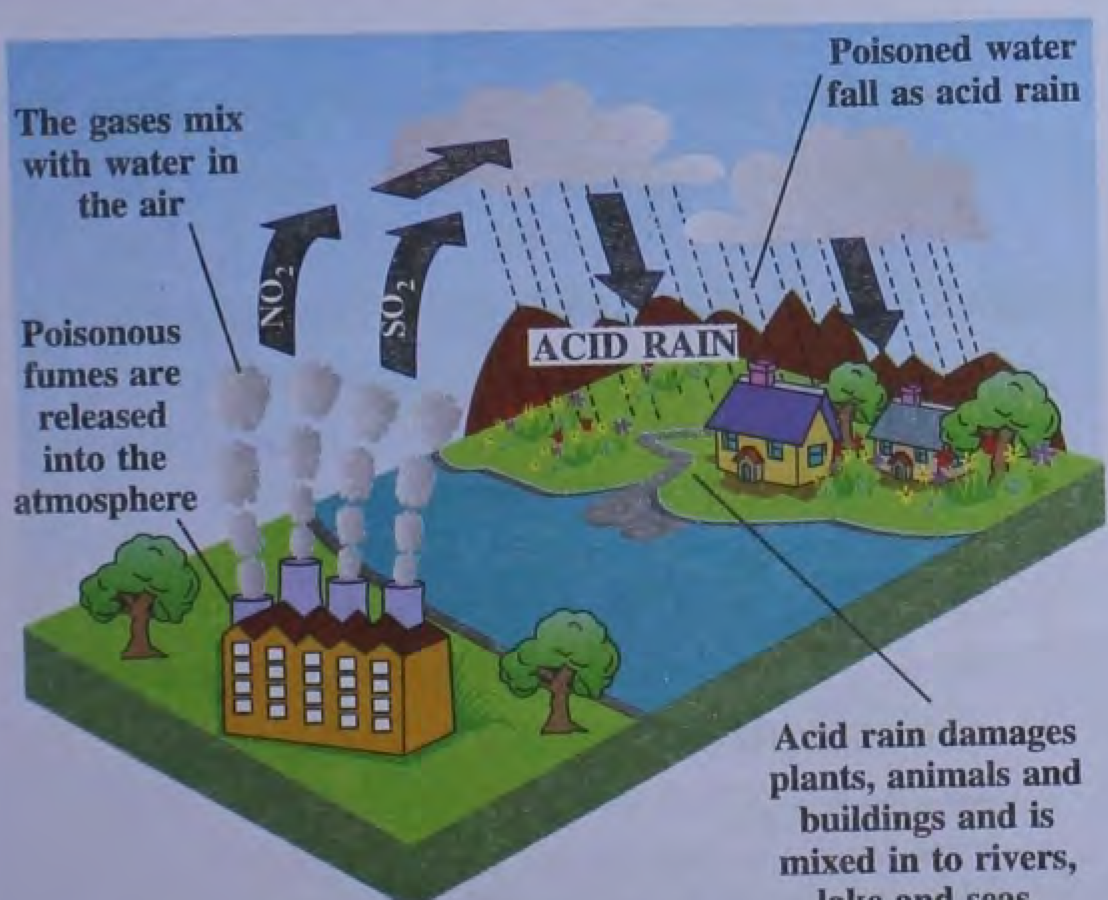


Fig. 4.6 : Acid rain

Do You Know ?

Acid rain corrodes the marble of the monument. The phenomenon is also called "Marble cancer". The supreme court has taken several steps to save the Taj. It has ordered industries to switch over to cleaner fuels like CNG and LPG. Moreover, the automobiles should switch over to unleaded petrol in the Taj zone.

The Taj Mahal at Agra is getting damaged due to acid rain. Why ?

Do You Know ?

Rain water has always been slightly acidic as carbon dioxide in the air dissolves in rain to form carbonic acid.

4. Other pollutants (CFCs) : Pollutants like chlorofluorocarbons (used in refrigerants and solvents), when mixed in air, react with the ozone layer, causing its depletion. As a result, the density of air is reduced and ultra-voilet rays from the sun reach directly to the earth. This might cause skin cancer and also add to global warming.

Global warming : An increase in the percentage of carbon dioxide, methane, nitrous oxide and chlorofluorocarbon traps the heat causing the temperature of the earth and its surroundings to rise. This is known as *global warming*.

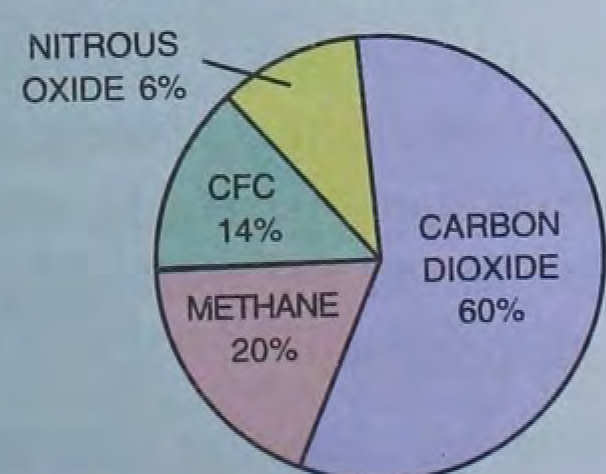


Fig. 4.7 : Contribution of different gases to global warming

- Lead compounds mixed in the air due to the burning of leaded petrol might cause damage to the nervous system.

In addition to above mentioned gases, automobiles which burn diesel and petrol, also produce such particles which remain suspended in air for long period. They reduce visibility and when inhaled, cause diseases. Power plants give out tiny ash particles which also pollute the atmosphere.

4.4 HOW TO PREVENT AIR POLLUTION

The whole world is facing serious problems due to air pollution. It has adverse effects on human health, vegetation and the atmosphere. Thus it is necessary to control the levels of pollution released into the air to protect life on the earth. Following steps should be taken to prevent air pollution :

1. By growing more trees and plants. Trees absorb carbon dioxide for photosynthesis and release oxygen formed during this process. Thus they help in balancing the amount of carbon dioxde and oxygen in air. They also help in bringing rain due to which other harmful gases are removed from air. Do you know about Van Mahotsav, when lakhs of trees are planted in July every year.
2. By using smokeless sources of energy, like solar energy and electrical energy, in place of the conventional fossil fuels. Smokeless *chulhas* use biogas and solar energy. This prevents air pollution.
3. By installing tall chimneys with filters in factories and power plants so that the smoke coming out of them is filtered and released high up into the air and the solid particles collect on the chimney walls.
4. By using internal combustion engines in vehicles for complete and efficient burning of fuel and to reduce the amount of unburnt fuel and carbon monoxide.
5. By locating industries away from residential areas.

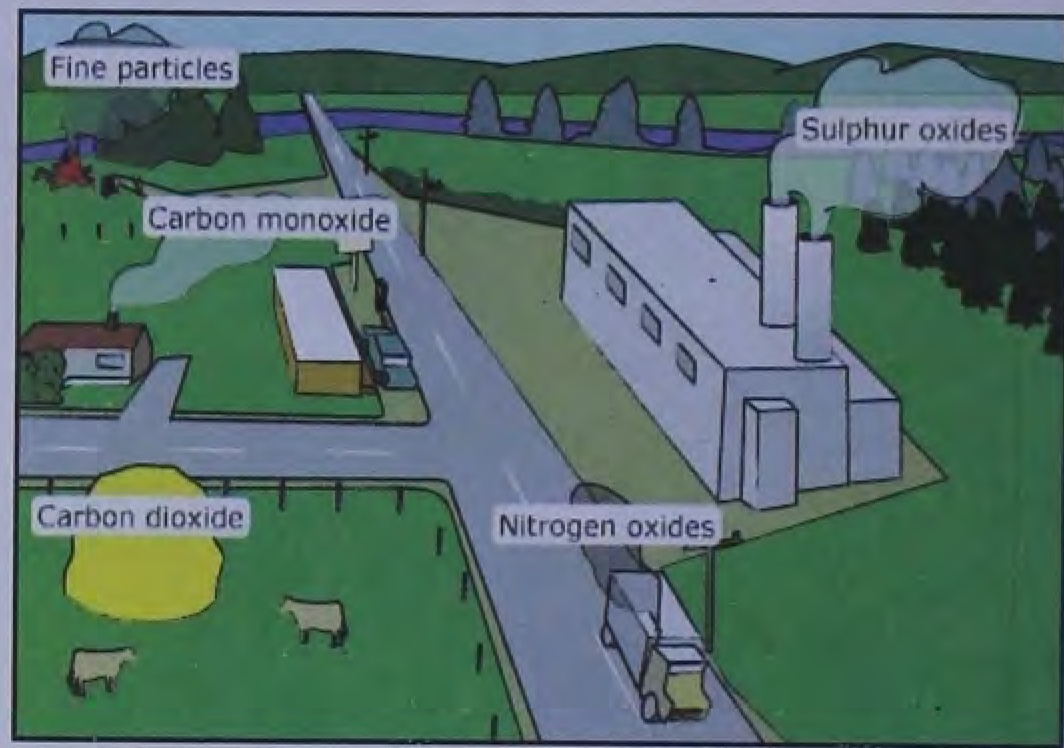


Fig. 4.8 : The common agents of air pollution in most cities.

6. By using lead-free fuels, such as Compressed Natural Gas (CNG), as a fuel for motor vehicles.
7. Vehicles should be regularly checked for pollution controls.

HOW CAN YOU CONTRIBUTE TO CONTROL AIR POLLUTION ?

1. Do not use plastic bags.
2. Do not misuse electricity and try to save it. This will ultimately lead to less consumption of fossil fuels for its production.
3. Do not burn paper, garbage dry leaves and other waste materials in open because they

produce smoke and some poisonous gases which pollute the air. It would be a better option to put them in a compost pit rather than burning.

4. Try to grow more plants which give more fresh air.
5. Keep your surroundings clean and also advise your friends and neighbours to do the same.

Activity 3

You have various options to reach your school such as walking, going by bicycle, travelling by bus or other public transport, using a car individually, travelling by car pool. Discuss in your class the impact of each of these options on the quality of air.

RECAPITULATION

- Air is a mixture of gases. It contains nitrogen, oxygen, carbon dioxide, water vapours, noble gases and impurities.
- The chemical composition of air was discovered by Lavoisier.
- Nitrogen is the inactive part of air. It dilutes oxygen. It is important for the growth of plants and animals.
- Oxygen is essential for respiration and combustion.
- Carbon dioxide helps most plants to prepare food through the process of photosynthesis.
- Water vapours are responsible for most climatic phenomena.
- Dust helps in condensation of water vapours into rain drops.
- Harmful gaseous substances present in air cause air pollution.
- Impurities like nitrogen dioxide, sulphur dioxide and sulphur trioxide cause acid rain.

EXERCISE – I

1. Give one use for each of the following inert gases:

(a) argon (b) helium
(c) neon (d) radon
(e) krypton (f) xenon

2. Answer the questions put against each of the following constituents of air :

(a) *Nitrogen :* Explain its significance for plants and animals.

(b) *Oxygen :* What is the percentage proportion of oxygen in air ? Why is oxygen called active air ?

(c) *Carbon dioxide :* "Although carbon dioxide plays no role in respiration, all life would come to an end if there was no carbon dioxide in air." Support this statement with relevant facts.

(d) *Water vapours :* Explain their role in modifying the earth's climate.

3. Define the following terms :

(a) pollutants (b) acid rain

4. "Air is a mixture." Support this statement citing at least three evidences.

5. What is air pollution ? What are the harmful effects of sulphur dioxide, nitrogen dioxide and hydrogen sulphide present in the air ?

6. (a) What are the causes of air pollution ?

(b) Suggest five measures to prevent air pollution.

(c) What is nitrogen-fixation ?

(d) What are the ways in which nitrogen fixation occurs ?

(e) Explain the conversion of nitrogen into nitrates when there is lightning.

B. Oxygen

Symbol : O; *atomic number* : 8; *relative atomic mass* : 16; *molecular formula* : O_2; *relative molecular mass* : 32; *atomicity* : 2; *valency* : 2.

4.5 DISCOVERY

Oxygen is a non-metallic diatomic gas. It is the most important constituent of air as it is vital for the existence of life on the earth and also supports combustion to produce energy.

Oxygen was first discovered by Joseph Priestley in 1774. He obtained the gas by heating mercury (II) oxide. The gas was first named as "active air" due to its properties.

Later, in 1789, *Antoine Lavoisier* studied the properties of the gas and proved that it is an element. He named it *"oxygen"* which means *acid producer*, because oxides, of some non-metals when dissolved in water produce acids.

4.6 OCCURRENCE

Oxygen is the most abundant element on the earth. It is available both in : (i) free state and (ii) combined state.

(i) In free state, oxygen occurs in the atmosphere to the extent of 21% by volume and 23.2% by mass. The atmosphere also contains oxygen in the form of ozone [O_3].

(ii) In the combined state, oxygen is present in air, water, animal and plant tissues, and in minerals.

(a) In air 0.03 – 0.04% is carbon dioxide.

(b) About 89% (by weight) of water is oxygen.

(c) The human body has 65% oxygen (by weight).

(d) Plants contain 60% oxygen (by weight).

(e) About 50% of the earth's crust is made up of oxygen in the form of oxides, carbonates, silicates, *etc*.

(f) It is also an essential component of carbohydrates, proteins, fats and nucleic acids.

1. *Some common oxides are* : Silica (sand : SiO_2)
   Haematite (iron ore : Fe_2O_3)
   Bauxite (aluminium ore : $Al_2O_3.H_2O$)
2. *Carbonate* : Limestone (calcium carbonate : $CaCO_3$)

4.7 PREPARATION OF OXYGEN

Oxygen can be prepared from

1. Air
2. Water
3. Compounds containing oxygen.

From air : Oxygen can be obtained from air on large scale. At first, air is made free from carbon dioxide, water vapours and dust particles. The air which now contains only nitrogen and oxygen is subjected to high pressure and then cooled and expanded so that it gets liquefied. The liquid air is then distilled. Nitrogen boils and turns into gas again at –195·5°C leaving behind liquid oxygen which turns into a gas at –183°C.

From water : In this method water is subjected to electrolysis, *i.e.*, electricity is passed through water containing small amount of acid. As a result water decomposes into hydrogen and oxygen gases. By this method also oxygen can be obtained on large scale.

$$\text{Water} \xrightarrow{\text{Electric current}} \text{Hydrogen} + \text{Oxygen}$$

$$2H_2O \xrightarrow[\text{Current}]{\text{Electric}} 2H_2 + O_2.$$

From compounds containing oxygen: Oxygen can be obtained by the thermal decomposition* of some compounds that contain oxygen.

Some of these compounds are : mercuric oxide, potassium nitrate, potassium chlorate, hydrogen peroxide, etc.

1. Action of heat on mercuric oxide : Mercuric oxide is a red powder. When it is heated in a test tube, it decomposes to give mercury and oxygen.

$$\underset{\text{(red powder)}}{\text{Mercuric oxide}} \xrightarrow{\textit{heating}} \underset{\text{(black mirror)}}{\text{Mercury}} + \text{Oxygen } (g)$$

$$2HgO \xrightarrow{\textit{heating}} 2Hg + O_2$$

A glowing splinter relights when brought near the mouth of the test tube, thus confirming the formation of oxygen by thermal decomposition of mercuric oxide.

2. Action of heat on potassium chlorate: Potassium chlorate is a white solid. When it is heated strongly, first it melts and then it begins to boil, giving off a gas that relights a glowing splinter. Potassium chlorate needs heating for quite sometime (to a high temperature) before it decomposes.

* Thermal decomposition is the breaking up of a compound on heating into some of its constituent elements or other compounds.

$$\underset{\text{chlorate}}{\text{Potassium}} \xrightarrow[\textit{Manganese dioxide (cat.)}]{\textit{heating}} \underset{\text{chloride}}{\text{Potassium}} + \text{Oxygen } (g)$$

$$2KClO_3 \xrightarrow[MnO_2]{\textit{heating}} 2KCl + 3O_2$$

The rate of decomposition of potassium chlorate can be increased by using manganese dioxide as a catalyst. The decomposition takes place at a lower temperature.

> CATALYST : A catalyst is a substance that increases or decreases the rate of a chemical reaction without itself undergoing any chemical change. Different substances are used as catalysts in different chemical reactions.

Oxygen can also be prepared by heating *red lead* and *potassium nitrate*.

1. $$\underset{\text{[tri lead tetroxide] (red powder)}}{\text{Red lead}} \xrightarrow{\textit{heating}} \underset{\text{(pale yellow solid)}}{\text{Lead monoxide}} + \text{Oxygen } (g)$$

$$2Pb_3O_4 \xrightarrow{\textit{heating}} 6PbO + O_2$$

2. $$\underset{\text{(white crystalline solid)}}{\text{Potassium nitrate}} \xrightarrow{\textit{heating}} \underset{\text{(molten form)}}{\text{Potassium nitrite}} + \text{Oxygen } (g)$$

$$2KNO_3 \xrightarrow{\textit{heating}} 2KNO_2 + O_2 (g)$$

Laboratory preparation of oxygen

Chemicals required :

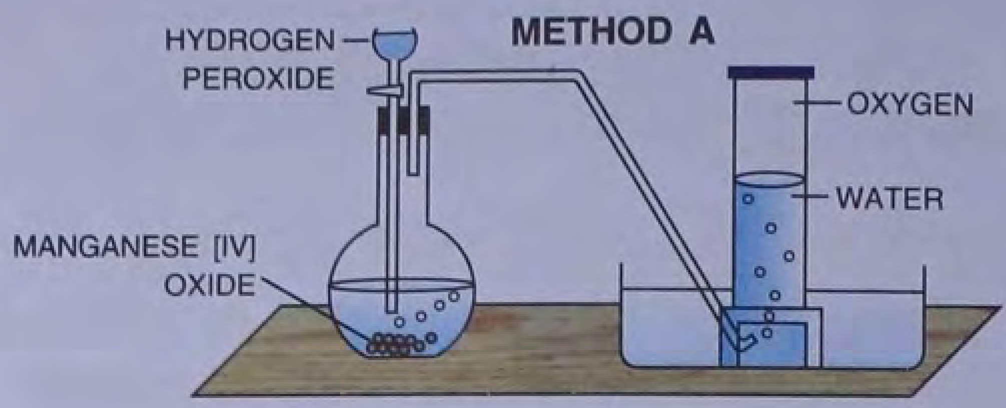
(i) A dilute solution of hydrogen peroxide

(ii) Manganese dioxide powder, which acts as a catalyst.

Chemical equation of the reaction :

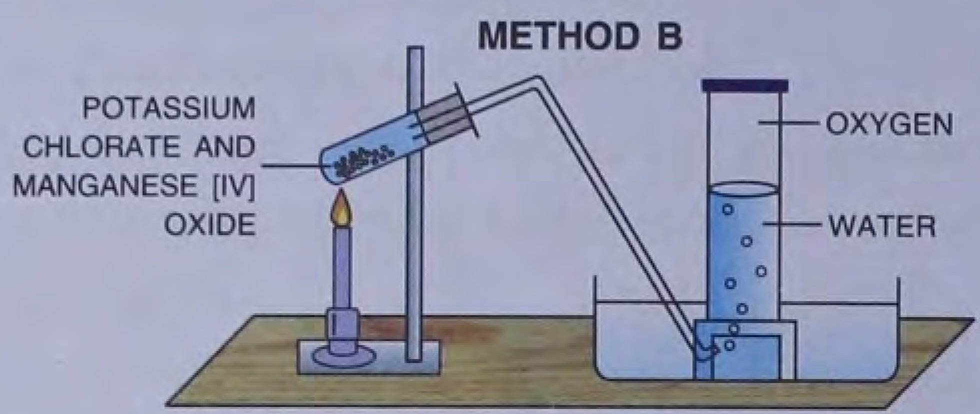
$$\text{Hydrogen peroxide} \xrightarrow{\text{Manganese dioxide}} \text{Water} + \text{Oxygen}$$

$$2H_2O_2 \xrightarrow{MnO_2} 2H_2O + O_2$$



Equation : $2H_2O_2 \xrightarrow[\text{as catalyst}]{MnO_2} 2H_2O + O_2[g]$

Fig. 4.9(a) : Preparation of oxygen from hydrogen peroxide, using manganese dioxide as catalyst



Equation : $2KClO_3 \xrightarrow{MnO_2} 2KCl + 3O_2[g]$

Fig. 4.9(b) : Preparation of oxygen from potassium chlorate, using manganese dioxide as catalyst

Procedure : A small quantity of manganese dioxide, a black powder, is taken in a flat bottom flask Fig. 4.9(a). A two-holed stopper is fixed into the mouth of the flask. Into one of the holes a thistle funnel is fitted, and through the other, a glass tube is introduced into the flask. The other end of the glass tube (delivery tube) passes into a beehive shelf placed in a trough containing water.

Now, hydrogen peroxide is added drop by drop into the flask with the help of the thistle funnel (slow addition controls the rate of production of oxygen). Manganese dioxide decomposes hydrogen peroxide very fast, and liberates oxygen, which passes through the delivery tube and bubbles out through the water in the trough. The first few bubbles are allowed to escape, since they contain air from the flask prior to the reaction.

Now, a gas jar filled with water is inverted over the beehive shelf. Oxygen is collected in the jar by downward displacement of water. As the gas keeps collecting in the gas jar, the water level in the jar keeps decreasing and the space lying above the water is gradually occupied by oxygen. When all the water has been displaced, the jar becomes full of oxygen. The jar is now covered with a greased lid and removed from the beehive shelf. In this way, a number of gas jars can be filled up with oxygen gas.

Since water is displaced downward by the gas collecting in the jar, the process is called *downward displacement of water.*

Why is oxygen collected by downward displacement of water? The reasons are:

1. Oxygen is only slightly soluble in water. Therefore, it can be collected over water without fear of excessive dilution.
2. Oxygen is slightly heavier than air, so it cannot be collected over air.

Activity 3

Test for oxygen

Take a gas jar filled with oxygen. Introduce a glowing splinter in the jar. You will notice that the glowing splinter rekindles, but the gas does not catch fire.

Now, keep moist blue and red litmus papers in the jar. There is no change in the colours of the litmus papers.

From this, the following properties of oxygen are deduced :

1. *Combustibility* : Oxygen supports burning (or combustion) but does not burn itself, which means it is non-combustible.

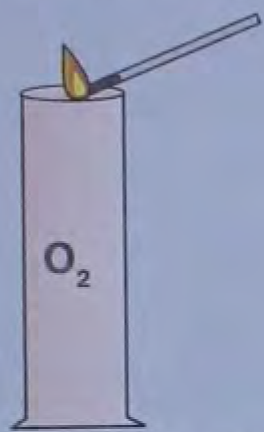


Fig. 4.10: The glowing splinter relights

2. *Neutral to litmus test* : Oxygen is neutral to litmus test. It does not change the colour of either the red litmus paper or the blue litmus paper.

Litmus : Litmus is a substance used as an indicator to know the nature of a solution. There are two types of litmus paper – *red* and *blue*.
In acidic solution, blue litmus changes into red colour but red litmus does not show any change in its colour. In alkaline solution, red litmus changes into blue colour but blue litmus does not change its colour. In neutral solution, neither red nor blue litmus change their colour.

Note : In the laboratory, oxygen can also be prepared by heating potassium chlorate with manganese dioxide but hydrogen peroxide is preferred.

Reasons for preferring H_2O_2 for laboratory preparation of oxygen :

1. No heating is required.
2. The rate of evolution of O_2 is moderate and therefore under control.
3. H_2O_2 is a safe chemical.

4.8 PROPERTIES OF OXYGEN

Physical properties of oxygen

1. Oxygen is a colourless, odourless and tasteless gas.
2. It is non poisonous in nature and supports life.
3. It is slightly heavier than air. Its vapour density is 16.
4. It is only slightly soluble in water. Oxygen dissolved in water is used by aquatic plants and animals for respiration.
5. It is liquefied into a bluish liquid at –183°C applying high pressure. Liquid oxygen has its boiling point at –183°C and its freezing point is –218.4°C.

Chemical properties of oxygen

Oxygen is chemically an active gas. It supports burning, therefore metals, non-metals and a large number of compounds burn in oxygen to produce new products which essentially contain oxygen in them along with other element(s). These new compounds are known as **oxides** and the process of burning of substances in oxygen is called **oxidation**. During burning, heat and light energy are also released.

But different substances burn in oxygen at different rates. Hence oxidation can be of three categories.

1. Spontaneous oxidation
2. Rapid oxidation
3. Slow oxidation

***Spontaneous oxidation* :** Most metals, non-metals and metal sulphides burn in oxygen when ignited to form their oxides. Such type of burning is called spontaneous oxidation. In this type of oxidation sometime mere contact of the substance with oxygen triggers instantaneous reaction.

Rapid oxidation : Substances like LPG, petrol, kerosene, candle, etc. burn in oxygen to produce large amount of heat and light energy. These reactions are of rapid oxidation.

Slow oxidation : This is a very slow process. It takes place over a period of time. Heat energy released is very less and no light energy is released during such oxidation, *e.g.* : rusting, respiration, etc.

Ignitiion temperature : The minimum temperature to which a substance must be heated to make it burn is called its ignition temperature.

Oxides : Oxides are binary compounds formed by the chemical combination of a substance (metal or a non-metal) with oxygen. *Examples* : Sodium oxide (Na_2O), Sulphur dioxide (SO_2), *etc.*

Burning of elements in oxygen

(A) *Oxidation of non-metals* : Non-metals like carbon, sulphur and phosphorus burn in oxygen to produce their respective oxides, with the release of heat. The process of burning and the nature of the oxide formed can be better understood by activity 4 ahead.

Burning of hydrogen in oxygen : Hydrogen burns in oxygen at very high temperature to produce water. Water is a neutral oxide.

$$\text{Hydrogen} + \text{Oxygen} \xrightarrow[\text{spark}]{\text{electric}} \text{Water} + \text{heat}$$

$$2H_2 + O_2 \xrightarrow[\text{spark}]{\text{electric}} 2H_2O + \text{heat}$$

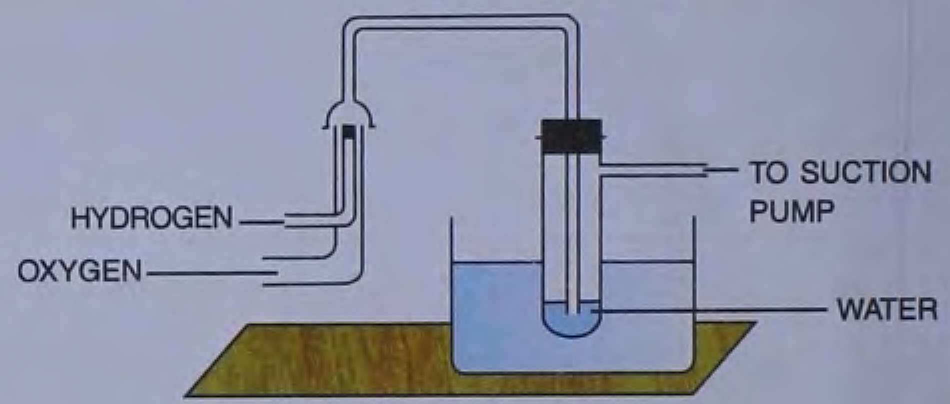


Fig. 4.11 : Burning of hydrogen and oxygen.

Table 4.2 : The products and observations of the reactions between non-metals and oxygen. and formation of acids with water.

Non-metal	*Reaction with oxygen and formation of acids*	*Observations*
1. Carbon	(a) Carbon + Oxygen → Carbon dioxide + heat $C + O_2 \xrightarrow{\text{heat}} CO_2$ + heat energy	***Flame :*** Carbon burns with bright sparks, forming carbon dioxide.
	(b) Carbon dioxide + Water → Carbonic acid $CO_2 + H_2O \rightarrow H_2CO_3$	***Litmus solution :*** Blue litmus turns into red.
2. Sulphur	(a) Sulphur + Oxygen $\xrightarrow{\text{heat}}$ Sulphur dioxide + heat $S + O_2 \xrightarrow{\text{heat}} SO_2$ + heat energy	***Flame :*** Sulphur burns with a bright bluish flame, giving the pungent smell of sulphur dioxide.
	(b) Sulphur dioxide + Water → Sulphurous acid $SO_2 + H_2O \rightarrow H_2SO_3$	***Litmus solution :*** Blue litmus turns into red.
3. Phosphorus	(a) Phosphorus + Oxygen $\xrightarrow{\text{heat}}$ Phosphorus pentoxide + heat $4P + 5O_2 \xrightarrow{\text{heat}} 2P_2O_5$ + heat energy	***Flame :*** Phosphorus burns with a dazzling flame, producing dense white fumes of P_2O_5.
	(b) Phosphorus pentoxide + Water → Phosphoric acid $P_2O_5 + 3H_2O \rightarrow 2H_3PO_4$	***Litmus solution :*** Blue litmus turns into red.

Activity 4

Take

(i) a piece of charcoal

(ii) a small amount of sulphur and

(iii) a piece of phosphorus each in three separate deflagrating spoons. Heat them until charcoal starts glowing and sulphur and phosphorus catch fire. Lower each of them quickly in separate gas jars containing oxygen.

When carbon, sulphur and phosphorus stop burning, remove the deflagrating spoons. Cool the jars and add blue litmus solution to each of them. Blue litmus turns red. This shows the acidic nature of the oxides formed.

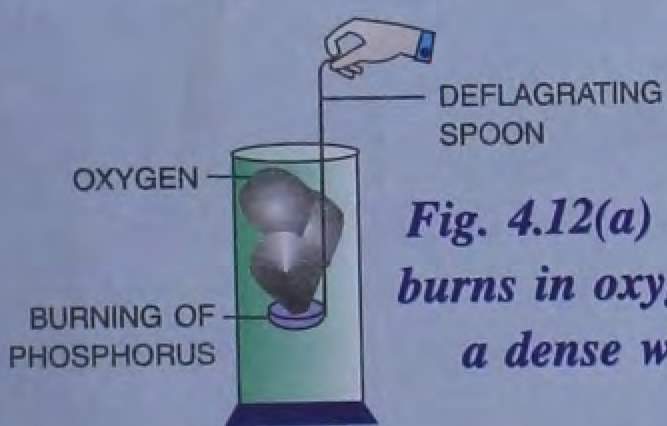


Fig. 4.12(a) : Phosphorus burns in oxygen giving off a dense white smoke

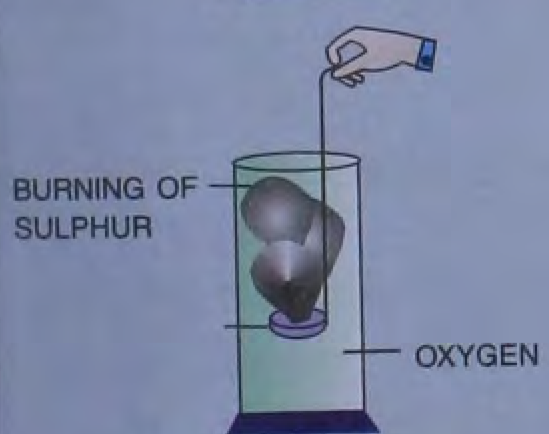


Fig. 4.12(b) : Burning of sulphur in oxygen

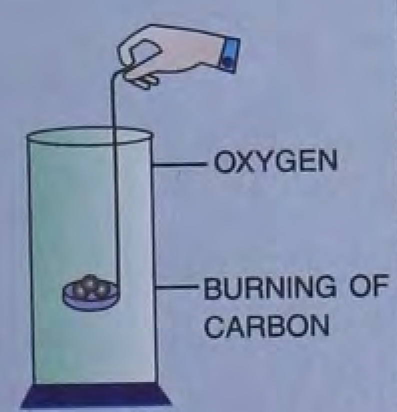


Fig. 4.12(c) : Burning of carbon in oxygen

(B) ***Oxidation of metals :*** Metals react with oxygen to give oxides, which are basic in nature. Soluble basic oxides change the colour of red litmus into blue. This can be shown by the following activity.

Burning of candle in oxygen : Candle burns in oxygen to produce carbon dioxide, water and energy in the form of heat and light.

Activity 5

Heat a piece of sodium in a deflagrating spoon till it melts. Now, lower it into a jar of oxygen. It burns brightly.

Once the metal stops burning and the jar is cooled, introduce red litmus solution and observe the change in its colour. Red litmus solution changes into blue.

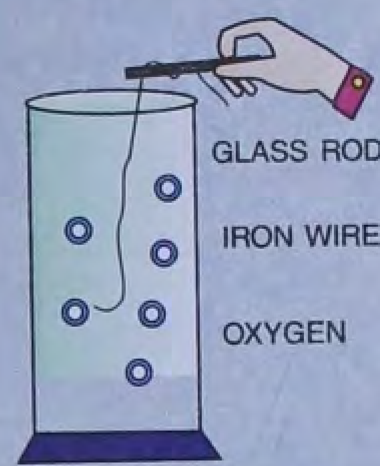


Fig. 4.13 : Iron burns in oxygen with bright sparks.

Repeat the same activity with metals like calcium, magnesium and iron, and observe the respective processes.

Wax + Oxygen ⟶ Carbon dioxide + Water vapour + Energy

Burning of Sulphides in oxygen : Metallic sulphides burn in oxygen to produce respective oxides.

Zinc sulphide + Oxygen → Zinc oxide + Sulphur dioxide

$$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2(g)$$

Lead sulphide + Oxygen → Lead monoxide + Sulphur dioxide

$$2PbS + 3O_2 \rightarrow 2PbO + 2SO_2(g)$$

Do You Know ?

Food can go bad by reacting with oxygen in the air. Hence chemicals called antioxidants are added to the food when it is made. Antioxidants react with oxygen and the food remains fresh for a longer time.

4.9 RUSTING

Rusting is a slow oxidation process in which iron slowly reacts with oxygen of the

Table 4.3 : The products and observations of the reactions between metals and oxygen. and formation of basic hydroxides with water.

Metal	*Chemical reaction with oxygen*	*Observations*
1. Sodium	(a) Sodium + Oxygen → Sodium oxide + heat $4Na + O_2 \rightarrow 2Na_2O$ + heat (b) Sodium oxide + Water → Sodium hydroxide $Na_2O + H_2O \rightarrow 2NaOH$	***Flame :*** It burns brightly, with a brilliant yellow flame. ***Litmus solution :*** Red litmus turns into blue.
2. Calcium	(a) Calcium + Oxygen → Calcium oxide + heat $2Ca + O_2 \rightarrow 2CaO$ + heat (b) Calcium oxide + Water → Calcium hydroxide $CaO + H_2O \rightarrow Ca(OH)_2$	***Flame :*** It burns with a bright brick red flame, forming a white solid. ***Litmus solution :*** Red litmus turns into blue.
3. Magnesium	(a) Magnesium + Oxygen → Magnesium oxide + heat $2Mg + O_2 \rightarrow 2MgO$ + heat	***Flame :*** It burns with a bright dazzling light, forming the white powder of magnesium oxide. ***Litmus solution :*** No change in the colour of litmus.
4. Iron	Iron + Oxygen → Triferric tetroxide + heat $3Fe + 2O_2 \rightarrow Fe_3O_4$ + heat (insoluble in water)	***Flame :*** Red hot iron burns with a bright spark, forming an oxide of iron. ***Litmus solution :*** No change in the colour of litmus.

air in presence of moisture and produces a flaky brown substance, called rust.

Rust is hydrated ferric oxide ($Fe_2O_3 . x$* H_2O), which forms a brownish red coating over iron. It easily crumbles off from the surface of the metal, thus exposing the free iron surface for further rusting.

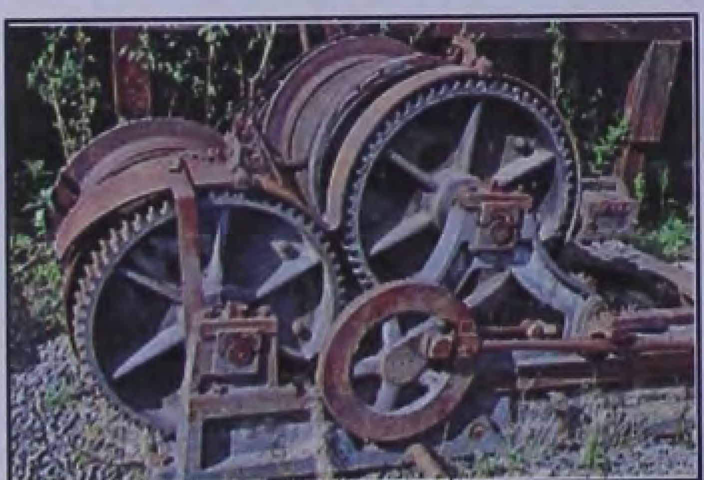


Fig. 4.14

* *x* can be any number.

$$\text{Iron} + \text{Oxygen} \xrightarrow[\text{slow process}]{\text{(from air) Moisture}} \text{Hydrated ferric oxide (rust)}$$

$$4Fe + 3O_2 \xrightarrow[\text{slow process}]{x\,H_2O} 2Fe_2O_3 . x\,H_2O$$

Rusting corrodes iron, weakens iron structures, and thus causes economic loss.

4.10 CONDITIONS FOR RUSTING

Air and moisture are necessary for rusting. This can be shown by the following activity.

The presence of acidic gases such as CO_2, SO_2, SO_3 and NO_2 is the air increases the rate of rusting of iron.

Activity 6

Take three small test tubes marked A, B and C. Put some bright iron nails in each of them.

In test tube A, put some boiled water which expel's all the air (oxygen) from it. Close it with a rubber stopper so as to make it air tight.

In test tube B, put a few pieces of anhydrous calcium chloride to absorb the moisture inside. Tightly close the test tube with an airtight rubber stopper. In test tube C, put some tap water and leave it open.

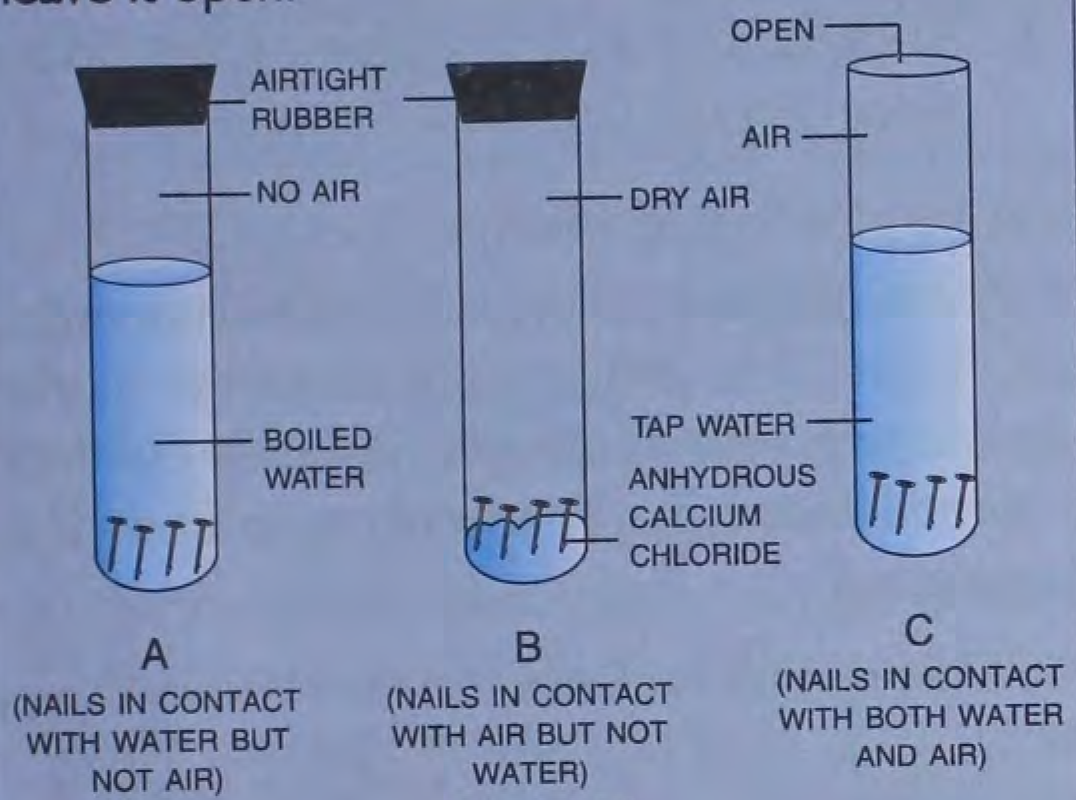


Fig. 4.15

After a few days, it is observed that the nails in test tube C get rusted. This is because they are in contact with both air and water. The nails in test tubes A and B are not rusted because, in test tube A, there is water but no air and in test tube B, there is air but no water. This proves that both air and water are necessary for rusting.

4.11 PREVENTION FROM RUSTING

Iron is the most useful metal for mankind. It is used for making heavy machines, bridges, vehicles, railway equipments, utensils, *etc*.

But iron gets rusted easily in the presence of air and moisture. If rust is allowed to form unchecked, iron gets corroded, resulting in wastage of metal. Thus, the prevention of rusting of iron is essential.

Iron can be protected from rusting if the surface of the iron is not allowed to come in contact with moist air. This is done by either metallic or non-metallic coating of iron.

4.11.1 Non-metallic coating

1. ***Painting with red lead*** **:** This coating is put on the heavy iron parts of vehicles, machinery, buildings, etc.
2. ***Oil paint*** **:** This paint is applied on doors and windows made up of iron which already have a base coating of red lead.
3. ***Enamel coating*** : Enamel is a mixture of iron or steel with silicates. It is used to coat cooking appliances, refrigerators, *etc*.
4. ***Coal tar*** **:** It is used for coating the lower parts of ships and bridges.
5. ***Grease or oil*** **:** Metallic tools and machine parts are coated with a thin, protective film of oil or grease.
6. ***Plastic coating*** **:** Plastic coating is used to cover steel pipelines, hangers, stands, etc.

4.11.2 Metallic coating

1. ***Galvanization*** **:** In this process iron sheets are dipped in molten zinc. Galvanization is used for those iron articles, which are exposed to heavy moisture, such as roof sheds, buckets, tubs, water pipes, *etc*. Water pipes are galvanized to protect them from rusting. They are known as G.I. (galvanized iron) pipes.

Galvanized steel is not used for food containers, since food acids dissolve zinc to form poisonous compounds.

2. ***Tin plating*** **:** In this case iron sheets are dipped in molten tin. These sheets are used to make boxes and cans for packing vegetables, meat, beverages, *etc*. Tin is a corrosion resistant and non-toxic metal.

3. ***Alloy formation*** **:** By this process iron is fused with nickel, chromium, carbon, *etc*., to form stainless steel, which is a lustrous, corrosion resistant substance, and is used for making cutlery, surgical instruments, *etc*.
4. ***Electroplating*** **:** Iron articles are electroplated with copper, chromium, tin, nickel, *etc*., for decorative purposes in jewellery, and for the durability of cutlery, motor parts, etc. But it is a costly process.
5. ***Aluminium painting*** **:** This process protects iron bridges, iron furniture, car bodies, *etc*., from rusting.
6. ***By cathodic protection*** **:** Preventing the corrosion of a metal by connecting it to a more reactive metal is called cathodic protection of metal. *For example*, when iron is connected to a piece of magnesium it does not get corroded as long as magnesium is present.

4.12 COMPARISON OF RUSTING AND BURNING

Rusting	*Burning*
Similarities :	
1. Rusting needs oxygen.	1. Burning too needs oxygen.
2. The process forms oxides.	2. The process too forms oxides.
Differences :	
1. Rusting is slow oxidation.	1. Burning is fast oxidation.
2. Little heat is released.	2. Large amount of heat is released.
3. Both air and moisture are necessary for rusting.	3. Only air is necessary for burning.

4.13 TESTS FOR OXYGEN

1. Oxygen rekindles a glowing splinter, indicating that it is a supporter of burning.
2. When colourless oxygen is brought into contact with colourless nitric oxide, a brown coloured gas, nitrogen dioxide, is formed.
3. Alkaline pyrogallol solution turns brown when oxygen is passed through it.

4.14 USES OF OXYGEN

Respiration : Oxygen is a life-supporting gas. There is no living thing known to us that can survive without oxygen. It burns our food to produce energy. This process is known as respiration.

Glucose + Oxygen → Carbon dioxide + Water + Energy

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{Energy}$$

Oxygen cylinders and masks are used to facilitate respiration in places where there is a deficiency of oxygen. Firemen, miners, aviators, sea-divers and astronauts use them.

Soil also holds some air in between the spaces of its particles. It is required for living beings in the soil and to the roots of the plants.

Burning : Oxygen is necessary for burning of fuels to produce energy in the form of heat and light.

Coal + Oxygen → Carbon dioxide + Heat + (light)

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

Uses in medicine **:**

- Oxygen cylinders are provided to persons suffering from breathing problems, so as to facilitate artificial respiration.
- Oxygen is a major constituent of *carbogen* (95% O_2 and 5% CO_2) that is given to the patients to stimulate natural breathing.

- A mixture of oxygen and nitrous oxide is used in dentistry as local anaesthesia.

Industrial uses :

- *For welding and cutting of metals :*
  (a) Oxygen mixed with hydrogen as fuel produces a flame with a very high temperature (about 2800°C), known as oxyhydrogen flame.
  (b) With acetylene, oxygen produces a flame with an even higher temperature (about 3300°C), commonly known as oxy-acetylene flame.
  Such high temperatures are required for cutting and welding of metals.
- *For removing impurities* : Oxygen is used to remove impurities from the substances that are used as raw materials in the steel industry. Thus, it helps to convert pig iron into steel and wrought iron, which are more pure forms of iron metal.
- *In chemical industries* : Pure oxygen is used as the oxidising agent in the manufacture of nitric acid from ammonia and of sulphuric acid from sulphur dioxide.
- *As a propellant fuel in spacecraft* : Liquid oxygen (lox) is carried by rockets that burn liquid hydrogen as fuel. This is because there is no oxygen in space.

4.15 RENEWAL OF OXYGEN IN AIR : OXYGEN CYCLE

All living beings use atmospheric oxygen to breathe. Oxygen is also used up in the burning of fuels and in the formation of oxides of nitrogen. Yet the amount of oxygen in the air remains more or less constant.

This is because green plants return oxygen to the atmosphere by the process of photosyn-

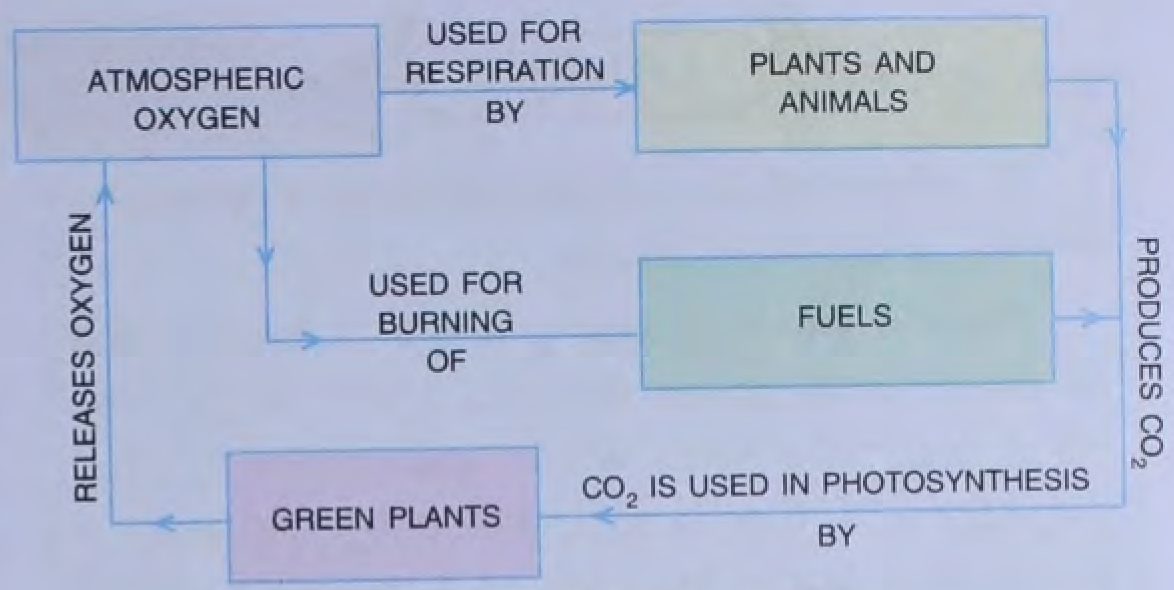


Fig. 4.16 Oxygen cycle

thesis. This circulation of oxygen is called the oxygen cycle. We can thus say that oxygen is a '*gift from plants*' to all other living beings.

Photosynthesis is the process by which carbon dioxide and water are used up by green plants in the presence of sunlight to produce glucose and oxygen gas.

Oxygen is released into the atmosphere but carbon dioxide is used up. Thus, the respective proportions of the two gases are naturally balanced.

Green plants contain chlorophyll, a green pigment which can trap the solar energy for photosynthesis.

$$6CO_2 + 6H_2O \xrightarrow[sunlight]{chlorophyll} \underset{\text{(glucose)}}{C_6H_{12}O_6} + 6O_2$$

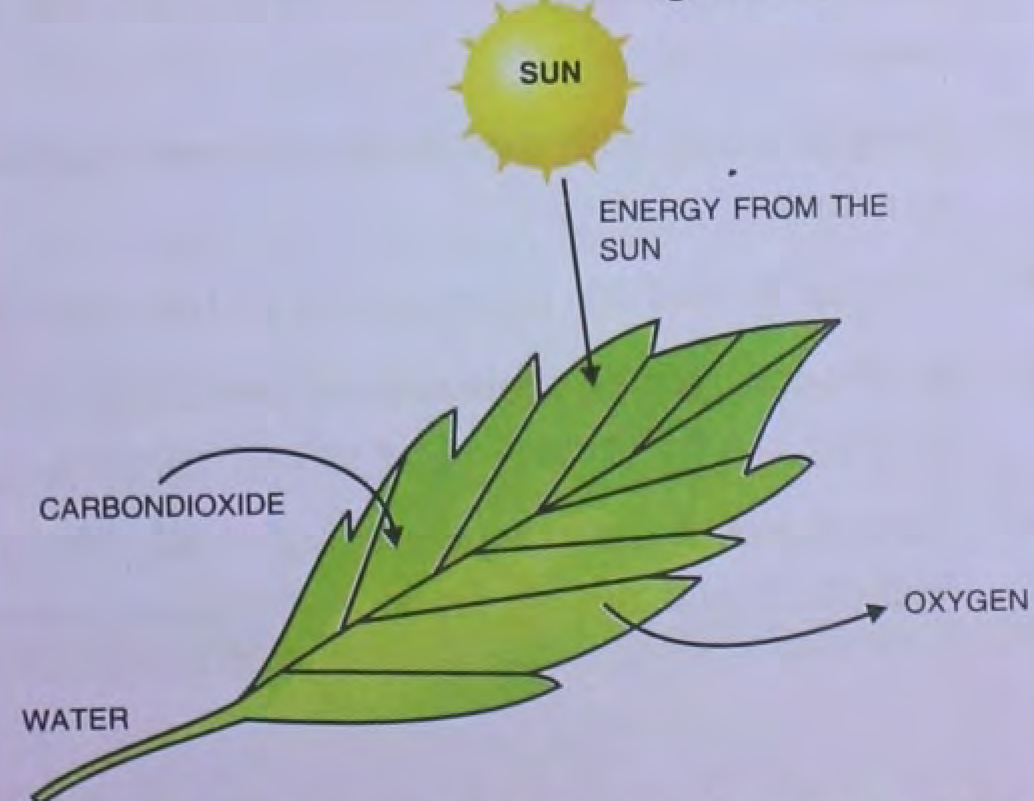


Fig. 4.17 : Renewal of oxygen in air by green plants during photosynthesis

Activity 7

To show that plants produce oxygen during photosynthesis.

Place a small aquatic plant in a beaker full of water and cover the plant with a funnel. Fill a test tube with water and invert it over the stem of the funnel. Place the apparatus in the sun. Some bubbles of a gas soon come out. This gas gets collected in the test tube by displacing water downward.

When the test tube has no more water left, take it out and introduce a glowing splinter in it. The splinter rekindles. This indicates the presence of oxygen.

From where has it come ? Obviously, it is produced by the plant through photosynthesis.

Note : This experiment cannot be carried out in dark or at night, since photosynthesis cannot take place in the absence of light.

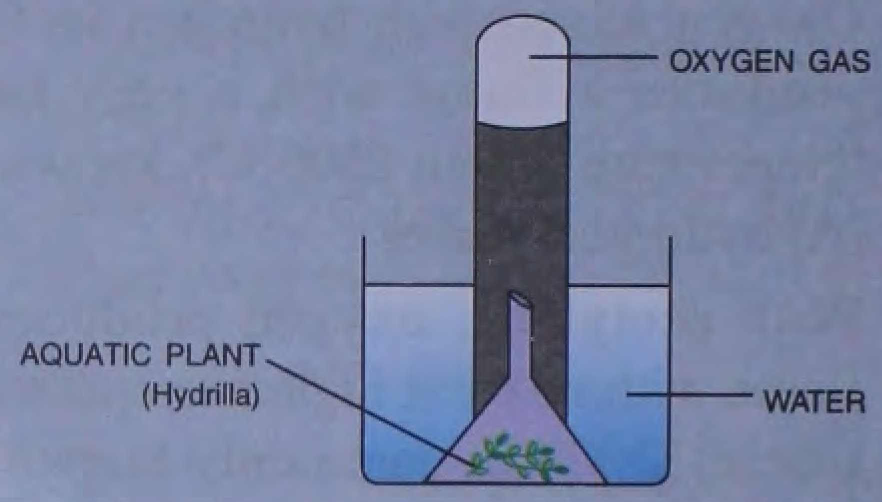


Fig. 4.18 : Plants produce oxygen during photosynthesis

RECAPITULATION

- Oxygen is the most important and the most abundant element found on the earth.
- About 21% of air by volume is oxygen. It is present in water as a solute and in the earth's crust in its combined state.
- Oxygen is prepared by the thermal decomposition of compounds containing oxygen.
- Oxygen is a non-combustible gas, but it supports combustion.
- It reacts with non-metals like carbon, sulphur, phosphorus, *etc.*, to form their oxides, which are acidic in nature.
- Oxygen reacts with metals like sodium, calcium, magnesium, etc., to form their oxides, which are basic in nature.
- Oxygen is vital for the existence of life. During respiration it burns food to release energy.
- In the presence of moisture oxygen forms rust, which is hydrated ferric oxide. Rusting corrodes iron. Rusting can be prevented by oiling, painting, galvanizing, electroplating, etc.
- Respiration, burning and rusting – all are oxidation processes. But burning is fast oxidation while respiration and rusting are slow oxidation processes.

EXERCISE – II

1. Name :
   (a) The most abundant element in the earth's crust.
   (b) The gas present in air which contains oxygen in combined state.
   (c) A metal highly resistant to rusting.
   (d) A mixture of oxygen and carbon dioxide used for artificial respiration.
   (e) Two substances from which oxygen can be obtained at a large scale.
   (f) An oxide and a carbonate containing oxygen.
   (g) Two substances which undergo rapid oxidation.
2. (a) Taking hydrogen peroxide, how would you prepare oxygen in the laboratory ?
   (b) What is the role of manganese dioxide in the preparation of oxygen ?
   (c) Write the balanced chemical equation for the above chemical reaction.
   (d) Why is hydrogen peroxide preferred in the preparation of oxygen gas ?
   (e) Why is oxygen collected by downward displacement of water ?
   (f) What happens when a glowing splinter is introduced in a jar containing oxygen ?
   (g) What happens when oxygen gas is passed through alkaline pyrogallol solution ?
3. (a) What happens when (i) mercuric oxide and (ii) potassium nitrate are heated ?
   (b) Why is potassium chlorate not used for laboratory preparation of oxygen ?
4. What are oxides ? Give two examples for each of metallic and non-metallic oxides.
5. Name the three types of oxidation processes. In which of these large amount of heat and light energy are evolved ?
6. What do you observe when the following substances are heated and then tested with moist blue and red litmus paper ?
   (a) Sulphur
   (b) Phosphorus
   (c) Calcium
   (d) Magnesium
7. Complete and balance the following chemical equations.

   $KNO_3 \xrightarrow{heat} KNO_2 + \text{..............}$

   $KClO_3 \xrightarrow{heat} \text{.........} + O_2$

   $HgO \xrightarrow{heat} \text{.........} + \text{................}$

   $CaO + H_2O \rightarrow \text{................}$
8. (a) Give four uses of oxygen.
   (b) How is oxygen renewed in air ?
9. (a) What is rust ?
   (b) State the two most important conditions for rusting.
   (c) State at least four ways of preventing rusting.
10. Give two differences between : Rusting and burning.

C Carbon dioxide

Molecular formula : CO_2

Relative molecular mass = 44

One molecule of carbon dioxide contains one atom of carbon and two atoms of oxygen.

4.17 DISCOVERY

Carbon dioxide gas is one of the most important constituents of air. It was discovered by *Van Helmont* in 1630 by burning charcoal in air.

In 1775, *Joseph Black* obtained carbon dioxide by the action of dilute acids on metal carbonates. Later, *Antoine Lavoisier* studied the gas and named it *acid carbonique*. He found that the gas was an oxide of carbon, which dissolved in water to produce an acidic solution. Later on it was named carbon dioxide.

4.18 OCCURRENCE

In nature, carbon dioxide occurs in a free state as well as in its combined state.

(i) In free state.

- About 0·03% – 0·04% by volume of carbon dioxide is present in air.
- It is also present in the rocks of volcanic regions.
- In natural water carbon dioxide is present in a dissolved state as it is fairly soluble in water.

(ii) In combined state :

It occurs as metallic carbonates and bicarbonates in the earth's crust and also in sea shells. The chief minerals containing CO_2 are dolomite ($MgCO_3.CaCO_3$), limestone ($CaCO_3$), *etc*.

Note : All life-forms are based on carbon-containing molecules like proteins, carbohydrates, fats, nucleic acid and vitamins. The exoskeletons and endoskeletons of various animals are also formed from carbonate salts.

4.19 PREPARATION OF CARBON DIOXIDE

Carbon dioxide can be prepared by any of the following methods :

(i) By burning carbon or its compounds :

The burning of carbon (charcoal, coke) *or carbon compounds produces carbon dioxide.*

(a) carbon + oxygen $\xrightarrow{\text{burning}}$ carbon dioxide + heat

$$C + O_2 \longrightarrow CO_2 + \text{heat}$$

(b) methane + oxygen $\xrightarrow{\text{burning}}$ carbon dioxide + water

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

(ii) By heating metal carbonates and bicarbonates :

Metallic carbonates and bicarbonates decompose on strong heating to produce carbon dioxide.

Copper carbonate $\xrightarrow{\text{heating}}$ copper (II) oxide + carbon dioxide

(a) $CuCO_3 \xrightarrow{\text{heating}} CuO + CO_2$

Sodium bicarbonate $\xrightarrow{\text{heating}}$ sodium carbonate + water + carbon dioxide

(b) $2NaHCO_3 \xrightarrow{\text{heating}} Na_2CO_3 + H_2O + CO_2$

(iii) By the action of dilute acids on Metallic carbonates and bicarbonates :

They react with dilute acids to produce carbon dioxide.

(a) Calcium carbonate + dilute hydrochloric acid → calcium chloride + water + carbon dioxide

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

(b) sodium carbonate + dilute sulphuric acid → sodium sulphate + water + carbon dioxide

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

(c) sodium bicarbonate + dilute hydrochloric acid → sodium chloride + water + carbon dioxide

$NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2(g)$

(d) baking soda* + vinegar (acetic acid) → sodium acetate + water + carbon dioxide

$NaHCO_3 + CH_3COOH \rightarrow CH_3COONa + H_2O + CO_2$

4.20 LABORATORY PREPARATION OF CARBON DIOXIDE

Carbon dioxide is prepared in the laboratory by the action of dilute acid on metal carbonate.

Chemicals required :

(i) Marble chips ($CaCO_3$)

(ii) Dilute hydrochloric acid

Chemical equation for the reaction

calcium carbonate + dilute hydrochloric acid → calcium chloride + water + carbon dioxide

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

Procedure : A Woulfe's bottle# is taken and some marble chips are placed in it. Through the mouth of the bottle, a thistle funnel is introduced with the help of a rubber stopper in such a way that its stem dips in the acid in the bottle. Through the second mouth of the Wolfe's bottle, a delivery tube is fitted. The other end of the tube is put in a gas jar.

Now, dilute hydrochloric acid is poured into the bottle through the thistle funnel so that the marble chips are completely immersed in the acid.

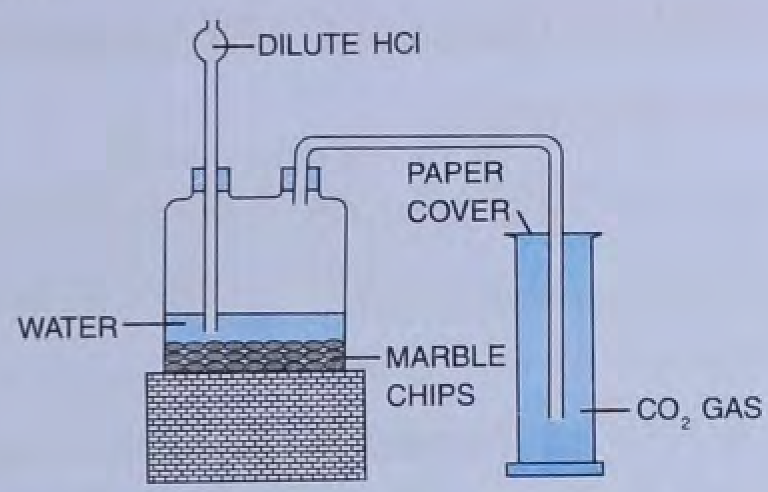


Fig. 4.19 : Laboratory preparation of carbon dioxide.

A vigorous chemical reaction takes place and carbon dioxide gas is released with strong effervescence. First, a few bubbles of carbon dioxide are allowed to escape, as they might contain air and acid as impurities. Thus, the gas is allowed to pass through the delivery tube into a gas jar, where it is collected by *upward displacement of air*, since CO_2 is heavier than air.

Why is calcium carbonate preferred ?

Calcium carbonate is preferred to other metallic carbonates to prepare carbon dioxide because it is cheap and easily available.

Why is sulphuric acid not used ?

Dilute sulphuric acid also reacts with calcium carbonate, just like hydrochloric acid does. But it is not used because the calcium sulphate which is formed during the reaction is insoluble

* The chemical name of baking soda is sodium bicarbonate ($NaHCO_3$). It is used to make food items light and spongy.

Woulfe's bottle is a double mouth glass apparatus used in the chemistry laboratory to prepare gases.

in water. It covers the marble chips and stops the reaction.

$$\underset{\text{(calcium carbonate)}}{CaCO_3} + \underset{\text{(sulphuric acid)}}{H_2SO_4\text{(dilute)}} \rightarrow \underset{\text{(calcium sulphate)}}{CaSO_4} + \underset{\text{(water)}}{H_2O} + \underset{\text{(carbon dioxide)}}{CO_2}$$

Why is carbon dioxide not collected over water?

Because carbon dioxide is highly soluble in water.

4.21 PROPERTIES OF CARBON DIOXIDE

Physical properties

1. **Nature :** Carbon dioxide is a colourless, odourless gas, with a faint acidic (sour) taste. It is non-poisonous.
2. **Density :** Under ordinary conditions, carbon dioxide is 1·5 times heavier than air. Its vapour density is 22.
3. **Solubility :** It is fairly soluble in water. Solubility increases with increase in pressure. Aquatic plants survive by using the carbon dioxide dissolved in water to make their food (photosynthesis).
4. **Liquefaction and solidification into dry ice :** Carbon dioxide can be liquefied under pressure. When liquid CO_2 is cooled to –78°C, under normal pressure, it changes into a snow-white solid, called *dry ice*. Dry ice has nothing in common with ice formed from water, except that it is a solid with snow-white colour.

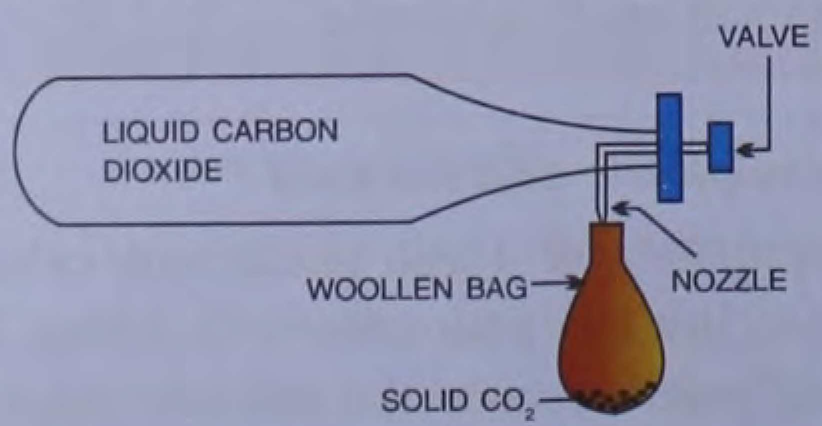


Fig. 4.20 : To show how CO_2 can be solidified

Dry ice, directly changes into gaseous carbon dioxide, from its solid state, *i.e.*, without passing through its liquid state. This is because dry ice is a sublimable substance.

5. **Physiological action :** Carbon dioxide is a non-poisonous gas, but an excess of this gas can cause suffocation. A person may die in an atmosphere of carbon dioxide due to lack of oxygen.

Chemical properties

1. **Combustibility :** Carbon dioxide is neither combustible nor is a supporter of combustion.

   However, some metals like sodium, potassium and magnesium continue to burn in presence of carbon dioxide.
2. **Action with litmus paper :** Carbon dioxide turns moist, blue litmus red. This shows that the gas is acidic in nature.
3. **Action with water :** Carbon dioxide dissolves in water to give carbonic acid (a weak acid).

$$\underset{\text{(carbon dioxide)}}{CO_2} + \underset{\text{(water)}}{H_2O} \longrightarrow \underset{\text{(carbonic acid)}}{H_2CO_3}$$

4. **Action with alkalis :** Carbon dioxide reacts with alkalis to produce salt and water.

$$\underset{\text{(sodium hydroxide)}}{2NaOH} + CO_2 \longrightarrow \underset{\text{(sodium carbonate)}}{Na_2CO_3} + H_2O$$

$$\underset{\text{(potassium hydroxide)}}{2KOH} + CO_2 \longrightarrow \underset{\text{(potassium carbonate)}}{K_2CO_3} + H_2O$$

When excess of carbon dioxide is passed through alkalis, a soluble bicarbonate is obtained.

$$Na_2CO_3 + CO_2 + H_2O \longrightarrow 2NaHCO_3$$
(sodium carbonate) (sodium bicarbonate)

$$K_2CO_3 + CO_2 + H_2O \longrightarrow 2KHCO_3$$
(potassium carbonate) (potassium bicarbonate)

Potassium hydroxide and sodium hydroxide are both capable of absorbing carbon dioxide, but potassium hydroxide is preferred. This is because potassium hydroxide has better absorbing capacity for carbon dioxide and potassium bicarbonate formed is soluble in water.

Carbon dioxide when passed through lime water [$Ca(OH)_2$] turns it milky. This is due to the formation of insoluble calcium carbonate. But when an excess of the gas is passed through the solution, the milkiness disappears. This is due to the formation of a soluble bicarbonate.

$$Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$$
(lime water) calcium carbonate (insoluble)

$$CaCO_3 + H_2O + CO_2 \longrightarrow Ca(HCO_3)_2$$
(soluble)

This reaction is also used to test carbon dioxide.

5. Action with metals : Metal like magnesium burns in presence of carbon dioxide to give magnesium oxide and free carbon (black).

Magnesium + Carbon dioxide $\xrightarrow{heat}$ Magnesium oxide + Carbon

$$2Mg + CO_2 \xrightarrow{heat} 2MgO + C$$

6. Action with non-metals : Carbon dioxide reacts with red hot coke to produce carbon monoxide, a highly poisonous gas.

Carbon dioxide + Coke $\longrightarrow$ Carbon monoxide

$$CO_2 + C \longrightarrow 2CO$$

4.22 TESTS FOR CARBON DIOXIDE

1. If a burning candle or a smouldering match stick is introduced in a jar containing carbon dioxide, it extinguishes. This proves that the gas is a non-supporter of combustion.

Activity 8

To show that carbon dioxide is heavier than air and a non-supporter of combustion

Take a jar containing air. Introduce a burning candle in it. Tilt a jar containing carbon dioxide over the jar with burning candle. You will observe that the candle flame goes off. This is because carbon dioxide being heavier spreads over the flame and the air goes up.

This also proves that carbon dioxide does not supports combustion.

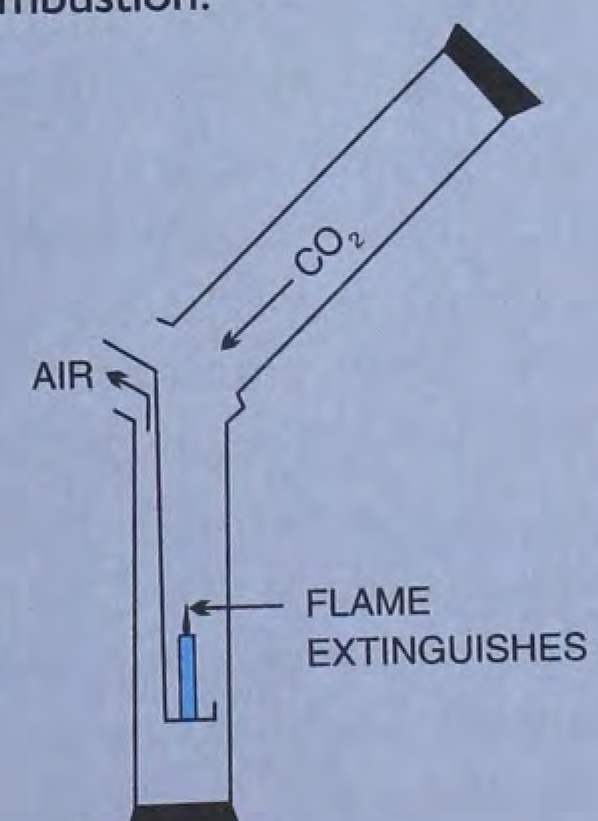


Fig. 4.21

2. When carbon dioxide is passed through lime water, the latter turns milky. This is an excellent test for carbon dioxide.

4.23 USES OF CARBON DIOXIDE

1. **In aerated drinks :** Carbon dioxide is used in the manufacture of aerated drinks. The gas is dissolved in water under pressure to give soda water.
   When the pressure is released, the bottled gas escapes with a brisk effervescence that adds *fizz* to the drink. Common soft drinks are formed by dissolving carbon dioxide in a sugar solution.
2. **Refrigeration and preservation of food stuffs :** Solid carbon dioxide (dry ice) is used as a coolant and a refrigerant in ships for preserving food articles like fruit, vegetable, meat, etc., which otherwise perish easily. Also, if grains are kept in an atmosphere of carbon dioxide, they remain in good condition for a long period, without allowing insect attacks.
3. **In hospitals :** A mixture of 5% carbon dioxide and 95% oxygen, called *carbogen,* is used for artificial respiration. It is given to patients suffering from gas poisoning, pneumonia, drowning, etc.
4. **In the manufacture of fertilizers (urea) :** Urea is an important nitrogenous fertilizer. It is prepared when carbon dioxide and ammonia are heated at 200°C under very high pressure.
5. **In the preparation of chemicals :** Carbon dioxide is used to manufacture chemicals like washing soda (sodium carbonate) and baking soda (sodium bicarbonate).
6. **In the baking industry :** Carbon dioxide is used to make the dough rise and become light. Baking powder is a mixture of baking soda ($NaHCO_3$) and potassium hydrogen tartarate. When it is added to the dough, the ingredients of baking soda react to release carbon dioxide. As the gas rises through the dough, spaces are formed, thus making the dough porous and the cakes and bread spongy.
7. **In photosynthesis :** Photosynthesis is a natural process. It helps to maintain the required quantity of carbon dioxide in the atmosphere.
   Plants containing chlorophyll absorb carbon dioxide from the atmosphere and water from the soil (in the presence of sunlight) to prepare their food (glucose). The other product released is oxygen gas.

$$\text{carbon dioxide + water} \xrightarrow[\text{sunlight}]{\text{chlorophyll}} \text{glucose + oxygen}$$

$$6CO_2 + 6H_2O \xrightarrow[\text{sunlight}]{\text{chlorophyll}} C_6H_{12}O_6 + 6O_2$$

Photosynthesis has its own great importance. It removes extra carbon dioxide from the atmosphere and restores oxygen. Also, vegetarian food stuffs like carbohydrates cannot be produced without photosynthesis.

8. **In extinguishing a fire :** Carbon dioxide helps to extinguish fires because :
   (i) it neither burns nor does it help in burning.
   (ii) being heavier than air, it insulates the burning substance by cutting off the supply of oxygen.

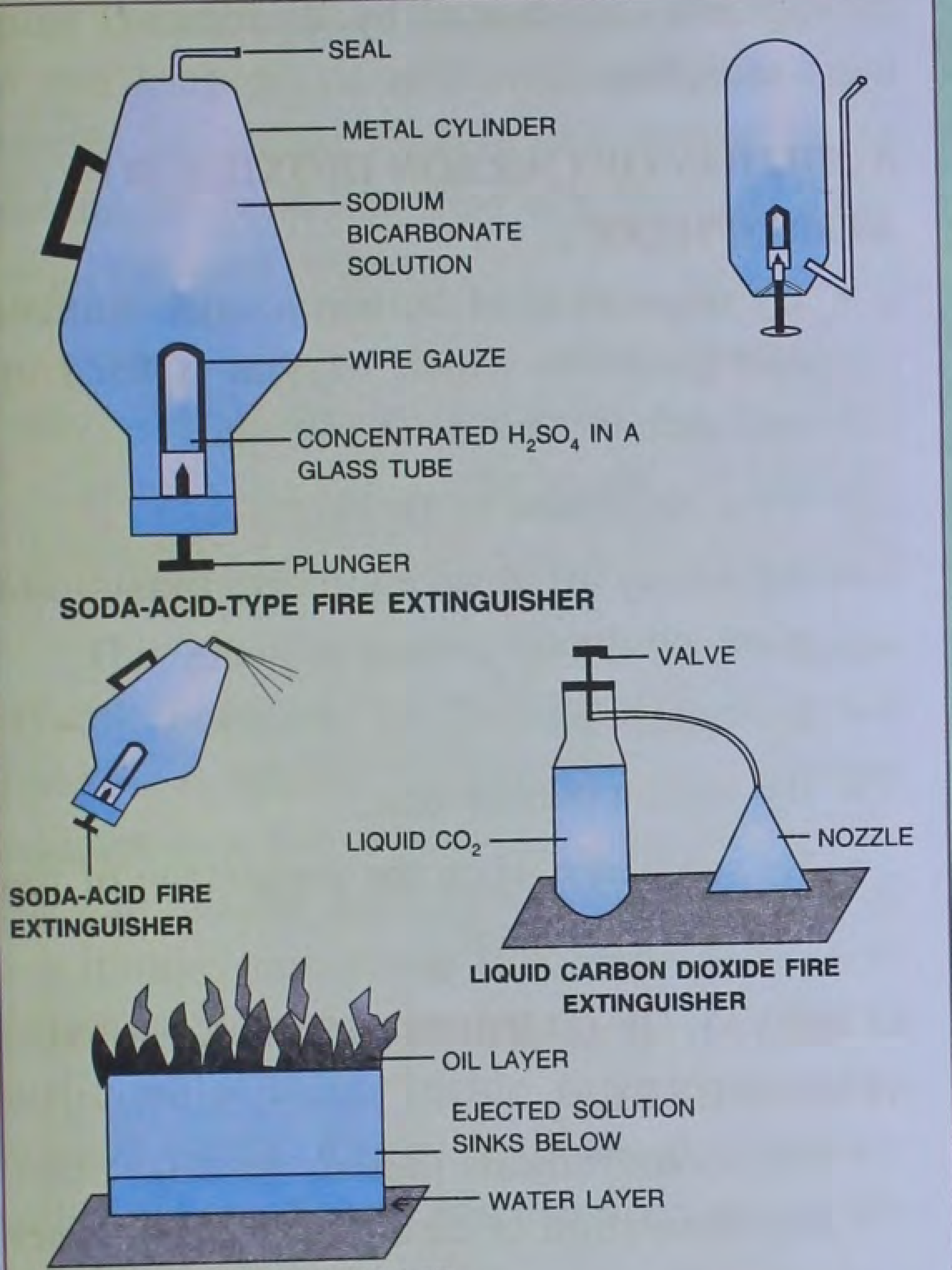
4.24 FIRE-EXTINGUISHER

Fire extinguishers are devices in which carbon dioxide is produced in different forms to be used as an extinguishing agent.

Some common types of fire extinguisher are :

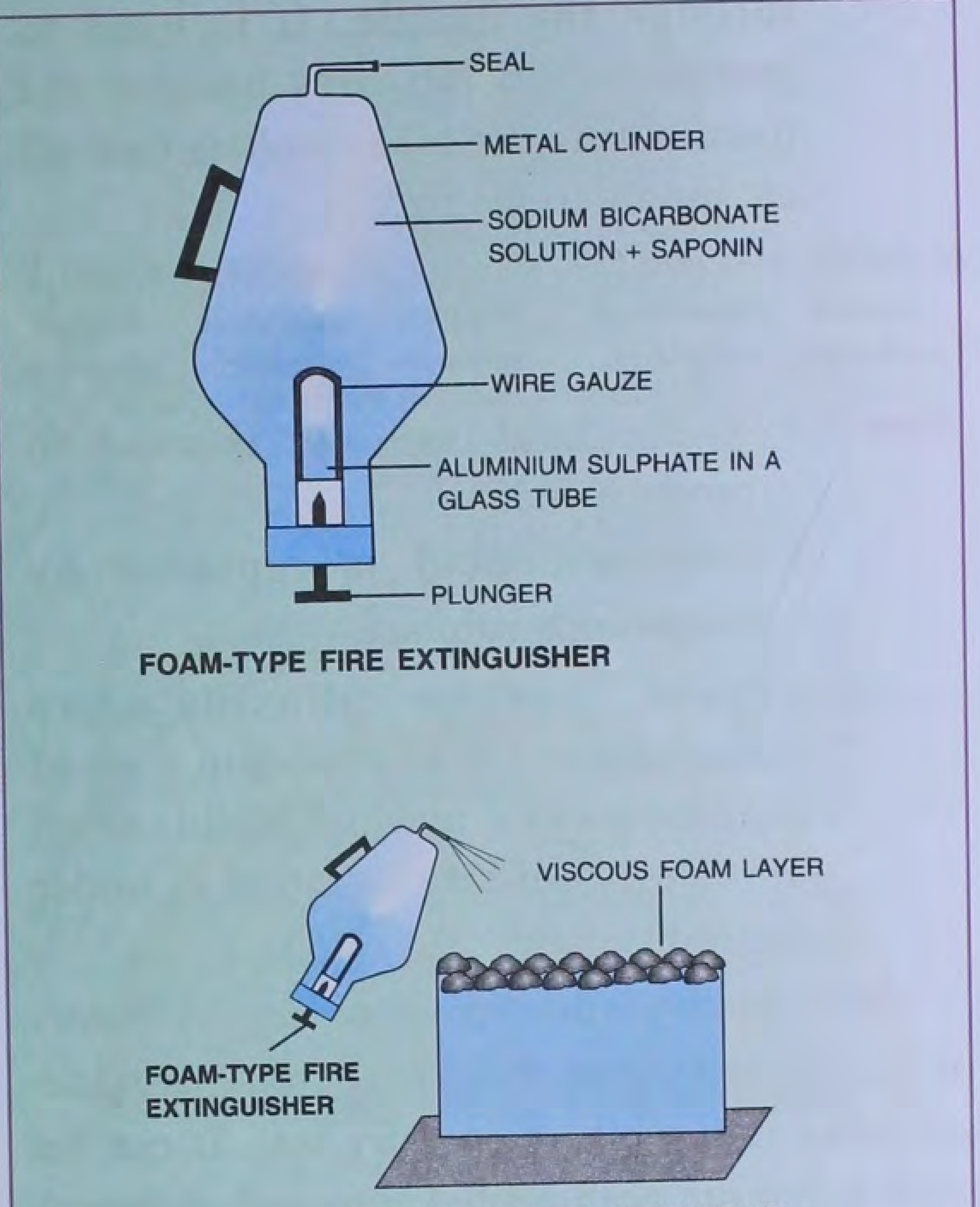
(i) soda-acid fire extinguisher
(ii) foam-based fire extinguisher
(iii) liquid carbon dioxide fire extinguisher

SODA-ACID FIRE EXTINGUISHER



A SODA-ACID FIRE EXTINGUISHER CANNOT FIGHT AN OIL FIRE

FOAM-TYPE FIRE EXTINGUISHER



A FOAM-TYPE FIRE EXTINGUISHER CAN FIGHT AN OIL FIRE

(i) Soda-acid fire extinguisher : It contains sodium bicarbonate and sulphuric acid in separate chambers. The extinguisher consists of a metallic cylinder filled up to two-thirds with a saturated solution of sodium bicarbonate. A sealed glass bottle containing concentrated solution is kept inside the cylinder. When the apparatus has to be used, the cylinder is inverted and made to hit the floor. As a result, the two chemicals come in contact with each other and the carbon-dioxide gas is produced. The gas comes out in the form of a solution through the nozzle with a great force. It spreads over the fire and cuts off the supply of oxygen to it and hence the fire is extinguished.

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

(Sodium bicarbonate) (dilute sulphuric acid) (sodium sulphate)

(ii) Foam-type fire extinguisher : It contains aluminium sulphate and sodium bicarbonate in two separate chambers. When needed, the two chemicals are made to mix with each other and react to produce carbon-dioxide and aluminium hydroxide which come out in the form of foam through the nozzle. It is used to extinguish oil fed fires because the foam covers the oil as well as cuts off air supply to the fire.

$$\underset{\text{(Sodium bicarbonate)}}{6NaHCO_3} + \underset{\text{(Aluminium sulphate)}}{Al_2(SO_4)_3} \rightarrow \underset{\text{(Sodium sulphate)}}{3Na_2SO_4} + \underset{\text{(Aluminium hydroxide)}}{2Al(OH)_3\downarrow} + \underset{\text{(Carbon dioxide)}}{6CO_2\uparrow}$$

Note :
- A chemical *saponin* is used to produce foam
- Sulphuric acid is replaced by aluminium sulphate

(iii) Liquid carbon dioxide fire extinguisher : It is a modern type of fire extinguisher, in which liquid carbon dioxide is stored in a steel cylinder under pressure.

On opening the valve of the cylinder, pressure falls and liquid carbon dioxide solidifies into white snow (dry ice). It can be used to put out both oil-fed fires and electrical fires.

Why the soda-acid and the foam-types of extinguisher cannot be used for fighting electrical fires ?

In both of these fire extinguishers, the solutions are prepared in water, which conducts electricity. As a result, it might generate an electric shock leading to short-circuit and another fire.

CARBON CYCLE

The process by which the amount of carbon dioxide is maintained in the atmosphere is called **carbon cycle.**

In the atmosphere the percentage of carbon dioxide is about 0·03% - 0·04% by volume. This remains almost constant because the addition of carbon dioxide to the atmosphere is balanced by its removal from the atmosphere.

ADDITION OF CARBON DIOXIDE TO ATMOSPHERE :

- By respiration of human beings, animals and plants in which oxygen is used up and carbon dioxide is released.
- By combustion of fuels.
- By decay of dead animals, plants and plant products.
- By industries.
- By volcanic eruptions.
- By sea water when the percentage of gas increases in water.

REMOVAL OF CARBON DIOXIDE FROM ATMOSPHERE :

- By photosynthesis *(details in 4B).*
- By dissolution of carbon dioxide in water when the percentage of gas increases in the atmosphere.

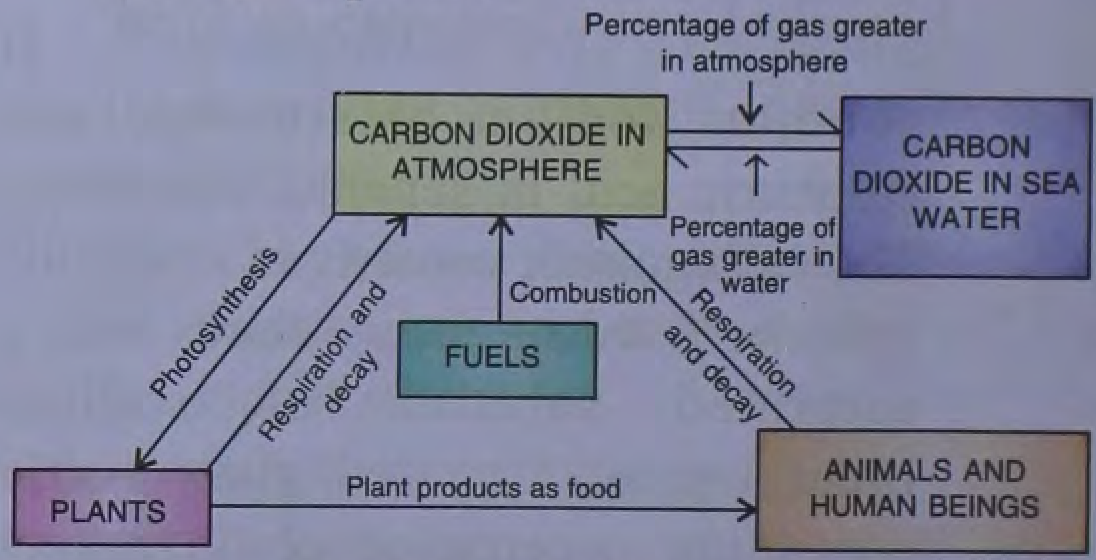


Fig. 4.22 : Carbon Cycle

4.25 GREEN HOUSE EFFECT AND GLOBAL WARMING

The earth receive heat energy from the sun in the form of radiations. Some of these radiations are absorbed while rest are reflected from the earth's surface. Most of the short wave radiations pass through the air but most of the long wave reflected radiations are trapped by carbon dioxide gas present in air making the earth hot. This is a blessing, for it keeps the earth warm.

The trapping of the earth's radiated energy by carbon dioxide present in the air, so as to keep the earth warm, is called 'green house effect'.

This effect is known as the "green house effect" because, in colder regions, this principle is applied to grow plants of warmer climates in a house made of glass walls. The glass allows the sun's heat to enter the house, but it does not allow this trapped heat to move out of it, thus making the house sufficiently warm inside to help to grow tropical plants. The glass house is popularly called a green house, and therefore we get the name "*green house effect.*"

Why does a closed car parked in the sun become unbearably hot inside ?

Carbon dioxide traps the heat of the radiations and causes greenhouse effect. However due to air pollution the total amount of carbon dioxide in air has increased. Besides that, there are other greenhouse gases in air due to pollution, such as nitrous oxide, ozone, chlorofluorocarbon, methane, etc. All these gases have created a thermal blanket around the earth trapping more heat in the form of reflected radiation than required. This causes further warming of the earth known as **global warming**.

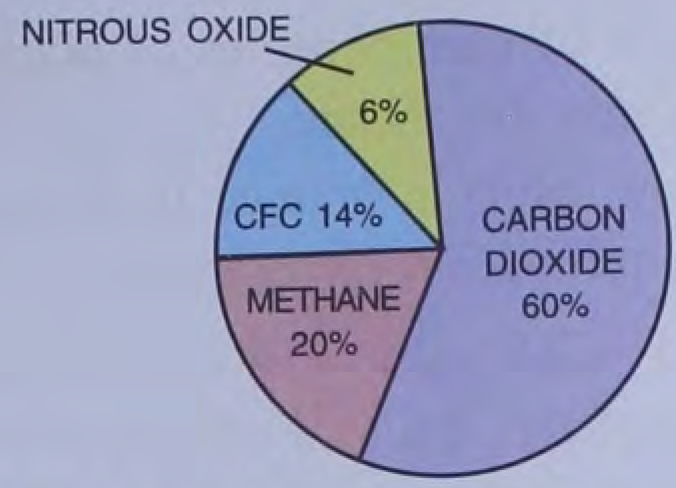


Fig. 4.23 : Contribution of percentage of different gases to global warming

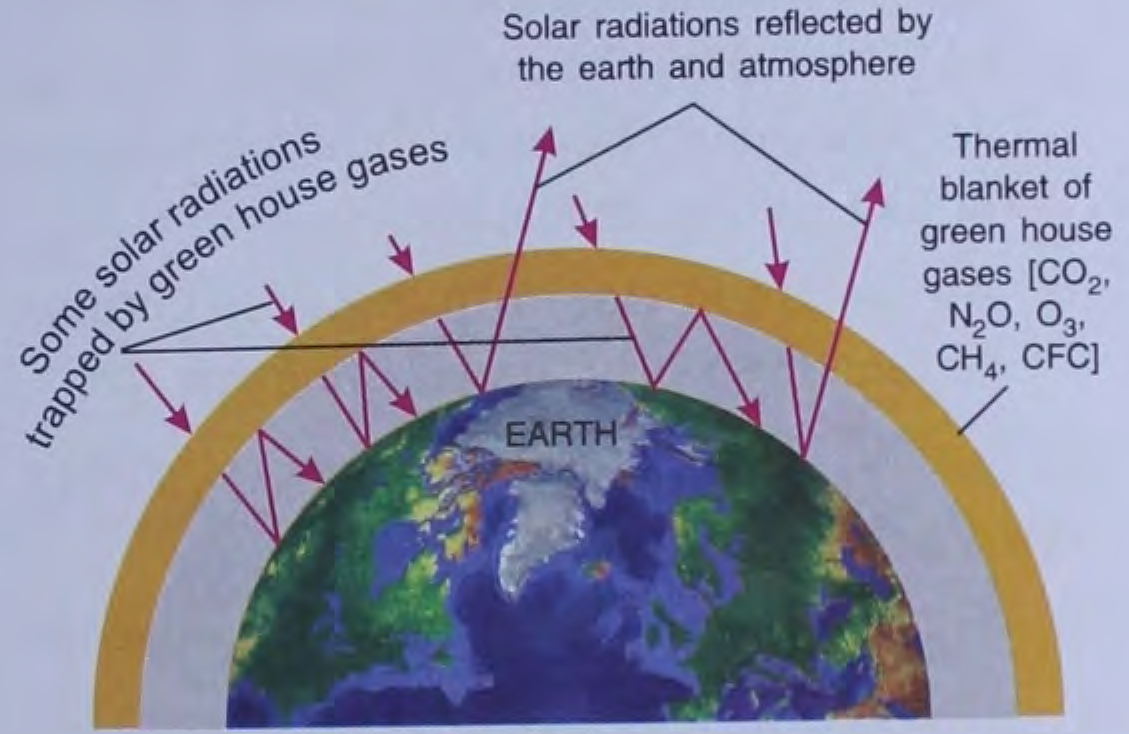


Fig. 4.24 : Global warming

EFFECTS OF GLOBAL WARMING

Global warming has serious consequences.

- According to scientists the average temperature of the earth has risen by 0·5°C in the past 100 years because of an increase in the amount of greenhouse gases in air.
- Ice in polar regions may melt causing floods in coastal regions and islands. As you know the Gangotri glacier in the Himalayas has started melting because of global warming.
- Disturbance in ecological balance may be caused. It could result in wide ranging effects on rainfall patterns, agriculture, forests, etc.

- Extinction of many species of plants and animals may be caused.
- This may result in change in the pattern of crop cultivation (crop cycle).

CAUSE OF INCREASED PERCENTAGE OF CARBON DIOXIDE IN THE ATMOSPHERE

- Deforestation or cutting down of vegetation. (As we know that plants help in the removal of carbon dioxide from air by photosynthesis). Thus, human activities contributes to the accumulation of CO_2 in the atmosphere.
- Air pollution due to industries, burning of fuels, use of chemical weapons, *etc*.

STEPS TO BALANCE CARBON DIOXIDE IN THE ATMOSPHERE

Since global warming will cause an unbalanced ecological system, serious efforts should be made to balance the percentage of carbon dioxide in the atmosphere. Some of them are :

- Growing more trees and plants.
- Using smokeless sources of energy like solar energy, biogas, *etc*.
- Using filters in the chimneys of factories and power houses.
- Reducing the consumption of fossil fuels.

Do You Know ?

Many countries have reached an agreement to reduce the emission of greehouse gases. The Kyoto Protocol is one such agreement.

RECAPITULATION

- Carbon dioxide is present in air upto 0·04% of the total volume of the atmosphere.
- Carbon dioxide is prepared by burning charcoal or any other fuel in the presence of oxygen.
- In the laboratory, carbon dioxide is prepared by the action of dilute acids on metallic carbonates and bicarbonates.
- Carbon dioxide is a colourless, odourless gas. It is heavier than air and is highly soluble in water.
- Carbon dioxide is a non-supporter of combustion nor does it burn itself. Therefore, it is used as the main anti-fire agent in fire extinguishers.
- Carbon dioxide turns lime water milky.
- Carbon dioxide is an acidic oxide that gives an acidic solution when dissolved in water.
- Carbon dioxide causes green house effect.

EXERCISE – III

1. (a) Name the chemicals required for the preparation of carbon dioxide in the laboratory.
   (b) How will you collect the gas ?
   (c) Write the balanced chemical equation for the above reaction.
   (d) Draw a labelled diagram for the preparation of CO_2 in the laboratory.
   (e) Why is sulphuric acid not used for the preparation of carbon dioxide in the laboratory ?
2. Write the balanced chemical equations for the preparation of carbon dioxide by :
   (a) heating calcium carbonate.
   (b) the action of acetic acid on sodium bicarbonate.
   (c) the action of dilute sulphuric acid on sodium bicarbonate.
3. What happens when :
   (a) a lit splinter is introduced into a jar containing carbon dioxide ?
   (b) moist blue litmus paper is placed in a jar containing carbon dioxide ?
   (c) carbon dioxide is passed through lime water first in small amounts and then in excess ?
   (d) a baking mixture containing baking powder is heated ?
   (e) a soda water bottle is opened ?
4. Give reasons for the following :
   (a) An excess of carbon dioxide increases the temperature of the earth.
   (b) Soda acid and foam types of fire extinguisher are not used for extinguishing electrical fires.
   (c) Solid carbon dioxide is used for the refrigeration of food.
5. What is a fire extinguisher ? What is the substance used in the modern type of fire extinguisher ? How is it an improvement over the soda acid-type and the foam-type fire extinguishers ?
6. Explain the term 'green house effect'. How can it be both beneficial and harmful for life on the earth ?
7. What steps should be taken to balance carbon dioxide in the atmosphere ?

OBJECTIVE TYPE QUESTIONS

1. Fill in the blanks :
   (a) .... is the most abundant inert gas present in air.
   (b) Oxides of sulphur and nitrogen combine with rain water to form .... and .... which cause ....
   (c) .... and .... are the most common air pollutants.
   (d) .... discovered the oxygen gas.
   (e) Oxygen occupies about .... of air by volume.
   (f) Carbon dioxide is .... than air.
   (g) Lime water is a solution of ....
   (h) Solid carbon dioxide is known as ....
2. Write **'true'** or **'false'** for the following statements :
   (a) Sodium bicarbonate and dilute sulphuric acid are used for preparing carbon dioxide in a soda-acid type fire extinguishers. ....
   (b) Carbonic acid gives carbon dioxide when treated with water. ....

(c) Oxygen gas turns red litmus into blue. ....

(d) Air is a mixture containing nitrogen and oxygen as the two main gases. ....

(e) Oxygen is collected by upward displacement of water. ....

3. Match the following :

	Column A	Column B
(a)	Global warming	(i) Hydrated ferric oxide
(b)	Acid rain	(ii) Manganese dioxide
(c)	Rust	(iii) Carbon dioxide
(d)	Catalyst	(iv) Ozone
(e)	Photosynthesis	(v) Nitrogen dioxide

MULTIPLE CHOICE QUESTIONS

1. This substance helps to reduce the release of pollutants in the air.

(a) sulphur dioxide

(b) chlorofluorocarbon

(c) smoke

(d) CNG

2. Carbon monoxide mixes with blood to form

(a) lime water

(b) carboxyhaemoglobin

(c) calcium carbonate

(d) water vapour

3. The natural way of adding oxygen to air which involves green plants is called

(a) photosynthesis (b) respiration

(c) burning (d) dissolution

4. Which one of the following is most likely to be corroded ?

(a) a steel cup-board

(b) a galvanised iron bucket

(c) an iron hammer

(d) a tin plated iron box

5. The gas which causes greenhouse effect is

(a) oxygen (b) nitrogen

(c) methane (d) hydrogen chloride

6. The process by which burning of food in our bodies takes place is

(a) photosynthesis (b) respiration

(c) decomposition (d) combustion

7. The substance used as a coolant to preserve food

(a) dry ice (b) methane

(c) oxygen (d) water vapour