Preface

'*Concise Chemistry Middle School*' meant for class VII students is a part of 'Integrated Science' with Physics and Biology books being brought out separately. The book has been written strictly in accordance with the latest curriculum prescribed by the council for the ISC Examinations, New Delhi.

The main objective of the book is to make the basic concepts of chemistry clear and interesting for the students. An attempt has been made to organize the contents carefully and present them in simple language, keeping in mind the needs of an average student. Through the help of simple diagrams, a conscious effort has been made to provide clear explanations for all aspects of the subject matter at the Class VII level. Many experiments and activities have been described to make the learning more interesting and appealing. Each chapter has been summarized at its end under the heading "Recapitulation" for a quick revision of the chapter. Detailed exercises are given at the end of each chapter to help the students test and assess their grasp of the subject in a self-help manner.

Great effort has been made to present the different topics in such a way as to elicit among students a spirit of enquiry, scientific temper and appreciation for chemical processes.

We hope that both the teachers and students will enjoy learning science through this series of chemistry text books. Inspite of our best efforts, some shortcomings might have escaped our notice. We shall feel obliged if the same are brought to our attention. Also, we shall gratefully acknowledge suggestions and criticisms for the improvement of the book.

Author

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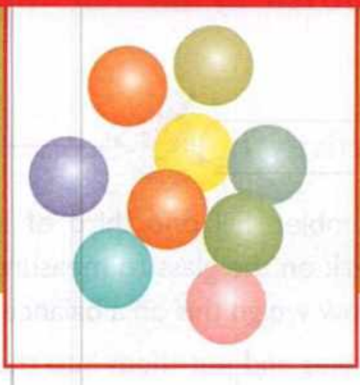


Matter and Its Composition

1

Theme : In our surroundings different types of matter/objects are found such as stones, water, soil, oil, sugar, air. Some of them have common characteristics in terms of states, some are solids, liquids and some are gases. These states vary in their shape, volume and texture. All these are made up of some materials which have mass and occupy space. The study of their composition is of great importance in daily life.

In this chapter you will learn :

- *Definition of matter.*
- *Matter has mass and occupies space – Explanation.*
- *Composition of matter – brief introduction.*

LEARNING OUTCOMES

The children will be able to :

- describe matter.
- discuss the constituents (atoms/molecules) of matter.
- explain the forces which keep atoms / molecules in matter together.

INTRODUCTION

When we look around us, we see different types of things such as water, soil, stones, minerals, plants, animals, etc. We also use innumerable objects in our daily lives like books, pens, bags, shoes, cars, etc. All these things are of different shapes and sizes. Some of them are living, like plants and animals, while some are non-living, like water, soil, etc. Some are natural like minerals, air, water, living beings while some are man-made like books, pencils, papers, houses, etc.

But what makes up all these substances ? The answer is **matter**. In fact the food we eat, the clothes we wear, the books we read, the chair on which we sit are all made up of different materials. In science, the term **matter** is used for all these materials.

> Matter is anything that has mass, occupies space and can be perceived by our senses.

That means matter is not only that, which we can see or touch, but also which we can feel, like air. We can not see or touch air but we can feel it.

Water, sugar, alcohol, milk, gold, coal, hydrogen, oxygen, rocks-are all **matter** because all of them have mass and occupy space.

Does matter of only one kind exist ?

No, there are different kinds of matter. A shirt is matter made up of cloth, a book is matter made up of paper, a shoe is matter made up of leather, etc.

> Name *two* objects made up of each of the following materials :
>
> 1. Metal, 2. Wool,
> 3. Cloth, 4. Plastic,
> 5. Leather, 6. Glass

MATTER HAS MASS AND OCCUPIES SPACE

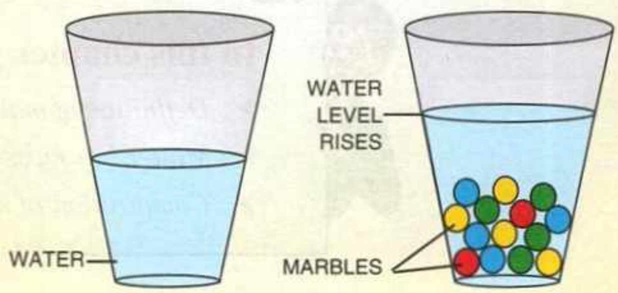
This can be proved by the following activity :

Activity 1

Take a glass tumbler. Fill one third of it with water. Put a mark on the glass to measure the level of water. Now weigh this on a balance.

Take some marbles and put them into the glass tumbler one by one. After some time you will notice that the water level crosses the mark and rises. This is because the marbles occupy space. Again weigh the glass with the marbles.

You will find that the second mass is greater than the first one. This proves that marbles have mass.



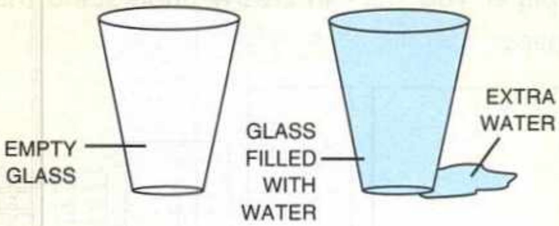
The activity proves that matter has **mass** and occupies **space**.

> - The quantity of matter that a body contains is known as its **mass**.
> - The **space** occupied by a body is called its **volume**.

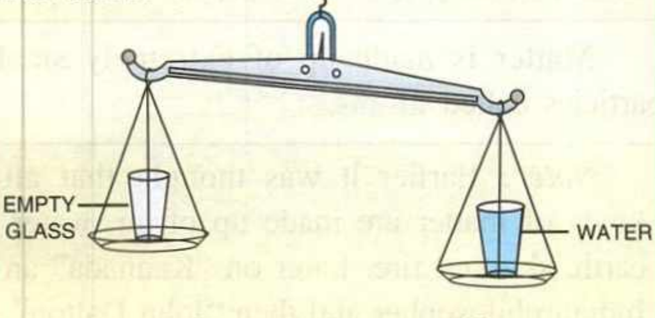
If we hold objects in our hands, then we can feel their mass. Hold a book and you will feel its mass.

Activity 2

Take two identical glass tumblers. Fill one of them with water upto the brim. Pour some more water into it. What do you observe ? The extra water flows out of the tumbler because there is no more space left in it. This is because water poured earlier has already occupied the space in the glass tumbler.



Now place the empty glass tumber and the one filled with water on the two pans of a weighing balance. The pan with the glass of water tilts to one side. This shows that **water has mass**.

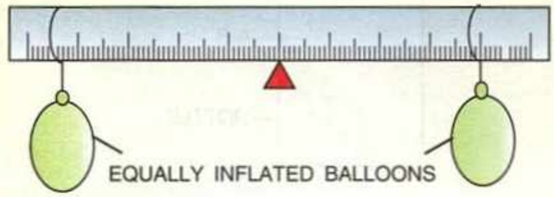


Balance tilted on one side

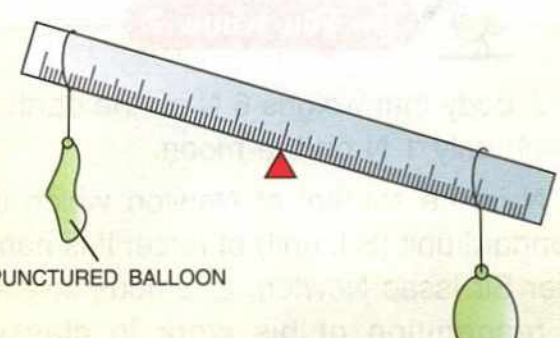
Activity 3

Take two similar balloons. Blow air in them. What do you observe ?

You will observe that the shape of balloons changes, they become inflated because air inside the balloons **occupies space**. Inflate them equally. Suspend one balloon to the left of a metre scale and the other one to the right of it, as shown in the figure below. Balance the scale in the middle with the help of a peg.



Now puncture one of the balloons with the prick of a needle. You will observe that air escapes from the balloon and the metre scale tilts towards the inflated balloon. This is because of the **mass of air** present in the inflated balloon.



Air occupies space and has mass

This proves that air, which is a kind of matter, occupies space and has mass.

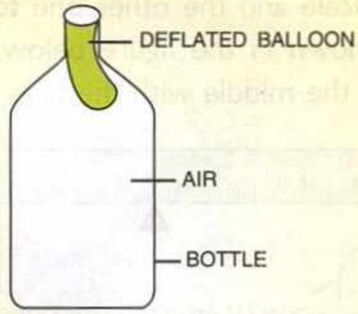
Activity 4

This can be done by children.

Take a plastic bottle, push a deflated balloon into it and stretch the open end of the balloon over the bottle's mouth.

Now, blow and try to inflate the balloon.

What do you observe ? Does the balloon get inflated ?



No, because the space inside the bottle is occupied by air and there is no space left for the balloon to be inflated.

This proves that although air is invisible, yet it occupies space.

Do You Know ?

A body that weighs 6 N on the earth will weigh only 1 N on the moon.

N is the symbol of Newton which is a standard unit (S.I. unit) of force. It is named after Sir Issac Newton, a famous scientist, in recognition of his work in classical mechanics.

Mass and weight are different from each other. Mass is the "quantity of matter" and weight is "the force with which the earth pulls a body towards itself". The mass of a body does not change but its weight changes from place to place.

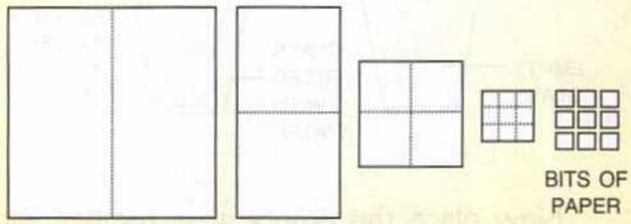
COMPOSITION AND CHARACTERISTICS OF MATTER

Now you know that all substances are made up of matter, but what is matter made up of ?

To understand this, let us do the following activity.

Activity 5

Take a sheet of paper. Tear it into two half sheets. Fold each half sheet and tear it again. Repeat this until a very small piece of paper is obtained. Now try to get even smaller bits of paper from that small piece. Each time you will notice that there is no change in the appearance and properties of paper. By looking at the bits of paper you still can clearly understand that it is paper.



Hence we can conclude that paper, a kind of matter, is made up of tiny particles which exhibit all the properties of paper.

Matter is made up of extremely small particles called **atoms**.

Note : Earlier it was thought that all kinds of matter are made up of air, water, earth, sky and fire. Later on "Kannada" an Indian philosopher and then "John Dalton", an English scientist, proposed that all kinds of matter are made up of atoms.

"An atom is the smallest possible unit of matter that exhibits all the properties of that matter".

Atoms usually do not have independent existence, therefore they combine with one another to form another minute particle called **molecule**.

"A molecule is the smallest unit of matter which exhibits all the properties of that kind of matter and also has an independent existence".

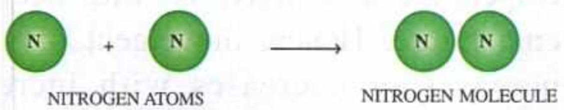
Molecules are bigger than atoms. However both the particles are too small to be seen through the naked eye or an ordinary microscope.

A molecule can be formed of atoms of the same kind or of different kinds.

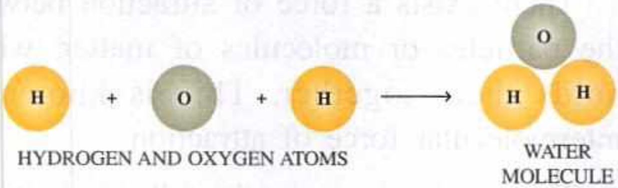
For example :

- A hydrogen molecule is made up of two hydrogen atoms.

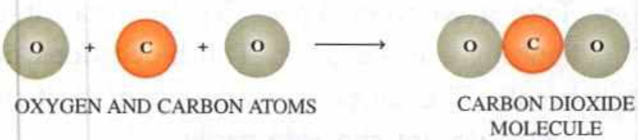
- A nitrogen molecule is made up of two nitrogen atoms.



- A water molecule is made up of two hydrogen atoms and one oxygen atom.



- A carbon dioxide molecule is made up of one carbon atom and two oxygen atoms.



CHARACTERISTICS OF PARTICLES OF MATTER

Properties of matter can be explained on the basis of arrangement and characteristics of particles (atoms and molecules) from which they are formed.

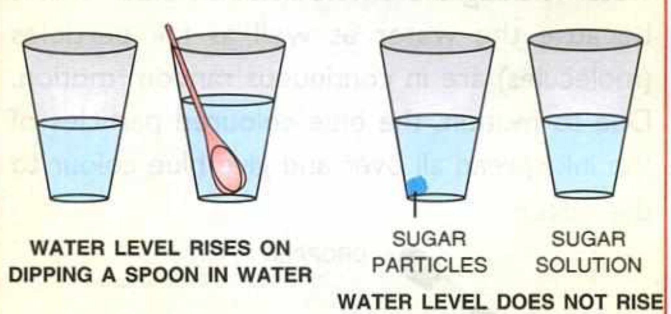
1. ***Particles of matter have space between them. This space is called interparticular or intermolecular space.***

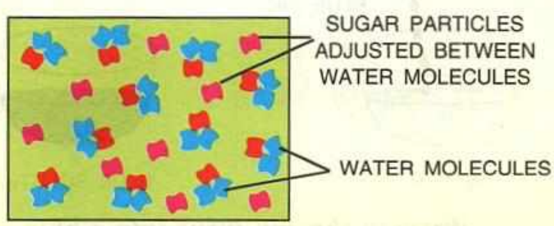
This can be shown by the following activity.

Activity 6

Take half a glass of water. Dip a spoon in it. What do you observe ? The water level rises, indicating that spoon occupies space.

Now remove the spoon, water comes down to its original level. Now add a spoon of sugar to it and stir well. The sugar disappears but the level of water in the glass does not rise, that means the volume of water has not





To show intermolecular space between water molecules

increased. But where did the sugar particles disappear ?

The sugar particles being smaller get adjusted between the water molecules. This shows that there are intermolecular spaces in water.

Why does the water level rise on dipping a spoon ?

2. ***Particles of matter are always in random motion :*** By now you know that matter is made up of minute particles which have gaps between them. But do these particles stand still in the bulk or do they keep moving ? This can be better understood by the following activity.

Activity 7

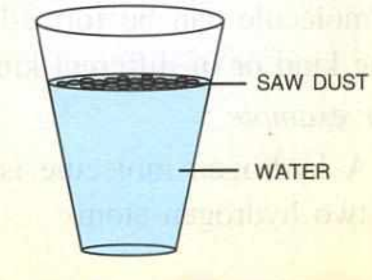
Take a cup of water. Add few drops of blue ink into it. What do you observe? You will observe that the ink slowly mixes uniformly in water making the whole solution blue. This is because the water as well as ink particles (molecules) are in continuous random motion. Due to motion, the blue coloured particles of the ink spread all over and give blue colour to the water.

Water in the cup turns into a blue solution due to ink

Activity 8

Take a glass tumbler, fill three fourth of it with water and sprinkle some saw dust on it. Observe it carefully using a magnifying glass.

You will notice that particles of saw dust move randomly on the surface of water.



Randomly moving particles of saw dust

Why do these particles move ? This is because they possess kinetic energy. The kinetic energy increases with increase in temperature and decreases with decrease in temperature. Hence, movement of particles increases or decreases with increase or decrease in temperature.

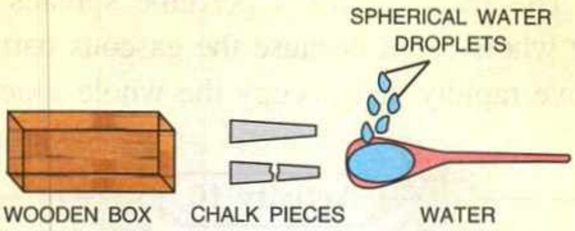
3. ***Particles of matter attract each other***

There exists a force of attraction between the particles or molecules of matter, which holds them together. This is known as intermolecular force of attraction.

This can be shown by the following activity.

Activity 9

- Take a wooden block. Try to break it by applying a force on it. The block does not break. The block is made up of particles which do not separate easily.



To show force of attraction between molecules

- Take a chalk piece, apply some force on it and it breaks up into two pieces.
- Take some water in a table spoon and throw it up. What do you observe ? Falling droplets of water are spherical in shape.

  Why are they spherical ? Because water molecules hold each other.

All these show that, there is intermolecular force of attraction between the particles of wooden box, chalk piece and water.

Hence, it is proved that intermolecular attraction between the particles keeps them together.

STATES OF MATTER

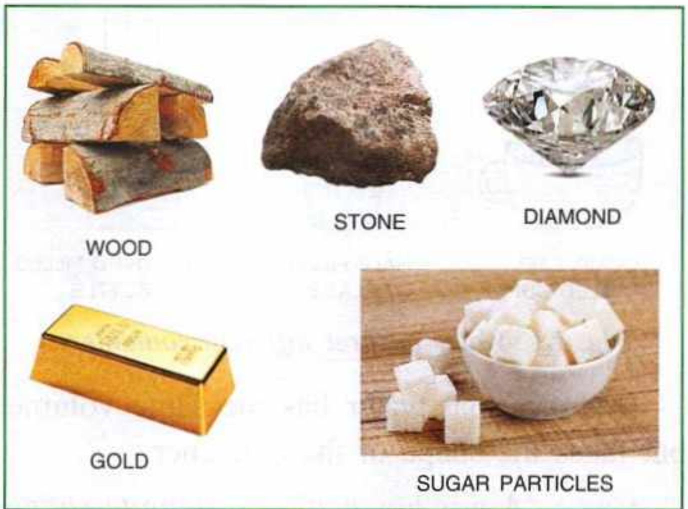
Now you know that intermolecular spaces, intermolecular attraction and random motion are three important characteristics of particles of any kind of matter.

If the force of attraction increases, the molecules move closer and the space between them decreases and if the force of attraction decreases, the molecules move apart and the space between them increases.

This fact accounts for the three different states of matter. Those are

• Solid • Liquid and • Gas

Solid : "*A solid has a definite shape and a definite volume*." The particles are tightly



packed in solids. The intermolecular force of attraction is very strong and intermolecular space is almost negligible. The particles are not free to move. They can only vibrate about their mean positions. Solids are rigid and incompressible.

Liquid : A liquid has a definite volume but no definite shape.

The particles in a liquid are less tightly packed in comparison to solids. In liquids, the intermolecular force of attraction is weaker and intermolecular gaps are larger. Thus the particles are free to move within the bulk. Liquids can flow and are therefore called fluids.

Example : Water, milk, oil, alcohol, petrol, etc.

Consider an experiment. Take a cup filled with water. Water acquires the shape of the cup. Pour this water into a glass. It fills half of the glass and takes the shape of the glass. Pour this water into a bottle. The bottle is filled one third and water takes the shape of the bottle.

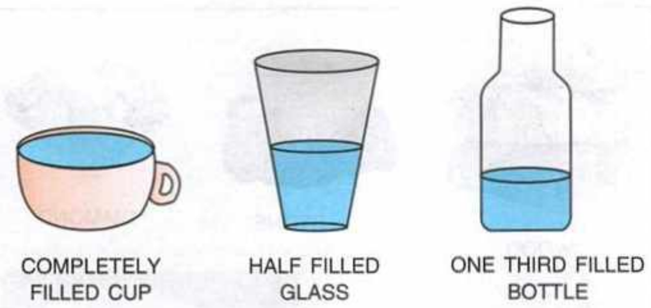


Fig. 1.1 Water in three different containers

It shows that water has the same volume but takes the shape of the container.

Gas : "*A gas has neither a definite shape nor a definite volume.*"

The particles in a gas are far apart. The intermolecular force of attraction between the particles is very weak and the space between them is large. The particles are free to move in any direction *i.e.* they can flow.

They can be compressed inside a small container and can spread into a large space available to them.

Example : Hydrogen, oxygen, nitrogen, carbon dioxide, air, etc.

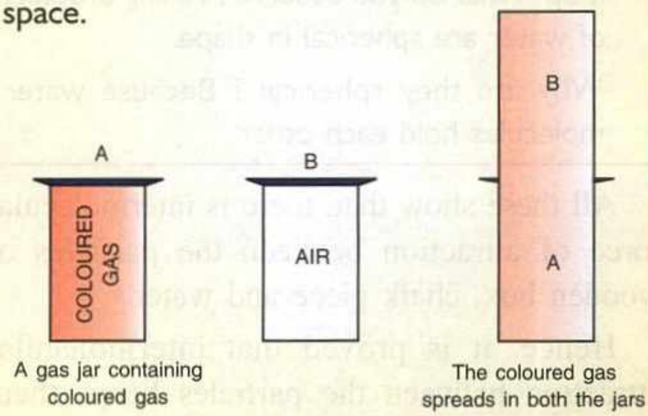
Gases also take the shape of the container in which they are kept.

Example : Air when pumped into a football, takes the shape of the football.

The fragrance of a perfume spreads into the whole room because the gaseous particles move rapidly and occupy the whole space.

Activity 10

Take two jars. Fill one of the jars with reddish brown bromine vapours and the other contains air. Invert the empty jar over the jar containing the bromine vapours and remove the lid. You will observe that the coloured gas also spreads in the upper jar because it gets more space.



This shows that gases have neither a fixed shape nor a fixed volume. They have no free surfaces.

All substances that can flow are called fluids. Liquids and gases are fluids.

Table 1.1 Properties of solids, liquids and gases.

S.No.	Property	Solids	Liquids	Gases
1.	Intermolecular space	Molecules are closely packed; have negligible intermolecular space.	Molecules are not closely packed; have more intermolecular space.	Molecules are at a greater distance from one another; have the maximum intermolecular space.
2.	Shape	Have fixed shape	Have no fixed shape. Take the shape of the container in which they are kept.	Have no fixed shape. Take the shape of the container in which they are filled.

3.	Volume	Have fixed volume.	Have fixed volume.	Have no fixed volume.
4.	Fluidity	Do not flow.	Flow from a higher level to a lower level.	Flow in all directions.
5.	Effect of pressure *i.e.* compression	Effect of pressure is very low.	Effect of pressure is higher than on a solid.	Effect of pressure is very high.
6.	Transparency	Solids are generally opaque *e.g.* wood, stones, *etc.* (glass and diamond are transparent)	Most of the pure liquids are transparent in nature *e.g.* water, alcohol, petrol.	All gases, oxygen, nitrogen carbon dioxide, *etc.* are transparent in nature.
7.	Lustre	Amongst the solids, all the metals have lustre.	Amongst the liquids, mercury is lustrous.	Gases are not lustrous.
8.	Solubility in water	Some solids are insoluble in water. *e.g.* wood, mud, etc. Other solids such as sugar, common salt are soluble in water.	Liquids can be miscible as well as immiscible in water. *e.g.* alcohol and vinegar are soluble (miscible) in water while oil and water, petrol and water are immiscible.	Some gases are insoluble in water. *e.g.* nitrogen, hydrogen. Some gases are soluble in water. *e.g.* oxygen, carbon dioxide, ammonia, etc.

INTERCONVERSION OF STATES OF MATTER

Interconversion of states of matter is the process by which matter changes from one state to another and back to its original state without any change in its chemical composition, when conditions are changed.

The change in the state of matter is mainly caused by

- change in temperature and
- by applying pressure.

In everyday life, we come across substances that change from one state to another when conditions are changed.

(1) Change of state by changing the temperature :

When temperature increases, a solid changes into liquid and then into vapour and when temperature decreases just the reverse happens.

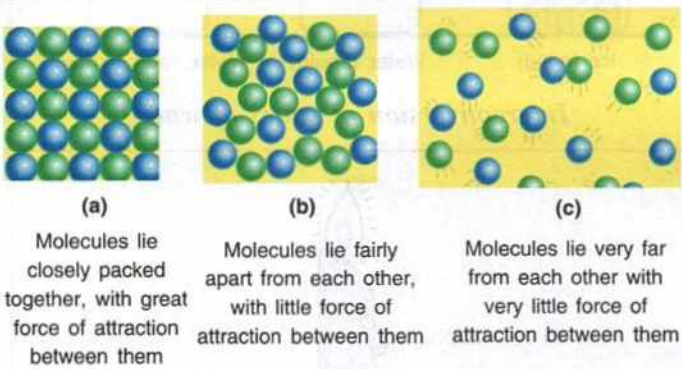


Fig. 1.2 The position of molecules in the (a) solid, (b) liquid and (c) gaseous states.

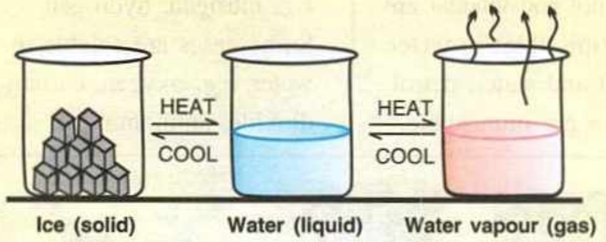
For example, water is a liquid under ordinary conditions but when it is kept in a refrigerator, it gets cooled and changes into ice at 0°C. Ice when kept at room temperature, again changes back into liquid water.

Water when heated starts changing into steam above 100°C, but when this steam is cooled, it again changes into its liquid form.

In all the *three* states, the properties of water remain the same.

When a substance changes from solid to liquid or liquid to vapour, heat energy is absorbed but when vapour changes to liquid or liquid changes to solid state, same amount of heat energy is evolved. The net energy change is almost zero, because change of state does not change the chemical composition of the substance.

Another example is wax. When you ignite a candle, solid wax melts into liquid wax which rises in the wick. The wax near the glowing wick melts and some part of the molten wax trickles down and solidifies.



Interconversion of states of water

States of wax

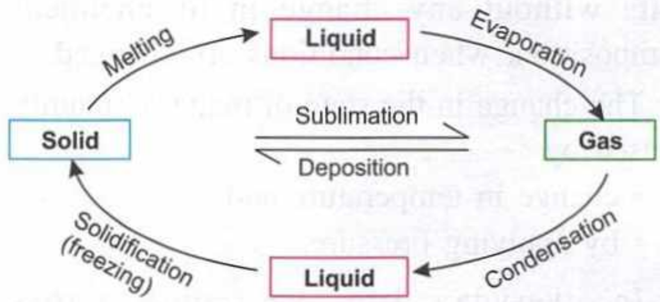
In both the above cases, the change of state of the substance is due to change in temperature.

(2) Change of state by changing the pressure :

The state of a substance can also be changed by applying pressure. For example, gases on increasing pressure change into liquid form. Thus we can obtain liquid oxygen, liquid carbon dioxide, liquid cooking gas, etc.

The cooking gas sold in the gas cylinders is in the form of liquid under high pressure, thus called as Liquified Petroleum Gas (LPG). When the regulator valve is opened, pressure is released and LPG comes out in the form of gas.

There are some substances like camphor, naphthalene, iodine crystals, ammonium chloride, etc. which change directly from solid to gaseous state on heating (this process is called sublimation) and vice versa on cooling.



RECAPITULATION

- Matter has mass and occupies space.
- Matter is made up of atoms and molecules.
- Atoms are the smallest particles of matter which may or may not have independent existence.
- Molecules are capable of independent existence. They are made up of atoms of same kind or different kinds.

- The atoms and molecules are in random motion.
- There are gaps between the molecules of matter called as intermolecular space.
- There exists a force of attraction between the molecules known as intermolecular force of attraction.
- Matter exists in *three* states : solid, liquid and gas.
- Matter can change from one state to another on changing temperature and pressure.
- The change of state of a matter from one form into another is called interconversion of states of matter.

EXERCISE

1. Define matter.
2. What is the difference between mass and weight?
3. If an object weighs 6 N on earth what will be its weight on moon ? What will be the change in its mass ?
4. Write your observation and conclusion for the following :
   (*a*) When few marbles are put in a glass half filled with water.
   (*b*) Ice is kept at room temperature.
5. State three main characteristics of the particles of matter.
6. Differentiate between an atom and a molecule.
7. Define :
   (*a*) Solid (*b*) Liquid
   (*c*) Gas
   Give *two* examples of each type.
8. Why are liquids and gases called as fluids ?
9. (*a*) Define interconversion of states of matter.
   (*b*) Why do solids, liquids and gases differ in their physical state ?
   (*c*) Under what conditions do solids, liquids and gases change their state ?
10. Give reasons :
    (*a*) When a stone is dipped in a glass containing some water, the level of water rises but when a spoon of sugar is added to it and stirred, the water level does not rise ?
    (*b*) A drop of ink added to water in a glass turns the whole water blue.
11. Fill in the blanks :
    (*a*) Air is a matter because it has .... and .... and it can be ....
    (*b*) The molecules are made up of ....
    (*c*) The quantity of matter in an object is called its ....
    (*d*) The state of matter with definite volume and definite shape is called ....
    (*e*) The substances which can flow are called ....
12. Name the terms for the following :
    (*a*) The change of a solid into liquid.
    (*b*) The force of attraction between the molecules of matter.
    (*c*) The particles of matter which may or may not have independent existence.
    (*d*) The process due to which a solid directly changes into its vapours.
    (*e*) The change of vapour into a liquid.
13. Classify the following into solid, liquid and gas :
    Coal, kerosene, wood, oxygen, sugar, blood, water vapour, milk, wax.

Project

- Think and try to develop a working model to show the existence of water in all the *three* states.

Physical and Chemical Changes

2

Theme : Different types of changes are regularly observed occurring in the environment. Some occur on their own and some are caused due to human activities to meet their requirements. Broadly, these changes are of two kinds : physical and chemical. Keeping in view the unending role of these changes, it becomes worthwhile to learn about them.

In this chapter you will learn :

- *Physical and chemical changes.*
- *Chemical change — formation of a new product with new properties.*
- *Differentiating between physical and chemical change.*
- *Classification as phycial and chemical change.*
- *Types of changes involved when there is a change of state of matter.*
- *Types of changes involved when there is a change of energy.*

LEARNING OUTCOMES

The children will be able to :

- differentiate between physical and chemical changes.
- perform activities related to physical and chemical changes.
- classify changes such as respiration, preparation of solution of sugar, burning of paper, ripening of fruit, spoiling of food materials as physical and chemical changes.
- discuss that in a chemical change, a new substance with different properties is formed.

INTRODUCTION

Change is an important feature of nature. Every moment several changes take place around us. These changes are exciting and they generate in us the curiosity to know the reasons behind each of them.

Some common changes which we observe in nature and in our surroundings are changes of day and night, change of climate, rainfall, melting of ice, freezing of water, growth of plants and animals, digestion of food, burning of fuel, ripening of fruits, cooking of rice, formation of curd from milk, rusting of iron, etc.

But what happens to the substance when a change occurs in it ?

Let us try to understand with the help of following examples :-

(i) A raw mango is green but it turns yellow on ripening.


Raw mango


Ripe mango

Thus when a fruit ripens, its ***colour*** changes.

(ii) A sapling is very small in size but it becomes larger with time as it grows into a plant, *i.e.* its shape and size change.


A sapling


A plant

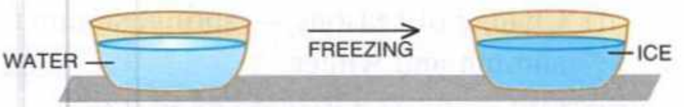
Thus when plants grow, their ***shapes and sizes*** change.

(iii) Molten wax is soft but it becomes hard on cooling.

Raw rice is hard but boiled rice is soft.

Thus, the ***hardness*** of the substance might also change when a change occurs.

(iv) Water changes into ice when kept in the freezer for few hours.



Thus a substance can change its ***state*** when a change occurs.

(v) The earth revolves around the sun which means the ***position*** of the earth with respect to the sun changes continuously with time.

From the above examples it is clear that, when changes take place, the substances may change their colour, shape, size, hardness, state, position, etc.

Thus we see that almost all substances around us undergo changes. But while some changes are easy to detect, others are too small to be noticed. Some of these changes are useful to us while others are not. We always think and try to ensure that useful changes should take place faster while the harmful changes should stop or they should rarely happen.

Activity 1

Make a list of five objects which do not show any changes in them with time.

We should remember that **there is always a reason** (*i.e.*, some cause) **behind every change**. Since most of the changes are different in nature, we need to classify them and study them accordingly in detail.

TYPES OF CHANGES

There are different types of changes based on how or on what basis, we try to classify them.

Slow Changes and Fast Changes

The changes that take longer time to complete are called slow changes. These changes may take hours, days, months or even years to occur.

Examples of slow changes :

(i) A young boy growing old. It takes a few years.

(ii) The evaporation of water from a lake, though happening continuously, takes hours.

(iii) The germination of seeds takes days.

(iv) Formation of fossil fuels from dead plants and animals is a very slow change. They take hundreds and thousands of years to be formed.

(v) Rusting of iron, tooth decay, freezing of water, change of seasons are all slow changes.

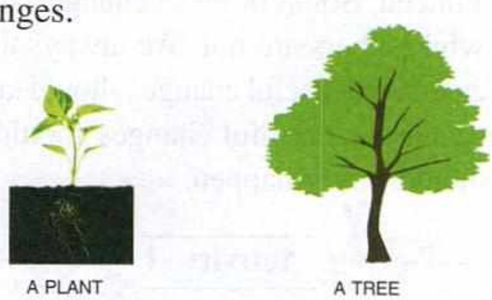


Fig. 2.1 A plant transforming into a tree is a slow change

The changes that take place in a very short interval of time are called fast changes.

Examples of fast changes :

(i) When a piece of paper is lit, it immediately catches fire and changes into black ash and the smoke released is lost into the air.

(ii) Bursting of an inflated balloon.

(iii) Bursting of a cracker.

(iv) Lighting of an electric bulb.

Fig. 2.2 Burning of a matchstick is a fast change

Activity 2

Classify the following changes into slow or fast change.

Blinking of eyes, change of seasons, explosion of crackers, rusting of iron, growing of nails, formation of curd from milk, cutting of a cloth, cooking of rice.

Natural and Man-made Changes

Some of the changes take place in nature by themselves and are never ending. Such changes are called natural changes. The formation of coal from dead and decaying plants is a natural change.

Examples of natural changes

Change of day and night, change of seasons, earthquakes, growth of all living organisms, growing of a tree, eruption of volcanoes.

Any change that occurs due to the efforts of human beings is called a man-made change.

Examples of man-made changes

The formation of steel from raw iron, making a kite from a piece of paper, preparing chapattis from wheat flour, *etc.* are man-made changes.

Periodic and Non-periodic Changes

Changes that are repeated at regular intervals of time are called periodic changes. All these changes occur regularly after a fixed time period and not randomly.

Examples of periodic changes are :

(i) Change of day and night.

(ii) Change of seasons — spring, summer, autumn and winter.

(iii) Full moon and new moon nights.

(iv) Development of high tides and low tides in the sea.

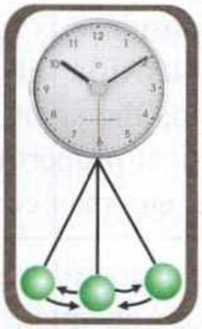


Fig. 2.3 Pendulum of a clock showing a periodic change

Changes that are not repeated at regular intervals and occur irregularly are called non-periodic changes. These changes can occur at any time and they do not have any periodicity.

Examples of non-periodic changes

These are **landslides, earthquakes***, power breakdown, *etc*. In our day-to-day life, we get fever, sneeze, headache, *etc*. These are some non-periodic changes that occur around, as well as within us.

An epidemic, a sudden shower of rain, a duststorm, thunder and lightning are also examples of non-periodic changes.

Desirable and Undesirable Changes

Changes that are useful to mankind are said to be desirable changes. For example, when cooking gas burns, it produces heat to cook our food. Similarly, milk turning into curd is a desirable change.

Any change that brings about destruction is an undesirable change. Floods and epidemics are undesirable changes.

* Landslides & earthquakes are categorised under 'natural changes.'

Activity 3

Classify the following changes into desirable and undesirable change :

Growing up of seedlings into plants, conversion of dung into manure, rusting of iron, souring of milk, breaking of a cup, drying of clothes, melting of ice, earthquake and eruption of volcanoes, ripening of fruits, curdling of milk.

Some changes are desirable at one time and undesirable at some other time.

For example : (i) Cutting of trees is desirable for those who need wood for cooking, but it is undesirable because it damages the environment.

(ii) Burning of a fuel for cooking is a desirable change but burning of a building is an undesirable change.

(iii) Timely arrival of rains is desirable, otherwise it is undesirable to a farmer as it causes flood and destruction.

Reversible and Irreversible Changes

When a change in a substance can be reversed by changing the conditions, it is said to be a reversible change. Water converting into steam at 100°C and steam reversing into water on cooling is an example of a reversible change. Melting and sublimation are also reversible changes. A reversible change is indicated by two opposite arrows ($\rightleftharpoons$ or $\rightleftarrows$).

$$\text{Water} \underset{\text{cooling}}{\overset{\text{heating}}{\rightleftharpoons}} \text{Steam}$$

Examples of reversible changes

Glowing of an electric bulb, stretching of a rubber band, ploughing of a field, melting of wax, dissolving sugar into water, vaporization of water.

If a substance cannot be brought back to its original state after a change, it is said to be an ***irreversible change***. On burning, a piece of paper changes to ash, it is an irreversible change because paper cannot be obtained back from ash.

Examples of irreversible changes

Grinding of wheat or corn into flour, cooking of food, rusting of iron, souring of milk, burning of candle or wood, ripening of fruits, growth of living organisms.

Activity 4

Tick (✓) Yes if the change is reversible and No if it is not.

Change	Reversible
1. Raw egg to boiled egg.	Yes/No
2. Batter to idli.	Yes/No
3. Wet clothes to dry clothes.	Yes/No
4. Woollen yarn to knitted sweater.	Yes/No
5. Grain to its flour.	Yes/No
6. Cold water to hot water.	Yes/No
7. Straight string to a coiled string.	Yes/No
8. Bud to flower.	Yes/No
9. Milk to Cheese.	Yes/No
10. Cowdung to biogas.	Yes/No
11. Ice cream to melted ice-cream.	Yes/No
12. Stretched rubber band to its normal size.	Yes/No
13. Souring of milk.	Yes/No
14. Ripening of a mango.	Yes/No
15. Dissolving sugar in water.	Yes/No

PHYSICAL AND CHEMICAL CHANGES

In science, all kinds of changes mentioned above can broadly be classified into *two* types :

(i) physical change (ii) chemical change.

Physical Change

A physical change is a temporary change, in which no new substance is formed and the chemical composition of the original substance remains the same, even though some of its physical properties like colour, state, shape, size, etc. may change.

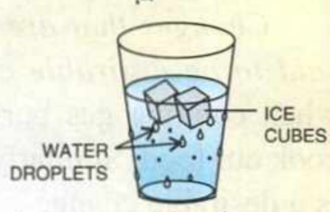
The interconversion of states of matter is a physical change. You might have observed that ice when taken out of a refrigerator melts and changes into water. If this water is put back in the refrigerator, it freezes into ice again. This means that the *properties of water and ice are the same. There is no change in chemical compostion. On melting or freezing, no new substance is formed, only the state of the substance changes.*

Similarly, when water is boiled it changes into steam. On cooling, the steam again changes back into water. Again no new substance is formed, only the physical state of the substance changes.

Thus, on removing the cause of change the substance returns to its original state.

Activity 5

Put some ice cubes in a dry glass tumbler containing water at room temperature and place it on a table for few minutes. Note down in your notebook :



(i) What do you observe on the outer surface of the beaker?

(ii) What happens to the ice inside the tumbler ?

(iii) Is this a form of condensation or melting ?

(iv) From where these water droplets have come ?

A cold electric iron becomes hot when current is passed through it. A hot iron is used for ironing clothes. But when the flow of the current is stopped, the hot iron becomes cold again.

Similarly preparation of sugar solution is a physical change as sugar can be easily recovered from its solution by the process of crystallization.

Activity 6

Take a carrot and cut it into pieces. What do you observe ?

The shape and size of the carrot has changed. Now observe the colour of the carrot pieces and taste one of them.

Do you find any difference between the colour or taste of the whole carrot and its pieces ?

No, there is no difference in the colour or taste. That means the properties of carrot are present in its pieces too although the shape and size have changed. Therefore, it is a physcial change.

Thus, physical changes only affect the physical form of a substance and the properties of the final product remain identical to the properties of the original substance.

Generally, the change can be reversed but not always. In the example of carrot mentioned above, once the carrot is cut into pieces, the original carrot cannot be obtained.

Physical changes can be understood further by some more examples, explained ahead.

Activity 7

Example 1 : Take a balloon and blow it. Take care that it does not burst. The shape and size of the balloon have changed. Now, let the air escape the balloon.

Example 2 : Take a piece of paper and cut it in four square pieces. Cut each square piece further into four square pieces. Lay these pieces on the floor or a table so that the pieces acquire the shape of the original piece of paper. Obviously, you cannot join the pieces back to make the original paper.

Example 3 : Take some dough and make a ball. Try to roll out a roti. May be you are not happy with its shape and wish to change it back into a ball of dough again. You can easily do it.

Example 4 : To observe a physical change with the help of chalk dust.

- Crush some pieces of chalk into dust. Add a little water to it and make a thick paste.
- Roll this paste into the shape of a chalk piece, and let it dry.
- What do you get ?
- You will get back the chalk with its original properties. Therefore, it is a physical change.

Activity 8

Take a glass of water. Put some salt into water and stir it. The salt dissolves and makes the water salty. There is no change in the appearance of the water.

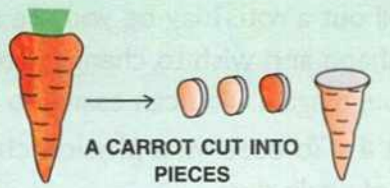
This shows that *salt retains its properties and composition*. This further indicates that *on mixing salt with water, **no new substance is formed***.

Dissolution of salt in water is a physical change.

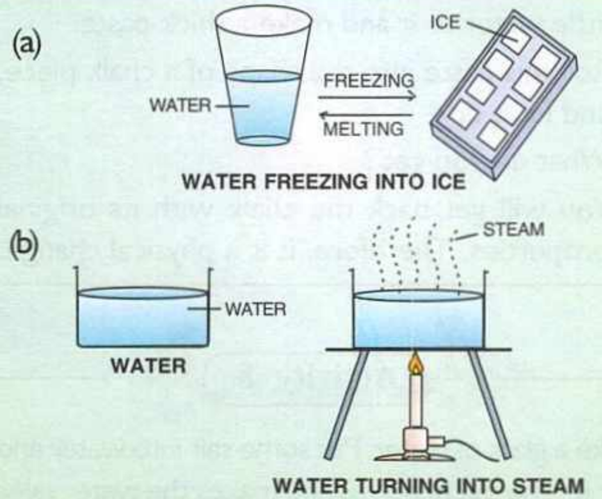
Now heat the solution. Water evaporates, leaving behind the salt.

WATER EVAPORATES LEAVING BEHIND SALT

We observe that by applying a simple method, only the physical properties of the original substance change. Therefore, ***the change is a physical change***.



An irreversible physical change



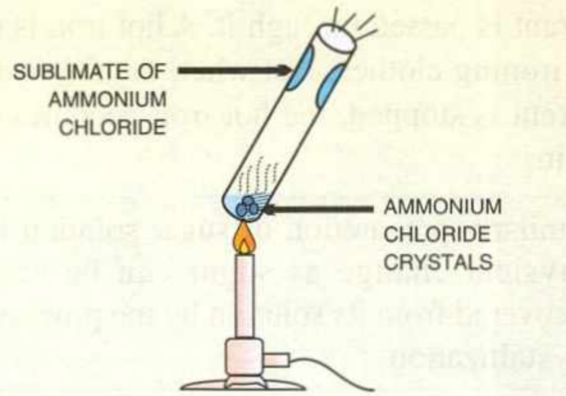
Reversible physical changes

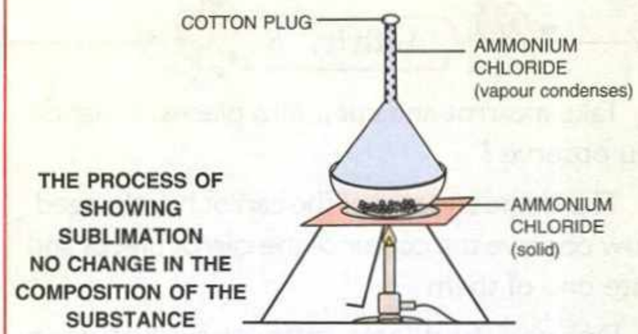
Activity 9

(To be demonstrated by the teacher)

Take some solid ammonium chloride in a test-tube and heat it gently.

You will observe that the solid changes into vapours. When the vapour touches the upper cooler part of the test tube, it changes back into solid ammonium chloride.





Ammonium chloride sublimates on heating

This shows that no new substance is formed, only the state changes directly from solid to gas. But when the vapour is cooled, it again changes into the original substance, that means the change is ***temporary*** and ***reversible***.

$$\text{Solid} \underset{\text{cooling}}{\overset{\text{heating}}{\rightleftharpoons}} \text{Gas}$$

Note : The process of changing a solid directly into a gas on heating and vice-a-versa without passing through a liquid state is called **sublimation**. The solid substance formed after cooling of vapours is called **sublimate**. Some other substances which can sublime are camphor, naphthalene balls, iodine, dry ice (solid carbon dioxide), etc.

Characteristics of a Physical Change

1. No new substance is formed.
2. There is no change in the composition of the substance.
3. The properties of the substance remain the same.
4. The change is temporary and can be reversed by changing the conditions in most of the cases.
5. There may be changes in the state, size, shape, colour, and smell of substances during physical changes.
6. There may or may not be any exchange of energy during a physical change.

Examples of physical changes

Melting of ice-cream, melting of butter, glowing of a bulb, cutting of grass, heating of an electric iron, boiling or freezing of water, sublimation of camphor or iodine, making of sugar or salt solution in water, beating of metals into sheets, magnetisation of iron, formation of clouds or mist, shaping of glass, crystallization of sugar, dissolution of ammonium chloride in water, *etc*.

TERMS INVOLVED IN SOME PHYSICAL CHANGES

Now you know that interconversion of states of matter is a physical change in which one state of matter changes into another state and vice versa. Similarly when a solution is formed, a substance mixes in another substance.

Now let us study the meaning of different terms used to explain physical changes.

- **Dissolving :** Dissolving is a process in which a substance known as solute mixes completely with another substance known as solvent to form a homogeneous mixture called solution. *Example :* Sugar dissolves in water.
- **Freezing :** The process in which a substance in a liquid state changes into its solid state on cooling at a particular temperature is called freezing or solidification.
- **Freezing point :** The temperature at which a liquid starts changing into its solid state at a given pressure is called its freezing point. All pure substances have a definite freezing point. *Example :* Pure water freezes at 0°C into ice.
- **Melting :** Melting is a process in which a substance in solid state changes into liquid state at a particular temperature.
- **Melting point :** Melting point of a solid is the temperature at which it starts melting. Solids have definite melting points. *Example:* Melting point of ice is 0°C. Numerically, the melting point and freezing point of a substance are the same.
- **Boiling :** The process in which a liquid on heating changes into its vapour state at a particular temperature is called boiling.
- **Boiling point :** The temperature at which a liquid starts changing into its vapours on heating at a given pressure is called its boiling point. All pure liquids have a definite boiling point. *Example :* Boiling point of water is 100°C.
- **Evaporation :** The process due to which a substance in liquid state changes into its vapour state at any temperature below its boiling point is called evaporation or vaporisation. *Example :* Water from rivers, lakes, ponds, etc. change into vapour due to evaporation.

- **Condensation :** The process in which a substance in vapour or gaseous state changes into liquid state upon cooling is called condensation.
- **Condensation point :** The temperature at which a gaseous substance starts changing into liquid state on cooling is called condensation point. Numerically, the boiling point and condensation point of a liquid are the same.

Differences between evaporation and boiling

Evaporation	Boiling
1. Evaporation is a slow process.	1. Boiling is a fast process.
2. Evaporation takes place from the surface of the liquid.	2. Boiling takes place from all parts of the liquid.
3. Evaporation takes place at all temperatures below its boiling point.	3. Boiling takes place at a fixed temperature on heating, *i.e.* at its boiling point.

CONDITIONS AFFECTING EVAPORATION

Evaporation is a slow process which occurs at all temperatures. Wet clothes dry up due to slow evaporation of water from the surface of those clothes.

Rate of evaporation depends upon the following :

- **Nature of liquids :** Some liquids evaporate faster like petrol, nail polish remover, alcohol, etc. while some evaporate slowly like water.
- **Surface area :** Evaporation takes place from the surface of a liquid. Hence if surface area of the liquid increases, evaporation increases. *Example :* If water collected on small part of the floor is spread over the whole floor, it dries up quickly.
- **Temperature :** Evaporation increases with increase in temperature.
- **Humidity :** Humidity is the amount of water vapour present in air. If humidity of air is high, evaporation is slow and if air is dry (with less water vapour), the evaporation is fast.

Wet clothes dry faster during summer due to high temperature and less humidity while they take time in drying during rainy season and winter because of high humidity.

Note : Boiling is an extreme form of evaporation.

Chemical change

Chemical change is a permanent change in which new substance(s) is/are formed whose chemical composition and physical and chemical properties are completely different from those of the original substance(s).

We cook food everyday from raw grain and raw vegetables. The cooking requires heat energy which is supplied by a kerosene stove, cooking gas or an electric heater. Now, it is interesting to know whether you can get back the raw grain and vegetables from this cooked food.

The answer is NO, because *the composition of the raw substances change due to heat used for cooking and new substances are formed.*

$$\text{Raw vegetable} \xrightarrow{\textit{heat}} \text{Cooked vegetable}$$

The cooked materials retain their new forms even after the cause of change (heating) is removed. This shows that *the change is permanent and irreversible.* Such changes are chemical changes.

Examples of chemical changes

Rusting of iron, ripening of fruits, bursting of a cracker, growing of a plant into a tree, souring of milk, preparation of soap from oil, changing of sugar into a black powdery substance on heating, burning of magnesium ribbon, burning of coal, decomposition of organic matter, boiling of egg, etc.

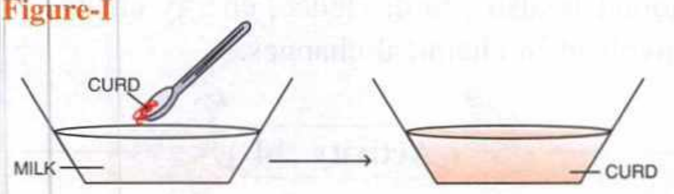
Some changes can be classified in more than one type. *For example :*

Formation of curd from milk is

- a desirable change
- a chemical change
- a slow change
- an irreversible change

The following figures and activities describe some more examples of chemical changes.

Figure-I



MILK CHANGING INTO CURD (A PERMANENT CHANGE)

Figure-II

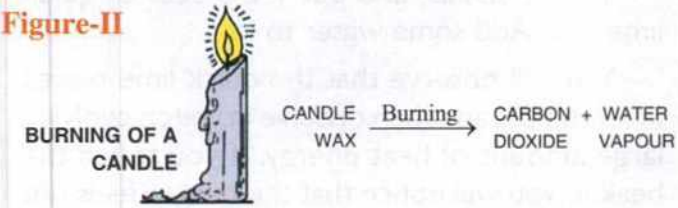


Fig. 2.4 Some chemical changes are shown above.

Activity 10

Roll out a roti from the ball of dough and bake it on a pan. Can we get the dough back ?

No, because it is a chemical change.

Burning : Burning is a chemical change in which a substance reacts with oxygen or air to produce a new substance called oxide with the evolution of energy in the form of heat and light. *Example :* Burning of fuel, candle, etc.

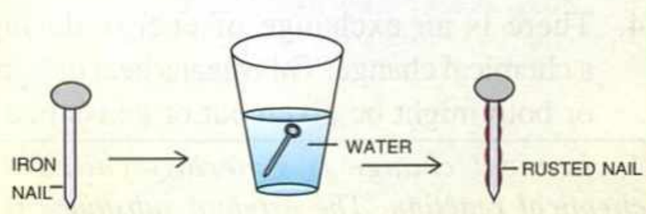
Activity 11

Take a piece of paper and burn it. It turns into *ash*. This is a new substance, whose properties are different from that of the paper. Ash cannot be changed into paper again. Therefore, the burning of paper is a chemical change.

Give examples of some other substances which on burning produce ash.

Activity 12

Take an iron nail and bring it near a magnet. The nail gets attracted towards the magnet. Now leave the nail in tap water for few days. Then take it out and observe carefully. You will see a reddish brown coating on the nail. This coating is called ***rust****. Again bring the magnet near the nail. But now the nail is not attracted towards the magnet. This shows that rust is a new substance, which is not magnetic in nature. You cannot get iron back from rust. Therefore, the change is irreversible and permanent. Hence, rusting of iron is a chemical change.



Rusting of iron

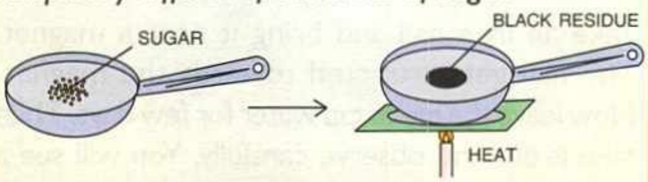
* ***Rust*** is a hydrated oxide of iron.

Rusting is a chemical process in which iron reacts with oxygen in presence of moisture to produce a reddish brown substance called **rust**.

Activity 13

Put a spoonful of sugar in a pan and heat it. You will observe that the sugar first melts and then changes its colour to reddish brown. Ultimately, it turns black and gets charred. Now stop heating the sugar and try to get it back. You cannot. On heating the sugar you get a black residue, called ***charcoal***# and some gaseous products like carbon-dioxide and water vapour. The gases immediately mix with air and you do not even see them.

Now, taste the black substance, charcoal. It is not sweet. This shows that *its properties are completely different from those of sugar.*



Burning of sugar

Characteristics of a Chemical Change

1. The change is permanent and cannot be reversed.
2. One or more new substances are formed.
3. Composition and properties of the original substance change.
4. There is an exchange of energy during a chemical change. This means heat or light or both might be given out or consumed.

*A chemical change is generally called a **chemical reaction**. The original substance is called the **reactant** and the new substance formed is called the **product**.*

$$\text{Reactant/s} \xrightarrow[\text{change}]{\text{chemical}} \text{Product/s}$$

Charcoal is a form of carbon, an element.

How will you know that a chemical change has taken place ?

We can tell if a chemical change has taken place because it is usually accompanied by :

Change in colour : Ripening of fruit is a chemical change. The colour of the raw fruit changes on ripening. Burning or charring of sugar or burning of a matchstick gives a black substance.

Evolution of a gas : Reaction of a metal like zinc with dilute hydrochloric acid is a chemical change because a salt called zinc chloride is formed and a gas called **hydrogen** is evolved.

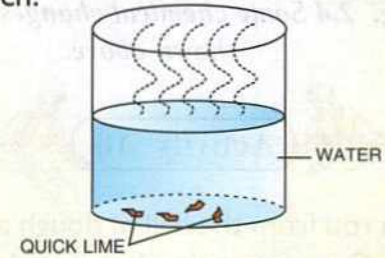
Release or absorption of energy in the form of heat, light and sound : Burning of a cracker is a chemical change. When a cracker explodes, it produces heat and light energy and sound is also heard. Hence, energy change is involved in chemical changes.

Activity 14

(To be demonstrated by the teacher)

Take a beaker and put 1-2 pieces of quick lime in it. Add some water to it.

You will observe that the quick lime pieces first crumble and then dissolve in water, evolving large amount of heat energy. If you touch the beaker, you will notice that the beaker feels hot to the touch.



Large amount of energy is evolved during a chemical change

A new white solid substance, calcium hydroxide, is formed which partially dissolves in water to produce a solution called lime water. The remaining white solid, called slaked lime, settles at the bottom of the beaker.

This proves that dissolution of quick lime in water is a chemical change in which energy change also takes place.

Different types of energies are needed for different chemical changes.

Example :

- **Heat** is necessary for the cooking of food, burning of paper, etc.
- **Light** is necessary for photosynthesis (which takes place during daytime) or during photography.
- **Electricity** is necessary to decompose water into its constituent elements, hydrogen and oxygen.

Activity 15

(To be demonstrated by the teacher)

Take some dilute hydrochloric acid in a test tube. Add some zinc granules to the acid in the test tube.

You will observe some bubbles coming out with some sound. This indicates **evolution of a gas**.

Touch the test tube. It has become hot. This indicates that some heat energy has been released during the reaction.

Bring a lighted match stick near the mouth of the test tube. A pop sound is heard and the flame of the match stick gets extinguished. This confirms that the gas evolved is **hydrogen gas**.

IMPORTANCE OF CHEMICAL CHANGES

Various types of chemical changes take place in our daily life. Some are natural while some are man-made. Most of them are very useful to us. Some are listed below :

1. Raw grains cannot be eaten but when they are cooked, chemical changes take place in them and they become edible.
2. Soaps, detergents, paints, fertilizers, medicines, *etc.* are all produced due to chemical changes.
3. Many useful metals like iron, aluminium, copper, *etc.* are extracted from their combined states by various chemical processes.
4. Burning of fuel is an important chemical change because it produces a lot of heat energy which is used for domestic and industrial purposes.
5. Different life processes taking place in plants and animals are all chemical changes which help to sustain life. *Examples :*
   - Digestion of food is a process which breaks our food into simpler compounds by the action of enzymes which are then absorbed by our body to release energy.
   - Respiration is a chemical process that takes place in all living beings. In this process, oxygen present in air which is inhaled by the living beings reacts with the digested food to release energy, carbon dioxide and water.

     Glucose + Oxygen $\rightarrow$ Carbon dioxide + Water + Energy.

   This change cannot be reversed.

An example of simultaneous physical and chemical change

When a candle is lit, the wax melts and turns into liquid state. As some of the molten wax drops on the floor or table, it solidifies again. Therefore, this is a ***physical change.***

Simultaneously, most of the molten wax rises up the wick, turns into vapour and burns with the flame. Two new substances are formed: water vapour and carbon dioxide. The candle becomes smaller and smaller. This is a ***chemical change.***

Thus, we see that the melting of wax is a physical change and the burning of the candle is a chemical change.

Differences between physical and chemical changes

Physical change	*Chemical change*
1. Change is temporary.	1. Change is permanent.
2. No new substance is formed. There is change only in physical properties.	2. New substances are formed, with entirely different properties.
3. Change can be reversed by simple methods.	3. Change cannot be reversed by simple methods.
4. Heat or light, may or may not be given out or consumed.	4. Heat or light, or both, are given out or consumed.
5. The original form of the substance can be obtained easily by simple physical methods.	5. The original substance cannot be obtained by simple physical methods.

RECAPITULATION

- Changes in matter take place around us all the time.
- The changes that we see around us can be classified as natural or man-made, slow or fast, desirable or undesirable, periodic or non-periodic, reversible or irreversible, physical or chemical, etc.
- All changes can broadly be classified into two types (i) physical and (ii) chemical changes.
- A change in which no new substance is formed and where the composition and the properties of the substance involved remain the same is known as a physical change.
- A change in which a new substance is formed whose composition and properties are entirely different from those of the original substance is known as a chemical change.
- Energy is either released or absorbed during these changes. Physical changes may or may not involve energy exchange but chemical changes always do so, in the form of heat and light.
- Rusting is a slow chemical process while burning is a fast chemical process.
- The process of a liquid changing into a gas at a particular temperature is called **boiling**. It is a fast process.
- The process of a liquid changing into a gas at room temperature is called **evaporation**. It takes place from the surface of a liquid and is a slow process.

EXERCISE

1. (a) Define :
   (i) a physical change
   (ii) a chemical change
   (c) Give two examples for each of the above two changes.
2. What are reversible and irreversible changes ? Give one example for each.
3. Mention a change which is always
   (a) desirable
   (b) undesirable
   (c) periodic
4. Is burning a physical change or a chemical change ? Why ?
5. A burning candle shows both physical and chemical changes. Explain.
6. State three differences between evaporation and boiling.
7. State four differences between physical and chemical changes.
8. What do you observe when :
   (a) water is boiled,
   (b) a piece of paper is burnt,
   (c) some ice cubes are kept in a glass tumbler,
   (d) solid ammonium chloride is heated,
   (e) an iron nail is kept in tap water for few days,
   (f) a spoon of sugar is heated in a pan,
   (g) a lighted match stick is brought near the mouth, of the test tube containing hydrogen gas,
   (h) quick lime is dissolved in water,
   (i) little amount of curd is added to a bowl containing warm milk and kept for five hours ?
9. Name a chemical change which takes place in presence of :
   (a) Heat (b) Light (c) Electricity

OBJECTIVE TYPE QUESTIONS

1. Fill in the blanks.
   (a) A new substance is always formed in a .... change.
   (b) Melting of ice is a .... change.
   (c) When a candle burns, wax melts. Melting of wax is a .... change.
   (d) Chemical change occurs as a result of .... between two substances.
   (e) Burning of a fuel is a .... change.
   (f) Revolution of the earth around the sun is a .... change.
   (g) Growing of a seedling into a plant is a .... change.
2. State whether the following are physical or chemical changes.
   (a) glowing of a bulb
   (b) burning of sugar
   (c) heating of water
   (d) growing of a piglet into a pig
   (e) burning of wood
   (f) passing electric current through a heater's rod
   (g) water cycle in nature
   (h) respiration in living beings
   (i) shaping a piece of glass
   (j) lightning
   (k) dissolving sugar in water
   (l) heating a mixture of iron filings and sulphur
   (m) mixing oil with water
   (n) cutting wood into small pieces.
   (o) photosynthesis
   (p) Digestion of food
   (q) Melting of wax
   (r) Boiling of an egg
   (s) Slaking of lime

3. Match the following.

Column A	Column B
(a) Evaporation of water	(i) Non-periodic change
(b) Milk turning sour	(ii) Periodic change
(c) Earthquake	(iii) Chemical change
(d) Change of seasons	(iv) Physical change
(e) Glowing of bulb	(v) Reversible change

4. Write ***true*** or ***false*** against the following statements :

(a) Cutting of paper into pieces is a chemical change. ....

(b) Rusting of iron is a chemical change. ....

(c) Earthquake is a desirable change. ....

(d) Melting of ice is a physical change. ....

(e) Burning of sugar is a temporary change. ....

MULTIPLE CHOICE QUESTIONS

Tick (✓) the correct alternative from the choices given for the following statements :

1. A substance which cannot sublime is
   (a) iodine (b) camphor
   (c) sugar (d) dry ice
2. When you put some ice cubes in a glass, droplets of water are formed on the outer wall of the glass. This explains the phenomenon of
   (a) melting (b) freezing
   (c) condensation (d) evaporation
3. Burning is a
   (a) slow process (b) fast process
   (c) natural process (d) none of the above
4. Which one of the following is volatile in nature ?
   (a) common salt (b) petrol
   (c) water (d) milk
5. An example of both physical and chemical change is
   (a) burning of candle (b) melting of ice
   (c) cooking of food (d) glowing of bulb
6. The compound **rust** is a hydrated oxide of
   (a) copper (b) aluminium
   (c) iron (d) gold
7. When sugar is heated, its colour changes into
   (a) red (b) blue
   (c) black (d) grey
8. A pop sound is heard when a lighted match stick is brought near the mouth of a jar. This indicates the release of
   (a) oxygen gas (b) hydrogen gas
   (c) nitrogen gas (d) water vapour
9. When we add water to the following substances, which one will show a chemical change ?
   (a) salt (b) sugar
   (c) oil (d) quick lime

Project

- Maintain a record for one year of the seasonal changes in vegetables, clothing and natural events around you. Identify the changes that can or cannot be reversed.
- Observe preparation of dishes at your home. Identify two changes in the process that can be reversed.

Elements, Compounds And Mixtures

3

Theme : The earth mainly consists of mixtures containing elements and compounds. These are of different types and the separation of components of these mixtures is required for practical utility. In this theme, there is discussion on elements, compounds and mixtures and different techniques applied for separation of the components of mixtures to get pure substances.

In this chapter you will learn :

- *Identification of elements, and compounds from representation of their symbols and formulae.*
- *Mixtures and compounds: difference between mixtures and compounds on the basis of the chemical composition of constituents.*
- *Recall that a mixture is formed when two or more substances are mixed in any proportion such that their particles are in intimate contact with one another without undergoing a chemical change.*
- *Types of mixtures: -*
  - *Homogeneous and Heterogeneous mixtures*
  - *On the basis of State: • Solid –solid; Solid-liquid; Liquid-liquid*
- *Separation techniques*
  - *evaporation,* • *distillation,* • *use of separating funnel,*
  - *sublimation,* • *fractional distillation.*
- *Examine the principle behind each separation technique;*
- *Chromatography as a separation technique; Paper chromatography.*

LEARNING OUTCOMES

The children will be able to :

- identify elements and compounds on the basis of their properties and the type of atoms present in them.
- differentiate between mixtures and compounds on the basis of their properties and composition of constituents.
- provide examples of elements, compounds and mixtures from daily life.
- discuss different separation techniques of components of mixture.
- justify the reason for the use of a particular separation technique.
- explain chromatography and its importance.

A. Elements and Compounds

INTRODUCTION

There are millions of substances in this world such as iron, aluminium, water, common salt, air, etc. They are all different from one another in their composition, properties and uses.

- They are made up of different kinds of matter.
- They may be pure and impure.

To study these substances accurately and conveniently, they have been classified on the basis of similarities and dissimilarities into three main classes : elements, compounds and mixtures.

Pure substances : Pure substances have a definite composition and a definite set of properties such as boiling point, melting point, density, etc. They are all homogeneous *i.e.*, their composition is uniform throughout the bulk. **Both elements and compounds are pure substances.**

Impure substances : Impure substances are made up of two or more pure substances mixed together in any proportion. They do not have any definite set of properties. They retain the properties of their constituent substances. They may be homogeneous or heterogeneous, *i.e.* their composition is not uniform throughout the bulk. They are all mixtures. *e.g.* : air, sugar solution, sand and stone, etc.

Activity 1

Make a list of five pure and five impure substances which you use in your daily life.

You have already studied about pure substances, elements and compounds and symbols of some of the elements and compounds in your previous class (VI).

Let us first recall the two main classes of pure substances *i.e.* elements and compounds with the following activity.

Activity 2

Following are the symbols and formulae for some of the elements and compounds.

Na, H_2, CO_2, NH_3, O_2, Fe, He, HCl, N_2, H_2O, FeS, Cl_2.

Separate them as elements and compounds and give their names.

What conclusion do you make on the basis of the above activity ?

SUBSTANCES

- **Pure substances** (Homogeneous)
  - **Elements**
    - **Metals** *e.g.* : Copper, Iron
    - **Non-metals** *e.g.* : Hydrogen, Oxygen, Carbon
    - **Metalloids** *e.g.* : Silicon, Arsenic
    - **Noble gases** *e.g.* : Helium, Neon
  - **Compounds**
    - **Inorganic** *e.g.* : Water, Salt
    - **Organic** *e.g.* : Sugar, Proteins, Vinegar
- **Mixtures (Impure substances)**
  - **Homogeneous Mixtures** *e.g.* : Tap water, Air, etc.
  - **Heterogeneous Mixtures** *e.g.* : Sand and Water, Oil and Water, etc.

Activity 3

Following is a list of some substances. Classify them as elements and compounds and form two separate groups.

Water, iron, sodium chloride, copper, plaster of paris, calcium oxide, aluminium, silicon, sodium sulphate, helium and sodium hydrogen carbonate.

ELEMENTS

Elements : An element is a pure substance that cannot be converted further into anything simpler than itself by any physcial or chemical process. Thus, each element has its own unique properties.

Some of the examples are oxygen, hydrogen, sulphur, carbon, iron, gold, silver, etc.

Do You Know ?

Robert Boyle was the first scientist to use the term element in 1661.

Antoine Laurent Lavoisier (1743-94) was the first to establish experimentally useful definition of an element.

These elements are made up of extremely small particles called atoms which cannot be seen through naked eyes.

Atoms are the smallest units of an element.

All atoms in an element are identical.

Examples : A piece of aluminium sheet contains only aluminium atoms and oxygen molecules contain only atoms of oxygen. Atoms of oxygen and aluminium are different from each other.

At present 118 *elements are known. Of these,* 92 *are natural elements (most of them are found in combined state in the earth's crust) while rest* 26 *have been artificially created.* Some elements are solids, some are liquids and some are gases. In fact, elements are the basic pure substances from which millions of substances are made.

Do You Know ?

Of the 118 elements known to us, some are radioactive in nature, because they emit radiations which may be harmful.

CLASSIFICATION OF ELEMENTS

Based on their properties, elements have been classifed into (i) metals (ii) non-metals (iii) metalloids (iv) noble (or inert) gases.

Metals : Most of the elements known to us are metals. *Examples :* Gold, silver, copper, aluminium, iron, zinc, tin, lead, etc.

Do You Know ?

- Chalk, milk and our bones contain a common metal **calcium**.
- Chlorophyll contains **magnesium** which helps to capture the energy from sunlight for photosynthesis by plants.
- In mammals, **iron** is found in red blood cells in haemoglobin which carries oxygen in the body.
- Chocolate wrappers are made of aluminium (metal).

Non-metals : Non-metals are very less in number in comparison to metals. Excluding inert gases, there are only eleven non-metals known to us. *Examples :* Hydrogen, oxygen, nitrogen, carbon, chlorine, sulphur, phosphorus, fluorine, bromine, iodine and astatine.

Metalloids : These elements show some properties of metals and some properties of non-metals. They are hard solids. *Example :* Boron, silicon, germanium, arsenic, antimony tellurium and polonium.

Inert or noble gases : These elements do not react chemically with other elements or compounds, so they are known as noble or inert gases. They are found in air, in traces. They are only six in number — helium, neon, argon, krypton, xenon and radon.

Activity 4

Following is a list of elements. Select metals, non-metals, metalloids and noble gases from the list : gold, graphite, chlorine, sodium, arsenic, helium, sulphur, xenon, antimony.

SYMBOLS OF ELEMENTS

Now let us revise the method by which each element was given a symbol (studied in class VI).

1. Each element is denoted by a symbol which is usually the first letter of its name in English or Latin [always written in capital].

Example : Oxygen is an element. It is denoted by the symbol 'O'. Similarly, hydrogen is denoted by the symbol 'H'.

2. However, when the first letter of more than one element is same, the symbol is denoted by two letters, first letter is written in capital while the second is written in small letter.

Example : (i) Carbon and cobalt are elements whose first letter is 'C'. *Carbon* is denoted by the symbol 'C'. *Cobalt* is denoted by two letters 'Co'. (ii) Boron is represented by symbol 'B' while bromine is denoted by 'Br' and barium by 'Ba'.

3. These symbols also represent an atom of that element.

Example :

(i) 'H' represents the element hydrogen as well as one atom of hydrogen.

(ii) 'C' represents the element carbon as well as one atom of carbon.

4. Some symbols have been taken from the names of elements in Latin, German or Greek.

Example : The symbol of iron is Fe from its latin name Ferrum, sodium is Na from Natrium, potassium is K from Kalium. Copper is Cu from Cuprum, etc. Therefore, each element has a name and a unique chemical symbol.

Now-a-days, IUPAC (International Union of Pure and Applied Chemistry) approves names of elements.

Table 3.1 : Names and symbols of some elements derived from their English names.

Name in English	*Symbol*	*Name in English*	*Symbol*
Hydrogen	H	Helium	He
Nitrogen	N	Neon	Ne
Oxygen	O	Argon	Ar
Carbon	C	Krypton	Kr
Sulphur	S	Radon	Rn
Phosphorus	P	Xenon	Xe
Boron	B	Chromium	Cr
Chlorine	Cl	Cobalt	Co
Fluorine	F	Radium	Ra
Bromine	Br	Manganese	Mn
Iodine	I	Nickel	Ni
Arsenic	As	Barium	Ba
Platinum	Pt	Uranium	U
Germanium	Ge	Silicon	Si

Table 3.2 : Names and symbols of some elements derived from their Latin and Greek names.

Name in English	*Name in Latin/Greek*	*Symbol*
Sodium	Natrium	Na
Potassium	Kalium	K
Magnesium	Magnesia	Mg
Aluminium	Alumen	Al
Calcium	Calx	Ca
Iron	Ferrum	Fe
Copper	Cuprum	Cu
Zinc	Zinke	Zn
Silver	Argentum	Ag
Gold	Aurum	Au
Mercury	Hydrargyrum	Hg
Lead	Plumbum	Pb
Tin	Stannum	Sn
Antimony	Stibium	Sb


Activity 5


Write the names and symbols of first twenty elements you have studied in class VI.

Compounds : A compound is a pure substance formed by the chemical combination of two or more elements in a fixed ratio by mass.

Hence, it can be broken down into simpler substances by only chemical means.

Example : Common salt is a compound chemically known as sodium chloride, that can be broken down into its constituent elements sodium and chlorine only by chemical means.

Similarly water, a compound, can be broken down into more simpler substances, hydrogen and oxygen, from which it is formed.

Some other common compounds are sand, carbon dioxide, sugar, chalk, washing soda, alcohol, *etc.*

The smallest unit of a compound is molecule.

Properties of molecules of one compound are different from that of molecules of other compounds.

CHARACTERISTICS OF COMPOUNDS

- The properties of compounds are entirely different from those of its constituent elements.

  Example : Sodium is a highly reactive poisonous metal while chlorine is a greenish yellow gas but the compound formed by chemical combination of these two elements *i.e.* sodium chloride, known as common salt, is added to food and is completely safe to eat.

- Compounds can be broken down into their constituent elements only by chemical means, not by physical means.
- Compounds have a fixed composition of their own.
- Energy is either absorbed or liberated during the formation of a compound.
- A compound is represented by a definite chemical formula.

3.3 Table showing some common compounds, elements present in them and their formulae

Compounds	Elements present	Formulae
1. Water	Hydrogen and oxygen	H_2O
2. Sodium chloride (common salt)	Sodium and chlorine	$NaCl$
3. Magnesium oxide	Magnesium and oxygen	MgO
4. Calcium oxide (quick lime)	Calcium and oxygen	CaO
5. Carbon dioxide	Carbon and oxygen	CO_2
6. Sodium carbonate (washing soda)	Sodium, carbon and oxygen	$Na_2CO_3 \cdot 10H_2O$
7. Sodium bicarbonate (baking soda)	Sodium, hydrogen, carbon and oxygen	$NaHCO_3$
8. Hydrated calcium sulphate (plaster of paris)	Calcium, sulphur, hydrogen and oxygen	$CaSO_4 \cdot 1/2H_2O$
9. Cane sugar	Carbon, hydrogen, oxygen	$C_{12}H_{22}O_{11}$
10. Silica (sand)	Silicon and oxygen	SiO_2
11. Glucose	Carbon, hydrogen, oxygen	$C_6H_{12}O_6$
12. Sodium sulphate	Sodium, sulphur, oxygen	Na_2SO_4

EXERCISE – I

1. Write the symbols of helium, silver, krypton, antimony, barium.
2. Write the names of the following elements Na, C, Kr, U, Ra, Fe, Co.
3. Define :
   (a) Elements *(b)* Compounds
4. Name the main metal present in the following:
   (a) Haemoglobin *(b)* Chalk
   (c) Chlorophyll *(d)* Chocolate wrappers
5. Give *four* examples of non-metallic elements.
6. What do yo understand by
   (a) Metalloids *(b)* Noble gases
   Give *two* examples of each.
7. Select elements and compounds from the following list :
   Iron, plaster of paris, chalk, common salt, copper, aluminium, calcium oxide, cane sugar, carbon, silica, sodium sulphate, uranium, potassium carbonate, silver, carbon dioxide.

B. Mixtures and separation of the components of mixtures

Most of the subtances that we come across in our daily life are mixtures. Mixtures are made up of elements, compounds or both elements and compounds. Components of a mixture are mixed in any proportion without any chemical combination.

Mixtures can be defined as impure substances which are formed by mixing two or more pure substances (elements and/or compounds) in any proportion such that they do not undergo any chemical change and retain their individual properties.

The substances which form mixtures are called components or constituents of mixtures.

Example : Air is a mixture. Its constitutents are oxygen, nitrogen, carbon dioxide, water vapour, dust particles, etc. All these constituents retain their individual properties.

Activity 6

Identify the mixtures from the following list : Air, water, sugar, salt, milk, tea, alcohol, honey, soil, glucose.

Kinds of Mixtures

We come across different kinds of mixtures in our day-to-day life. Some of them quite obviously look like mixtures.

Example : In a mixture of salt and sugar, or sand and water, one can easily recognize the two components.

But there are mixtures in which we cannot see the components.

Example : *Sugar solution. We cannot see sugar and water separately in the solution.*

Hence, mixtures are divided into *two* main types :

1. Heterogeneous mixtures
2. Homogeneous mixtures.

Heterogeneous Mixtures

A mixture in which the components or constituents are not uniformly distributed throughout its volume and can be easily recognized separately is called a ***heterogeneous mixture.***

Example : Soil is a heterogeneous mixture of many elements and compounds. Its composition changes from place to place. That is why we find different substances in the soil at different places.

Other examples of heterogeneous mixtures are water and petrol, sand and stones, sulphur and iron filings, rice and lentils.

A mixture of two or more solids is always considered as a heterogeneous mixture, whether you mix and grind them thoroughly or not.

Homogeneous Mixtures

A mixture in which its constituents are uniformly distributed throughout its volume and cannot be recognized separately is called a homogeneous mixture.

Example : A salt solution is a mixture made up of salt and water, but we cannot see salt particles and water separately. If we add one, two or three spoonfuls of salt in a glass of water and stir it, in each case, the solution formed is homogeneous but the proportion of salt and water is not the same.

We come across many substances which are thought to be pure. But actually, they are impure, homogeneous mixtures. *Example* : tap water, milk, air, honey, fruit juice, ice-cream, ink, medicines, bronze, brass, butter, cough syrup, *etc*. A mixture of two or more gases is always considered a homogeneous mixture because all gases mix with each other in all proportions.

Fig. 3.1 Mixtures that look like pure substances.

Do You Know ?

1. **Tap water** is not pure because it contains small amounts of dissolved salts and air in it which we cannot see. They add taste to water. (*Pure water has no taste*).
2. **Ink** is a mixture of many dyes depending on required shades and applications.
2. **Milk** is made of fats, carbohydrates, proteins, salts, vitamins and water present in different proportions. Cream floats on milk when it is cooled after boiling.
3. **Honey** contains sugar and a number of other substances.
4. **Fruit juice** is a mixture of sugar, salts and other organic compounds.
5. **Medicines** are made by mixing different pure substances in different proportions.
6. **Alloys** are homogeneous mixtures of two or more metals or non-metals prepared by mixing them in molten state, *e.g.*
   (a) Brass is an alloy of copper and zinc.
   (b) Bronze is an alloy of copper, tin and zinc.

Characteristics of mixtures

1. In mixtures, components are loosely held together without any chemical force acting on them or between them. Hence components retain their individual properties.

   ***Examples :* (1)** In a mixture of salt and chilli powder, salt particles retain their salty taste and chilli powder particles retain their hot and bitter taste.

   (2) In a mixture of salt and sugar, both the components retain their salty and sweet tastes respectively.

   Above two examples indicate that atoms and molecules of the components forming a mixture remain separate, retain their properties and do not form any new substance.

2. Mixtures do not have any fixed amount of components *i.e.* they can have their components in varying proportions.

   Example : A mixture of sugar and water can be formed by mixing varying proportions of these two substances.

Activity 7

Take three glasses. Fill three-fourth of each glass with water. Add a spoonful of lime juice to the first glass and stir it properly so that lime juice mixes well with water. To the second glass, add two spoons of lime juice and stir it. To the third glass, add three spoons of lime juice and stir it. Now taste all the *three* lime solutions you have prepared. You will find that all samples are sour to taste but the degree of sourness is different. In each case, we are getting a homogeneous mixture of lime juice and water but they differ in their tastes due to the difference in the ratio of water and lime juice in them.

I
A glass with one spoon of lime juice in water (sour)

II
A glass with two spoons of lime juice in water (more sour than I)

III
A glass with three spoons of lime juice in water (more sour than both I and II)

3. Mixtures do not have any specific set of properties.

   Example : In a mixture of rice and wheat, both the components can be easily recognized because together they do not show any definite set of properties.

4. Components of mixtures can be separated by simple physical methods.

   Example : Salt solution is a mixture of salt and water. When this solution is heated, water gets evaporated leaving behind salt.

5. *The melting point or the boiling point of a mixture is not fixed. It depends on the proportions of its components present in it, e.g. pure water boils at 100°C but salty water boils at a higher temperature than 100°C.*
6. *Mixtures can be heterogeneous or homogeneous.*
7. Formation of mixtures *does not involve any energy exchange.*

DIFFERENCES BETWEEN COMPOUNDS AND MIXTURES

To understand the differences between mixtures and compounds, let us do the following activity.

Activity 8

Comparison of a mixture of iron and sulphur and their compound iron sulphide

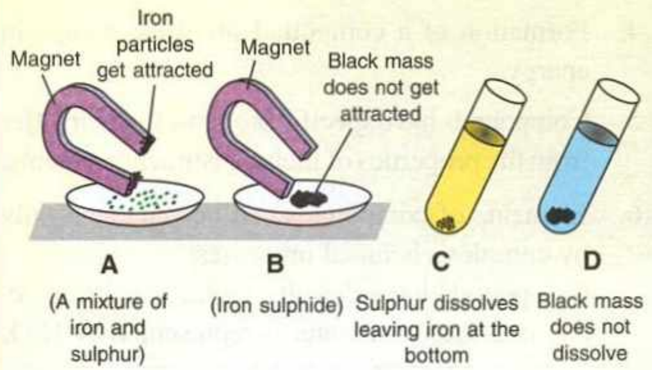
To be demonstrated by the teacher to make the difference between compounds and mixtures more clear.

Mix 56 g of iron filings and 32 g of sulphur thoroughly in a mortar and place some portion of it on a watch glass. We shall call it Sample **A**. Now take the remaining portion of the sample in a test tube and heat the bottom of the test tube. The black mass formed is put on another watch glass. We shall call it sample **B**.

(a) Bring a magnet over sample A and sample B. What do you observe ?

In sample A, iron is attracted by the magnet whereas in sample B nothing happens.

(b) Put portions of sample A and sample B in carbon disulphide taken in two separate test tubes. What do you notice ?



In sample A, sulphur dissolves in carbon disulphide; while the black mass in sample B settles down in the test tube without dissolving.

Therefore it is clear that in sample A, iron and sulphur particles retain their individual properties. However in sample B, on heating, iron chemically combines with sulphur forming iron sulphide. Therefore in iron sulphide, iron and sulphur particles do not exist separately as such. They lose their individual properties.

The above experiment confirms that there are two ways in which different kinds of matter can be made to combine.

(i) They can be merely brought together in any proportion and mixed to form a **mixture**.

(ii) They may be heated or allowed to react chemically to form a **compound**.

Table 3.4 Differences between compounds and mixtures

Compound	*Mixture*
1. A compound is a pure substance.	1. A mixture is an impure substance.
2. Compounds are always homogeneous.	2. Mixtures may be homogeneous or heterogeneous.
3. A compound has a fixed composition, *i.e.* it is formed when two or more pure substances chemically combine in a definite ratio by mass.	3. A mixture has no fixed composition, *i.e.* it is formed by mixing two or more substances in any ratio without any chemical reaction.
4. Formation of a compound involves change in energy.	4. Formation of a mixture does not involve any change in energy.
5. Compounds have specific properties which differ from the properties of their constituent elements.	5. Mixtures do not have any specific set of properties. They exhibit properties of their components.
6. Elements of compounds can be separated only by complex chemical processes.	6. Components of mixtures can be separated by simple physical methods.
7. Compounds have definite molecular formulae. *e.g.* a molecule of water is represented by H_2O.	7. Mixtures have no definite formulae. *e.g.* air.

FORMATION OF MIXTURES AND TYPES OF MIXTURES ON THE BASIS OF STATES OF COMPONENTS

Various types of mixtures are formed by mixing solid, liquid and gaseous substances in different proportions on the basis of their properties and uses. Mixtures may exist in any of the three states of matter, i.e. solid, liquid or gas, depending upon the physical states of its components.

Table 3.5 Examples of mixtures and their types

S. No.	States of components	Types of mixtures	Examples
(i)	Solid + solid	Heterogeneous	Sand and sugar, sand and salt, sand and stone, *etc.*
		Homogeneous	Brass, bronze, stainless steel, (all alloys), *etc.*
(ii)	Solid + liquid	Heterogeneous	Sand and water, charcoal and water, *etc.*
		Homogeneous	Sugar in water, salt in water, iodine in alcohol, *etc.*
(iii)	Liquid + liquid	Heterogeneous	Oil in water.
		Homogeneous	Alcohol and water, acetone and water, *etc.*
(iv)	Gas + liquid	Homogeneous	Aerated drinks like cold drinks, beer, *etc.*
(v)	Gas + gas	Homogeneous	Pure air
(vi)	Solid + gas	Heterogeneous	Smoke (contains soot particles) in air.

NEED FOR THE SEPARATION OF COMPONENTS OF MIXTURES

We need many substances for purposeful uses in our daily life. But most of these substances are available in the form of mixtures. These mixtures contain unwanted substances which degrade their properties.

Examples : (1) Cereals like rice, wheat or pulses often contain small stones, husk, etc. as impurities. Before cooking, these impurities need to be removed since they are harmful.

(2) Common salt is an important substance used in our food to add taste and nutrients. It is present in sea water in plenty, in the form of a mixture. Therefore it is necessary to separate common salt from sea water for its purposeful uses.

The purpose of separating the constituents of a mixture are to :

(i) remove undesirable and harmful substances.

(ii) get useful substances and

(iii) get completely pure substances for preparing other useful substances. *e.g.* Water is required in its purest form to prepare medicines, in laboratories for preparing solutions, in car batteries, etc. Therefore, all the impurities present in water need to be removed.

METHOD OF SEPARATION

The process by which constituents of a mixture are set apart from one another to get pure substances is called separation.

The principle of separation depends upon the

- type of mixture
- characteristic properties of mixture, such as size, shape, colour, density, melting point, boiling point, solubility, ability to sublime, volatality, magnetic nature, etc.

Thus for different types of mixtures, different methods are applied to separate the components.

(A) Separation of solid-solid mixtures

Hand-picking : This method of separation can be used when the quantity of a mixture is small and the substance to be separated forms a small portion of the mixture. The substance should be large enough in size to be recognized by naked eyes and picked out by hand. Small stones are picked out from rice, pulses and spices by this method.

Winnowing : The process of separation of grain from husk and hay with the help of wind is called winnowing. This method is used to separate light solids from heavier ones. This technique is generally used by farmers.

Example : Take a mixture of rice and husk. When it is allowed to fall from a height, rice grains, being heavier, fall vertically while husk gets blown away by air and forms a heap at a small distance away from the heap of rice. In this way, rice is separated from husk.

Magnetic separation : This method is used when one of the components of the mixture is magnetic in nature *i.e.* gets attracted towards a magnet. Iron, being

Fig. 3.2 Separation by a magnet

magnetic, gets attracted towards a magnet and hence can be separated from other non-metals by this method.

Example : Mixtures of iron and sulphur, iron and sand, *etc*. can be separated by moving a magnet over them. Iron gets attracted to the magnet and is separated.

Gravitational method : This method is used only when one of the components is much heavier than water and the other component is much lighter than water.

Example : If a mixture of sand and sawdust is put in water, sawdust being lighter floats while sand settles down. Now sawdust with water is slowly decanted and transferred to another container leaving the sand at the bottom and then filtered to separate the sawdust.

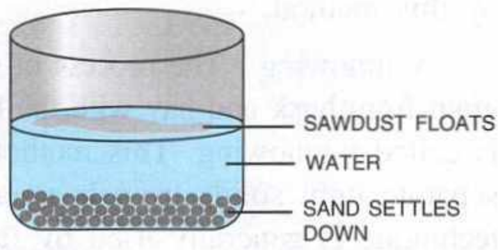


Fig. 3.3 Separation by gravitational method

Sublimation : *The process in which a solid changes directly into its vapours on heating is called* ***sublimation****.* This method is used for solid mixtures in which one of the components can *sublime* on heating. The solid which sublimes escapes as vapour, while the other one is left behind.

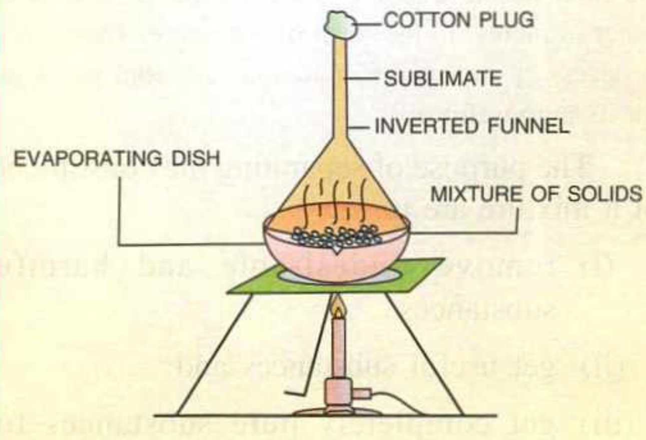
Example : Mixture of sand and iodine, common salt and ammonium chloride, *etc*. are separated by sublimation.

On cooling, the vapour again turns into a solid. *Camphor, naphthalene, iodine, and ammonium chloride are some solids that undergo sublimation.*

Activity 9

To separate common salt and ammonium chloride

Take a mixture of common salt and ammonium chloride and place it in a dish and cover with an inverted funnel and heat it. On heating, ammonium chloride changes into vapour, which condenses into a solid along the neck of the funnel (from where it may be scraped off), whereas common salt is left behind in the dish.



Sublimation : Separating a mixture of common salt and ammonium chloride

Solvent Extraction Method : This method is used when only one of the solid components is soluble in a liquid.

Example : A mixture of sand and salt can be separated by this method. Salt gets dissolved in water while sand settles down in the container. The salt solution is then filtered. Salt is separated from the solution by evaporation. In this way, they can be separated.

(B) Separation of solid-liquid mixtures

These mixtures can be homogeneous (a sugar solution) or heterogeneous (a mixture of sand and water). Different methods are used depending upon the type of mixture.

Sedimentation and decantation : *The settling down of suspended, insoluble, heavy solid particles in a solid-liquid mixture when left undisturbed is called* ***sedimentation****.*

The solid which settles at the bottom is called the ***sediment*** *while the clear liquid above it is called the* ***supernatant liquid****.*

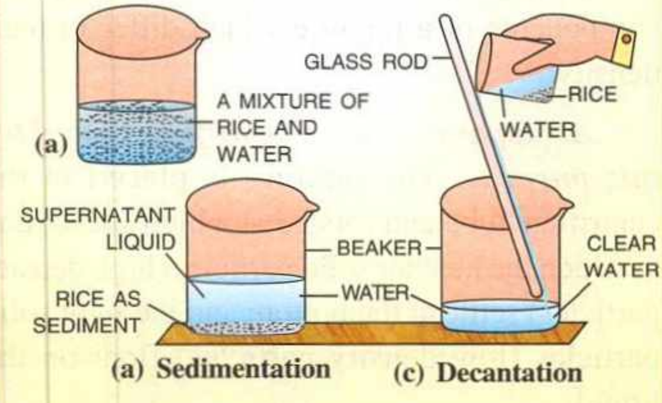
The process of pouring out the clear liquid, without disturbing the ***sediment****, is called* ***decantation****.*

This method is used for a heterogeneous mixture of solid and liquid where the solid component is insoluble and heavier than the liquid component.

Example : A mixture of sand and water, pulses and water, etc.

Activity 10

Take some rice and water in a beaker and stir it. Now allow the mixture to stand for some time. You will see that the rice settles at the bottom of the beaker. This is called *sedimentation*. Now pour out water gently into another vessel without disturbing the rice. This is called decantation.



(a) Sedimentation **(c) Decantation**

Filtration : *The process of separating insoluble solid particles from a liquid by allowing it to pass through a filter is called filtration.*

This process is used for separating the components of a heterogeneous solid-liquid mixture in which solids are insoluble in liquids.

The substances that can be used as filters are a layer of sand, charcoal, cotton, glass wool, unglazed porcelain, filter paper, *etc*. Even the strainer that we use to separate liquid tea from tea leaves is a filter.

These filters allow liquids to pass through them but not solids. The insoluble solid left on the filter is called the ***residue***, while the liquid which passes through the filter is called the ***filtrate***.

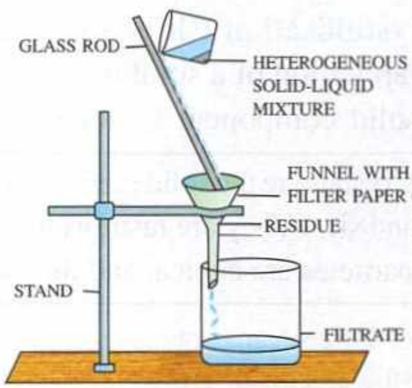


Fig. 3.4 Process of filtration to separate insoluble suspension from water (on small scale)

Example : Mixtures like chalk and water, clay and water, tea and tea leaves, sawdust and water, *etc.* are separated by this method.

Evaporation : *Evaporation is the process of converting a liquid into its vapour state, either by exposing it to air or by heating.*

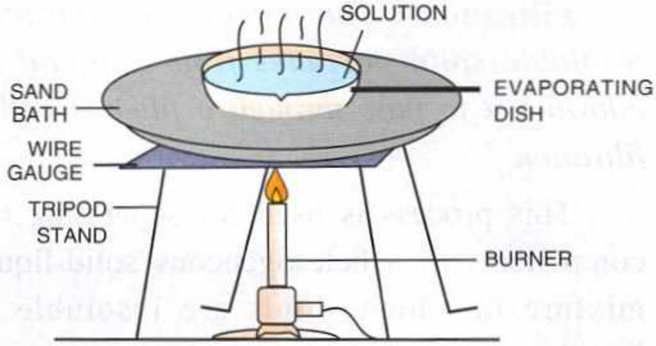


Fig. 3.5 Evaporation

This method is used to separate the components of a homogeneous solid-liquid mixture, like salt from sea water. Sea water is collected in shallow beds and allowed to evaporate in the sun. When all the water is evaporated, salt is left behind. By this method, we get only the solid, whereas the liquid escapes in the form of vapour. For separating a solid from its solution, we usually evaporate it until whole of the liquid escapes in its vapour form.

Crystallisation : It is a process in which slow evaporation of a solution containing more of the solid component is done.

> *Note :* Crystals are the solid particles with definite shape and size. They are lustrous too. *Example :* Sugar particles are cubical and they shine.

Example : Pure sugar is obtained from its solution in water by the process of crystallisation.

At first the sugar solution is heated to evaporate water at a faster speed. When very less of water is left, the solution is cooled. On cooling, the sugar dissolved in it starts separating out in the form of **crystals**.

Distillation : *Distillation is the method of getting a pure liquid from a solution by evaporating and then condensing the vapours.*

When the solution is heated, the liquid component of the mixture evaporates in the form of vapour. The vapours are then condensed back into the liquid form which is very pure and is called as the **distillate**.

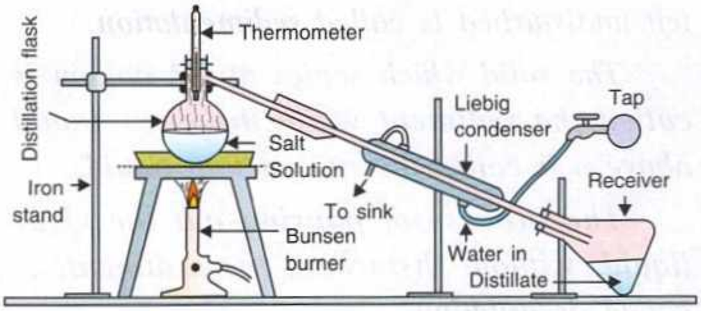


Fig. 3.6 Distillation

Tap water, which is a mixture containing dissolved salts, is purified by *distillation*. The pure water so obtained is called the *distilled water.* It is used by doctors for preparing medicines, by chemists for making solutions and in industries for various purposes.

The advantage of this process is that both the components of the solid-liquid mixture are obtained.

Centrifugation : *Centrifugation is the method of separating solids from liquids where the mixture is homogeneous. This is also called churning.*

The process is used to separate the components of a mixture which differ in their density.

An apparatus called centrifuge is used for this purpose. The mixture is placed in the centrifuge tube and rotated at a high speed, due to which the heavier solid particles (high density particles) settle at the bottom and the light solid particles (low density particles) float on the liquid.

Cream is separated from milk by this method. At home, we use mixers or traditional churners to separate cream from milk. This process is used even now *in dairies.* In washing machines, this principle is used to squeeze out water from wet clothes.

(C) Separation of liquid-liquid mixtures

> ***Note :*** (1) Homogeneous liquid-liquid mixtures : Liquids which dissolve in each other completely in all proportions are called miscible liquids. *Example* – alcohol is miscible with water.
>
> (2) Heterogeneous liquid-liquid mixtures : Liquids which do not dissolve in each other are called immiscible liquids. *Example* – oils are immiscible with water.

By separating funnel : It is a simple device used to separate the components of a liquid-liquid heterogeneous mixture.

Example : Kerosene oil and water. The mixture is placed in a separating funnel and allowed to stand for sometime. The components form two clear layers. Water being heavier forms the lower layer and oil being lighter forms the upper layer. When the stopper of the funnel is opened, the heavier liquid trickles out slowly and is collected in a vessel. The stopper is closed when the bottom layer is entirely removed from the funnel. In this way, the two liquids are separated.

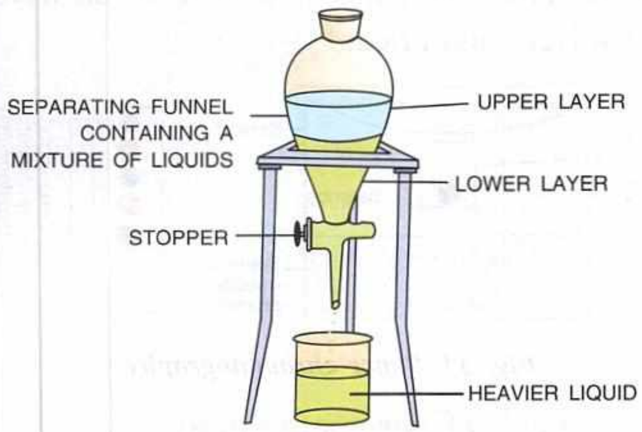


Fig. 3.7 Separation of immiscible liquids using separating funnel

Fractional distillation : The process of distillation used to separate the components of a homogeneous liquid-liquid mixture on the basis of the difference in their boiling points is called fractional distillation. The difference in boiling points of the different liquids must be 25°C or more.

Example : A mixture of water and alcohol. Alcohol boils at a lower temperature than water. The vapours of alcohol are collected and cooled while water is left behind in the flask.

For the separation of components, a fractionating column is fixed over the distilling flask, so that if water vapours move up along with alcohol, it should condense and come back to the flask.

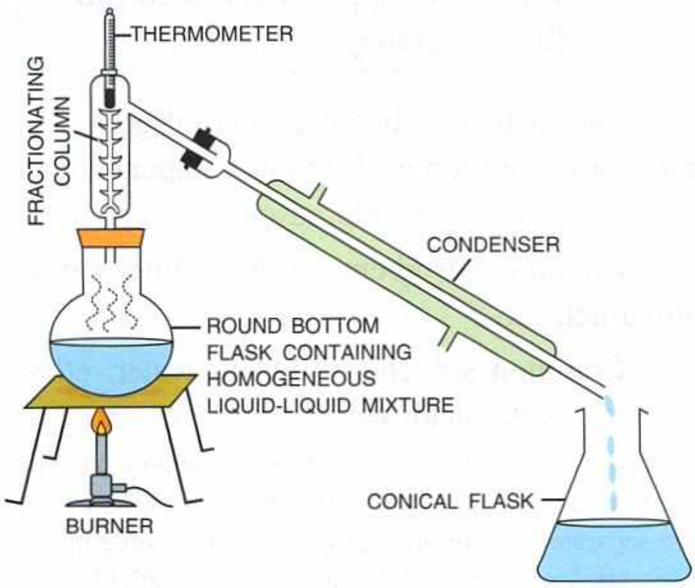


Fig. 3.8 Fractional distillation of petroleum

Petrol, kerosene, diesel, *etc.* are obtained from crude petroleum oil in a similar way.

(D) Separation of a gas - liquid mixture :

A mixture of gas in liquid can be separated by heating. Dissolved gas escapes from the liquid on heating.

Example : Drinking water contains air dissolved in it. When it is boiled, air escapes and so the boiled water becomes tasteless.

(E) Modern techniques :

Chromatography : This is one of the latest techniques to separate the coloured components of a mixture when all the components are very similar in their properties.

The name "chromatography" means colour writing. It is named so, because earlier it was used to separate mixtures containing coloured components only, but these days this technique is applied to colourless substances too.

> The process of separating different dissolved constituents of a mixture by their adsorption on an appropriate material is called chromatography.

The method is based on the difference in rates of adsorption of different components on the surface of a suitable adsorbent.

Common adsorbents used are filter paper, silica gel, etc.

Common solvents used are water, ethyl alcohol, acetic acid, etc.

Example : Components of ink are separated by this method. Ink is a mixture of different dyes, which are separated by chromatography because some of the dyes are less soluble and some are more soluble in a solvent.

Principle involved in chromatography

Chromatography separates the components of a mixture on the basis of differences between two phases, one of which is stationary while the other is mobile.

The simplest type of chromatography is "Paper chromatography".

In this method, a special type of paper called chromatographic paper (called Whatman filter paper) or ordinary filter paper is taken. A line is drawn with the pencil near the bottom edge of the paper. A drop of the mixture is placed on the filter paper above this line. The paper is then dipped in a solvent, taken in a beaker, such that the line drawn on the paper is above the level of the solvent.

The filter paper acts as the "stationary phase" while the solvent acts as the "mobile phase".

As the solvent rises on the paper, it takes along with it the drop of the substances. The component of the drop which is more soluble rises faster and we see various spots on the filter paper, each indicating a component of the mixture. The paper is then removed from the solvent and dried.

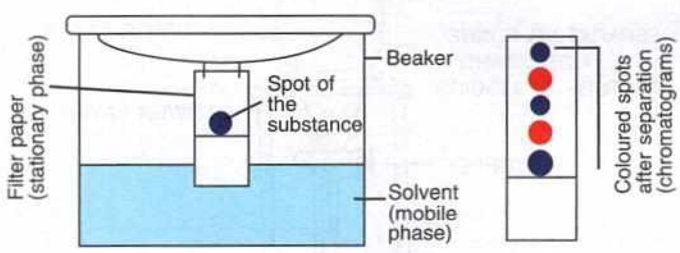


Fig. 3.9 Paper chromatography

Advantages of chromatography

- A very small quantity of the substance can be separated.

- Components with very similar physical and chemical properties can be separated.
- It identifies the different constituents of a mixture.

Use of chromatography

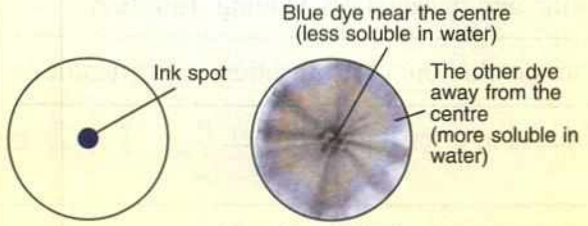
It can be used to separate :

- pigments from natural colours
- drugs from blood (pathological tests)
- colours in a dye.

Activity 11

Take a filter paper. Put a drop of ink on the centre of the paper and then slowly add some drops of water on the same point with the help of a dropper. You will observe that the blot of ink spreads out into different coloured rings. Each ring corresponds to a dye. The more soluble dye moves farthest while less soluble remains near the centre.

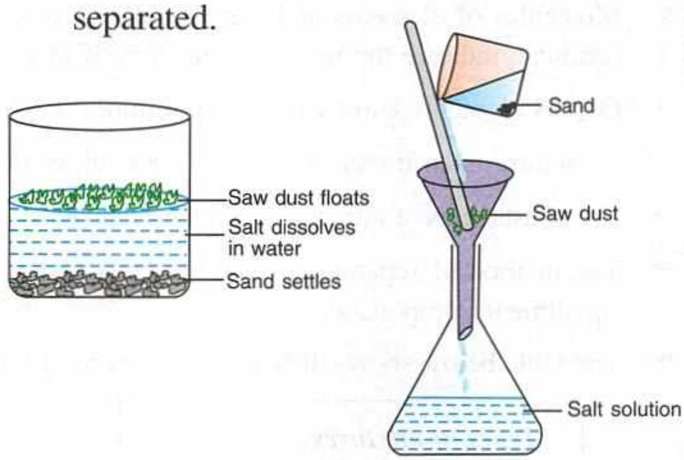
Chemists often use this technique for testing purity and doctors use it for pathological tests.



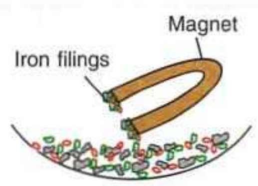
A filter paper with a drop of ink   Spreading of ink when water is added

Separation of constituents of the mixtures with more than two constituents :

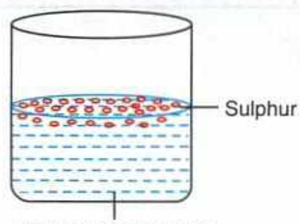
(a) Sand, sawdust and salt : The mixture is taken in a glass beaker and water is added to it. The beaker is then allowed to stand undisturbed for some time. Salt dissolves in water, forming a salt solution, because it is soluble in water. Sawdust being lighter floats on the surface of water while sand being heavier settles down. Now salt solution along with sawdust is decanted slowly on the filter paper fixed in a funnel such that sand is left in the beaker as sediment. Salt solution passes through the filter paper while sawdust remains on it. The salt solution is evaporated to get salt from the water. In this way, all the components get separated.



(b) Iron filings, sulphur and common salt : To separate the constituents of this mixture, first a magnet is brought near it. Iron filings get attracted to the magnet and separated. Now water is added to the mixture. Common salt dissolves in it leaving behind sulphur. The mixture is filtered. Sulphur collects on filter paper as residue while salt solution passes through the filter paper as filtrate. It is then evaporated to get salt from water.



A mixture of iron filings, sulphur and common salt.



Salt solution in water

RECAPITULATION

- Pure substances are broadly classified into elements and compounds. Mixtures are impure substances.
- Elements are made up of the same kind of atoms.
- Compounds are made up of different kinds of atoms combined chemically together in a fixed ratio.
- Atoms are the smallest units of elements and may or may not be capable of independent existence.
- Molecules are the smallest units of an element or compound capable of independent existence.
- Atoms of six known noble gases exist independently.
- Atoms of elements are represented by symbols.
- Molecules of elements and compounds are represented by formulae formed by symbols of atoms. The formulae indicate the number and types of atoms present in the molecules.
- Of 118 elements known to mankind, millions of compounds have been formed.
- A mixture is an impure substance made up of different kinds of elements and compounds held loosely.
- The constituents of mixtures retain their individual properties and can be separated easily by physical methods.
- The method of separation of constituents of a mixture depends upon the characteristic properties of its constituent components.
- The table below shows different methods used for separation :

Types of mixtures	*Methods of separation*
Solid-Solid (Heterogeneous)	Hand-picking, winnowing, sieving, sublimation, magnetic separation, gravitation, solvent extraction method.
Solid-Liquid (Heterogeneous)	Sedimentation and decantation, loading, filtration.
Solid-Liquid (Homogeneous)	Evaporation, distillation, crystallisation, centrifugation.
Liquid-Liquid (Immiscible) (Heterogeneous)	Decantation, using a separating funnel.
Liquid-Liquid (Miscible) (Homogeneous)	Fractional distillation.
Liquid-Gas (Homogeneous)	Boiling.

EXERCISE – II

1. State four differences between compounds and mixtures.
2. What are the characteristic properties of a pure substance ? Why do we need them ?
3. Give *two* examples for each of the following :
   (*a*) Solid + Solid mixture
   (*b*) Solid + Liquid mixure
   (*c*) Liquid + Liquid mixture
4. Define :
   (*a*) Evaporation (*b*) Filtration
   (*c*) Sublimation (*d*) Distillation
   (*e*) Miscible liquids (*f*) Immiscible liquids
5. Name the process by which the components of following mixtures can be separated.
   (*a*) Iron and sulphur
   (*b*) Ammonium chloride and sand
   (*c*) Common salt from sea water
   (*d*) Chaff and grain
   (*e*) Water and mustard oil
   (*f*) Sugar and water
   (*g*) Cream from milk
6. How will you separate a mixture of common salt, chalk powder and powdered camphor ? Explain.
7. How is distillation more advantageous than evaporation ?
8. (*a*) What is chromatography ?
   (*b*) Why is it named so ?
   (*c*) What are the advantages of chromatography ?
   (*d*) Name the simplest type of chromatography?
   (*e*) On what principle is this method based ?
   (*f*) What is meant by stationary phase and mobile phase in chromatography ?
9. On what principle are the following methods of separation based ? Give one example of a mixture for each of the methods mentioned in which they are used
   (*a*) Sublimation
   (*b*) Filtration
   (*c*) Sedimentation and decantation
   (*d*) Solvent extraction method
   (*e*) Magnetic separation
   (*f*) By using a separating funnel
   (*g*) Fractional distillation.

OBJECTIVE TYPE QUESTIONS

1. Fill in the blanks :
   (*a*) .... are made up of same kind of atoms.
   (*b*) .... and .... are pure substances.
   (*c*) In a ...., the substances are not combined chemically.
   (*d*) Clay is separated from water by a method called ....
   (*e*) .... is a process to obtain a very pure form of a solid dissolved in a liquid.
   (*f*) Camphor and ammonium chloride can ....
2. Give one word answers for the following :
   (*a*) The solid particles which remain on the filter paper after the filtration ....
   (*b*) The liquid which evaporates and then condenses during the process of distillation ....
   (*c*) The process of transferring the clean liquid after the solid settles at the bottom of the container ....

(*d*) The process by which two miscible liquids are separated ....

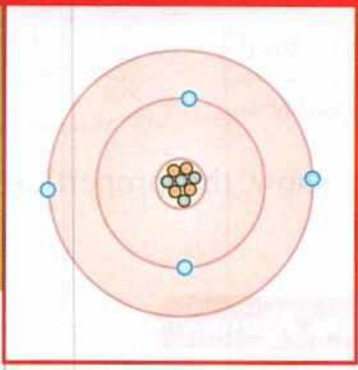
Multiple Choice Questions :

Select the correct alterative from the choices given for the following statements :

1. A pure liquid is obtained from a solution by :
   (*a*) evaporation (*b*) distillation
   (*c*) filteration (*d*) crystallisation
2. Components of crude petroleum can be separated by :
   (*a*) distillation (*b*) evaporation
   (*c*) filtration
   (*d*) fractional distillation
3. Example of a homogeneous mixture is :
   (*a*) tap water (*b*) distilled water
   (*c*) sand and water (*d*) water and oil
4. In chromatography, the filter paper is :
   (*a*) stationary phase (*b*) mobile phase
   (*c*) mixture (*d*) none of the above
5. A set of mixtures is :
   (*a*) ink, honey, ice cream, milk
   (*b*) tap water, gold, common salt, alloy
   (*c*) milk, brass, silver, honey
   (*d*) butter, petroleum, tap water, iron

Project

- Make a chart showing different methods of separation with the underlying principle of each.



Atomic Structure

4

Theme : Every matter is made up of tiny particles known as atoms and molecules. Molecules are also constituted by the atoms. Hence atoms are the building blocks of matter. The physical and chemical properties of matter are governed by atoms. Therefore, the knowledge of the concepts of atoms of elements and molecules of elements and compounds and radicals of compounds is necessary to understand different processes and principles of Chemistry.

In this chapter you will learn :

Atoms, Molecules and Radicals

- *An atom is the smallest particle of an element.*
- *It is not capable of independent existence.*
- *The properties of an element depend upon the atoms constituting it.*
- *A molecule is the smallest particle of an element or compound, capable of independent existence. It consists of one or more than one atom of the same or different elements.*
- *A radical is a single atom of an element or a group of atoms of different elements behaving as single unit and with a charge on group.*
- *Atomicity (no. of atoms in an entity) of elements and compounds – mono atomic, diatomic, triatomic, polyatomic.*
- *Associate the first 20 elements in the periodic table with their names and symbols*
- *Valency is the combining capacity of an element or the number of hydrogen atoms with which it combines or replaces.*

LEARNING OUTCOMES

The children will be able to :

- define atom, molecule and radical;
- discuss the significance of valency of elements and radicals;
- define valency in terms of number of hydrogen atoms combined or replaced by one atom of the element;
- apply the definition based on hydrogen atom to find out the valency of other elements and radicals;
- correlate the valency of the elements with group number of periodic table.

INTRODUCTION

Every matter is made up of very tiny particles called atoms. Molecules are formed from atoms. Atoms and molecules are too small to be seen through naked eye. They can only be seen through a powerful microscope. Let us know about atoms and molecules in detail.

AN ATOM

The word **atom** comes from the word **'atomos'** meaning 'indivisible' coined by a Greek philosopher Democritus (460-361 B.C.). He forwarded the idea that the universe was made up of tiny indivisible particles called atoms. In 1808, John Dalton an English scientist suggested that, an atom is the basic unit of matter.

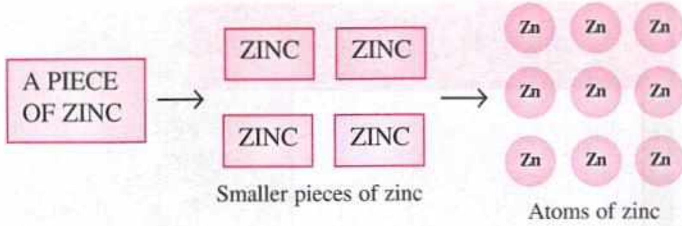
An atom is the smallest particle of an element that exhibits all the properties of that element. It ***may or may not exist*** *independently but takes part in every chemical reaction.*

Example : Take a small piece of zinc and crush it into smaller pieces. All these pieces show properties of zinc. On grinding crushed pieces further, they break up into very fine particles which still show the properties of zinc. But, there comes a stage when the particles cannot be further subdivided into particles exhibiting properties of zinc. These indivisible particles are the atoms of zinc.

"In other words atom is the smallest possible unit of an element".

Atoms of the same element are all identical. They differ from the atoms of other elements.

That is why different elements differ in their properties.



All the above show the properties of element zinc.

Do You Know ?

Atoms are so small that it would take millions of them, just to cover a full stop.

The main characteristics of atoms as suggested by John Dalton are :

- An atom is the smallest particle of matter which cannot be divided further into smaller particles.
- Atoms of the same element are all identical but they differ from the atoms of other elements.
- An atom of an element exhibits all the properties of that element.
- Atoms can neither be created nor be destroyed.
- Atoms may or may not have independent existence but they can take part in chemical reactions.

Originally it was thought that atoms of an element cannot be divided further, but studies in the early twentieth century showed that, an atom is itself made up of even smaller particles called fundamental particles or subatomic particles. They are :

• Electrons, • Protons and • Neutrons.

Electrons : *Electrons are the negatively charged particles in an atom with one unit negative charge and negligible mass.*

Protons : *Protons are the positively charged particles present in an atom with one unit positive charge and one unit mass.*

Neutrons : *Neutrons are the particles with no electrical charge, so they are neutral but have one unit mass.*

Following table shows the symbols, charge and mass of the three fundamental particles of an atom.

Farticle	Symbol	Charge in coulombs	Mass in grams
Electron	$_{-1}e^0$ or e^-	$1{\cdot}602 \times 10^{-19}$C	$9{\cdot}1 \times 10^{-28}$ g
Proton	$_{+1}p^1$ or p^+	$1{\cdot}602 \times 10^{-19}$C	$1{\cdot}6 \times 10^{-24}$ g
Neutron	$_0n^1$ or n^0	0	$1{\cdot}6 \times 10^{-24}$ g

The subscripts on *e, p* and *n* as −1, +1 and 0 represent the charge while the superscript 0, 1, 1 represent the mass. The mass of an electron is very less hence considered to be negligible.

A MOLECULE

"A molecule is the smallest particle of a pure substance (element or compound) which has independent existence. It exhibits all the properties of that pure substance" or *a molecule is a group of two or more atoms that are chemically bonded together by attractive forces.*

Molecules are of *two* types :

1. Molecules of an element.
2. Molecules of a compound.

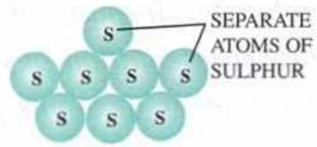
Molecules of an element

Two or more atoms of the same element combine to form a molecule of that element. The atoms of certain elements, like oxygen, nitrogen, chlorine, *etc*., cannot exist independently. So they join to form molecules that have independent existence. To form molecules, atoms always join in whole numbers.

***Examples* :**

1. Two atoms of hydrogen join to form one molecule of the element hydrogen.

2. Eight atoms of sulphur join to form a molecule of sulphur.



A SULPHUR MOLECULE (S_8)

Atomicity

The number of atoms of an element that join together to form a molecule of that element is known as the *atomicity* of that molecule. Depending upon the atomicity, the molecules of elements can be divided into :

(a) monoatomic molecules
(b) diatomic molecules
(c) triatomic molecules
(d) polyatomic molecules.

Monoatomic molecules : They contain only one atom. Atoms of metals and metalloids do not combine with their own type of atoms. So, their atoms are regarded as their molecules too. Similarly, atoms of inert gases exist freely under all conditions. All these elements are said to have *monoatomic molecules.*

***Examples* :** Na, Zn, Mg, *etc*., noble gases : He, Ne, Ar, Xe, *etc*.

Diatomic molecules : They contain two atoms of the same type.

***Examples* :** H_2, O_2, N_2, Cl_2, *etc.*

Triatomic molecules : They contain three atoms.

Examples : Ozone (O_3).

Polyatomic molecules : They contain more than three atoms.

Examples : Phosphorus (P_4), sulphur (S_8), *etc.*

> *Note :* Atomicity refers to the sum total of atoms of same or different elements present in a molecule.

Molecular formula of an element

The molecular formula of an element is the symbolic representation of its molecule. It indicates the number of atoms present in it.

Example : A molecule of chlorine is represented by 'Cl_2' which indicates that two atoms of chlorine join to form one molecule of chlorine. It also shows that the atomicity of chlorine is 2.

Table 4.1 : Names, symbols, atomicity and state of the molecules of common elements

Name of element	*Symbol of molecules*	*Atomicity [Number of atoms in one molecule]*	*State*
Hydrogen	H_2	2	Gas
Nitrogen	N_2	2	Gas
Oxygen	O_2	2	Gas
Fluorine	F_2	2	Gas
Chlorine	Cl_2	2	Gas
Bromine	Br_2	2	Liquid
Iodine	I_2	2	Solid
Ozone	O_3	3	Gas
Phosphorus	P_4	4	Solid
Sulphur	S_8	8	Solid

From the above it is clear that :

(i) 'H' represents one atom of hydrogen and 'H_2' represents a molecule of hydrogen.

(ii) '2H' represents two atoms of hydrogen and $2H_2$ represents two molecules of hydrogen.

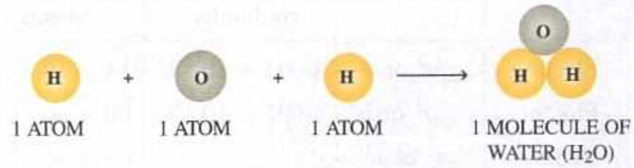
If a numeral is written on the left hand side of a symbol, it represents the number of atoms or molecules.

MOLECULES OF COMPOUNDS

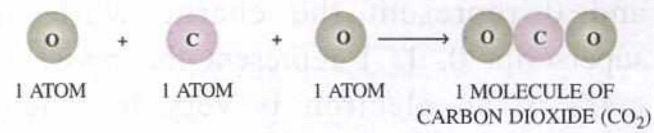
When atoms of two or more elements join together in a fixed ratio by mass, a molecule of a compound is formed.

Examples :

1. Two atoms of hydrogen and one atom of oxygen combine to form a molecule of water.



2. One atom of carbon combines with two atoms of oxygen to form a carbon dioxide molecule.



> *The smallest unit of a compound is its molecule.* It exhibits all the properties of that compound. Every compound has its own specific molecules, which are same in all respects but differ in their properties from the atoms of which they are made.

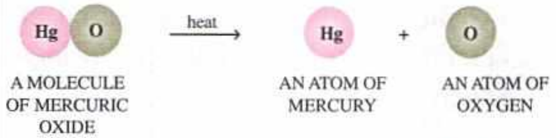
Accordingly, a water molecule is a liquid, but hydrogen and oxygen atoms are gaseous.

Similarly, carbon dioxide is a gaseous compound but carbon is a solid element.

A molecule of a compound can be broken into its constituent elements using chemical methods.

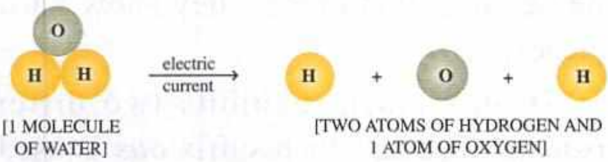
Examples :

1. Mercuric oxide is a solid compound. When it is heated, it decomposes to give mercury and oxygen, which are elements.



2. When electric current is passed through acidulated water, it ionises to give hydrogen and oxygen gases in the ratio of 2 : 1 [by volume].

   From whatever source water is taken and ionised, the ratio of gases hydrogen and oxygen is found to be the same.



Note : Molecules of different compounds show different properties. *e.g.* : Water molecules and sugar molecules are different from each other.

RADICALS

"A radical is an atom of an element or a group of atoms of different elements that behaves as a single unit with a positive or negative charge on it".

Radicals are of two types :

(i) **Basic radical :** They have positive charge and are also called cations. All metallic ions and ammonium ion are basic radicals.

(ii) **Acid radical :** They have negative charge and are also called anions. Most of the non-metallic ions and groups of non-metallic atoms with negative charge are acid radicals.

Ions : Electrically charged atoms or groups of atoms formed by losing or gaining electrons are called ions.

A molecule of a compound is usually made up of two parts. *Example :* Sodium chloride molecule is made up of sodium ion and chloride ion. Sodium ion is positively charged while chloride ion is negatively charged, represented by the symbols Na^+ and Cl^- respectively. The charge on these radicals show their combining capacity *i.e.* valency. These radicals keep their identity in many reactions.

Table 4.2 : Representation of some positive radicals and their valency

Name of radical	*Representation*	*Valency*
Hydrogen	H^+	1
Sodium	Na^+	1
Potassium	K^+	1
Silver	Ag^+	1
Ammonium	NH_4^+	1
Magnesium	Mg^{2+}	2
Calcium	Ca^{2+}	2
Zinc	Zn^{2+}	2
Iron (II)	Fe^{2+}	2
Copper (II)	Cu^{2+}	2
Iron (III)	Fe^{3+}	3
Aluminium	Al^{3+}	3
Gold	Au^{3+}	3
Tin (IV)	Sn^{4+}	4
Platinum (IV)	Pt^{4+}	4

Table 4.3 : Representation of some negative radicals and their valency

Name of radical	*Representation*	*Valency*
Chloride	Cl^-	1
Bromide	Br^-	1
Iodide	I^-	1
Hydroxide	OH^-	1
Acetate	CH_3COO^-	1
Nitrate	NO_3^-	1
Nitrite	NO_2^-	1
Bisulphate	HSO_4^-	1
Bisulphite	HSO_3^-	1
Bicarbonate	HCO_3^-	1
Oxide	O^{2-}	2
Carbonate	CO_3^{2-}	2
Sulphate	SO_4^{2-}	2
Sulphite	SO_3^{2-}	2
Dichromate	$Cr_2O_7^{2-}$	2
Nitride	N^{3-}	3
Phosphate	PO_4^{3-}	3

Table 4.4 : Differences between atoms, molecules and radicals

Atoms	Molecules	Radicals
1. An atom is the smallest particle of an element (matter) which may or may not have independent existence.	A molecule is the smallest particle of an element or a compound capable of independent existence, made up of one or more than one atom of same or different types.	A radical is a single atom of an element or a group of atoms of different elements behaving as a single unit with positive or negative charge on it.
2. An atom represents all the properties of that element.	A molecule represents all the properties of that element or compound.	Oppositely charged radicals combine to form molecules of compounds
3. *E.g.* : Na and Cl represent atoms of sodium and chlorine elements respectively.	*E.g.* : H_2O and CO_2 are the molecules of compounds water and carbon dioxide respectively. H_2 and O_2 are the molecules of elements hydrogen and oxygen respectively.	*E.g.* : Cl^-, NH_4^+, SO_4^{2-} ions are the radicals of chloride ion, ammonium ion and sulphate ion respectively. (NH_4^+, and Cl^- are oppositely charged ions which can combine to form a compound ammonium chloride [NH_4Cl]).

Valency

Valency is the combining capacity of an element or of a radical.

The valency of an element or of a radical can be defined as, the number of hydrogen atoms that will combine with or displace one atom of that element or radical.

Examples : The valency of hydrogen is taken as 1.

(a) In hydrogen chloride molecule (HCl), one atom of chlorine combines with one atom of hydrogen; hence valency of chlorine is 1.

(b) In water (H_2O), one atom of oxygen combines with two atoms of hydrogen; hence valency of oxygen is 2.

(c) In ammonia (NH_3) gas, one atom of nitrogen combines with three atoms of hydorgen; hence valency of nitrogen is 3.

(d) In a methane (CH_4) molecule, one carbon atom combines with four atoms of hydrogen; hence valency of carbon is 4.

Variable valency

Certain elements exhibit more than one valency, that means they show variable valency.

If an element exhibits two different positive valencies, then suffix ***ous*** is used for lower valency and suffix ***ic*** is used for higher valency or their valency is represented in Roman numerals beside their names.

Table 4.5 : Variable positive valency

Metal	*Radicals*	*Valency*
Iron	Ferrous [Iron (II)]	2
	Ferric [Iron (III)]	3
Copper	Cuprous [Copper (I)]	1
	Cupric [Copper (II)]	2

Non-metals like nitrogen, phosphorus and sulphur also show variable valency. Nitrogen and phosphorus show valencies of 3 and 5 while sulphur exhibits valency of 2, 4 and 6.

RELATIONSHIP BETWEEN VALENCY OF ELEMENTS AND PERIODIC TABLE

You know that valency is the combining capacity of an atom of an element with the atoms of other elements.

Let us study the table given below in which symbols and valency of first twenty elements of the periodic table are given :

Table 4.6 : Name, symbol and valency of first twenty elements

Name of the elements	*Symbol*	*Valency*
1. Hydrogen	H	1
2. Helium	He	0
3. Lithium	Li	1
4. Beryllium	Be	2
5. Boron	B	3
6. Carbon	C	4
7. Nitrogen	N	3
8. Oxygen	O	2
9. Fluorine	F	1
10. Neon	Ne	0
11. Sodium	Na	1
12. Magnesium	Mg	2
13. Aluminium	Al	3
14. Silicon	Si	4
15. Phosphorus	P	3
16. Sulphur	S	2
17. Chlorine	Cl	1
18. Argon	Ar	0
19. Potassium	K	1
20. Calcium	Ca	2

It is noticed that valency [combining capacity] of elements increases from 1 to 4 and then again decreases to 1. For some of the elements like Helium, Neon and Argon, the combining capacity is zero because they are inert gases.

Why do the atoms of some elements have the same valency? Is there any relationship between them? Do they show similar properties?

Examples : Both lithium and sodium have the same valency one. Both are metals.

- Sodium and chlorine also have valency one. But sodium is a metal while chlorine is a non-metal.

To understand this more clearly it is necessary to know about the **Periodic Table**.

"Periodic Table is a tabular arrangement of elements in vertical columns and horizontal rows indicating the regular trends in the properties of elements."

There are 118 elements known to us. In order to study these elements in an organised manner, they need to be classified.

The first attempt was made on the basis of some of their physical and chemical properties due to which elements could be classified into metals and non-metals.

Later on more fundamental properties were taken into consideration and elements were arranged systematically in a tabular form.

- The horizontal rows of the table are called **periods**.
- The vertical columns are called **groups**.

Let us see the first twenty elements in the periodic table below.

Groups (vertical columns) ↓ / Periods → (horizontal rows)	IA	IIA	IIIA	IVA	VA	VIA	VIIA	Zero
1	H							He
2	Li	Be	B	C	N	O	F	Ne
3	Na	Mg	Al	Si	P	S	Cl	Ar
4	K	Ca						

A part of periodic table showing first 20 elements.

The groups are numbered in Roman numerals as IA, IIA, IIIA, IVA, VA, VIA, VIIA and zero group.

The periods are numbered in Arabic numerals as 1, 2, 3, 4, 5, 6, 7.

You will notice that elements present in the same group have same valency (combining capacity) and it also corresponds to the group number upto IV.

Examples **:** Group IA has lithium, sodium and potassium. They are all reactive metals with valency one. Group IVA has carbon and silicon with valency 4.

Valency of elements present in groups V, VI and VII are 3, 2, 1 respectively. Group zero contains inert gases with zero combining capacity.

The above arrangement makes it very clear that metals with the same valency show similar properties and so do the non-metals.

You will study the details of the periodic table in higher classes.

Note : According to IUPAC system (International Union of Pure and Applied Chemistry), now the group number is also represented as 1, 2, 3, 4...... upto 18.

MOLECULAR FORMULA OF COMPOUNDS

Each compound is represented by a chemical formula with the help of symbols and valency of different atoms present in it. Since the formula represents the molecule of a compound, therefore it is more commonly known as its molecular formula.

A molecular formula of a compound is the symbolic representation of its (one) molecule. It shows the number of atoms of each element present in it. These atoms combine in whole numbers to form the molecule.

For example : A molecule of sulphur dioxide gas is represented as SO_2. It indicates that one molecule of SO_2 is formed by one atom of element sulphur and two atoms of element oxygen.

WRITING THE CHEMICAL FORMULA OF A COMPOUND

To write the chemical formula of a compound, the following information should be available:

(i) Symbols of the elements or the radicals that constitute the compound.

(ii) Valencies (combining capacity) of the elements or the radicals.

Step-by-step method for writing the formulae of chemical compounds.

1. *Example* – Calcium chloride

I. Write the symbols

On the left hand side	*On the right hand side*
Calcium Ca	Chloride Cl

II. Write the valency of the symbols

(Ignore the (+) and (–) signs)

At the top right corner	*At the top right corner*
Ca^2	Cl^1

III. Interchange the valency number

Ca^2 ⟶ 2 (to Cl) ; Cl^1 ⟶ 1 (to Ca)

Ca^2	Cl^1
1	2

IV. Write the interchanged numbers at the base

Ca_1 Cl_2

V. Write the formula of the compound

(ignore base number if it is 1)

$CaCl_2$

Note : The number 1 with Ca is not written in the formula because the symbol itself represents one atom.

One more example of writing a molecular formula is in the manner where valency number of positive and negative ions are divided by a common number.

2. *Example* – Magnesium oxide

Step I : Write the symbols and valencies.

Symbols	
Magnesium Mg	Oxide O

Valencies	
Magnesium 2	Oxide 2

Mg^2 O^2

Step II : Reduce the valency to the lowest ratio, if possible. [*It should be reduced here*].

$Mg^{\not{2}}$ $O^{\not{2}}$

Step III : Interchange the valencies of the radicals.

Mg^1 ⨯ O^1

1 1

Step IV : Write the interchanged numbers at the base.

Mg_1 O_1

Step V : (Ignore the base number, as it is one)

Therefore, the formula is **MgO**.

3. *Example* – Calcium nitride

Step I : Write the symbols and valencies.

Symbols	
Calcium Ca	Nitride N

Valencies	
Calcium 2	Nitride 3

Step II : Ca^2 N^3

Step III : Interchange the valencies of radicals.

Ca^2 ⨯ N^3

3 2

Step IV : Write the interchanged numbers at the base.

Ca_3 N_2

Step V : Therefore, the formula is $\mathbf{Ca_3N_2}$.

4. *Example* – Zinc hydroxide

Step I : Write the symbols and valencies.

Symbols	
Zinc	Hydroxide
Zn	OH

Valencies	
Zinc	Hydroxide
2	1

Step II : Zn^2 OH^1

Step III : Interchange the valency number. When the radical itself bears any number in its formula or in its symbol, or if it is OH radical and more than 1 number comes after exchanging the valency number, put the parenthesis (round brackets) sign enclosing the radical symbol.

Zn^2 ⨯ OH^1

1 ↙ ↘ 2

Step IV : Zn_1 $(OH)_2$

Step V : (Ignore the base number of Zn as it is one).

Therefore, the formula is $Zn(OH)_2$.

5. *Example* – Ammonium carbonate

Step I : Write the symbols and valencies.

Symbols	
Ammonium	Carbonate
NH_4	CO_3

Valencies	
Ammonium	Carbonate
1	2

Step II : NH_4^1 CO_3^2

Step III : Interchange the valency number

NH_4^1 ⨯ CO_3^2

2 ↙ ↘ 1

Step IV : Radicals already bear some numbers in their formulae. So parenthesis (round brackets) are required to be put around both the radical formulae.

$(NH_4)_2$ $(CO_3)_1$

Step V : (Ignore the base number of carbonate, as it is one).

Therefore, the formula is $(NH_4)_2CO_3$.

Activity

Write the molecular formulae of chlorides, oxides and sulphides of following bivalent metals (valency-2)

1. Copper 2. Iron 3. Lead 4. Mercury

Significance of molecular formula

The molecular formula of a compound other than saving time, space and energy also gives us the following information :

(i) It represents one molecule of a compound.

(ii) The number of each kind of atoms present, *i.e.*, the ratio in which the atoms are present in one molecule.

(iii) The mass of one molecule of the compound can be calculated. Molecular mass is the algebric sum of the masses of all the atoms present in a given molecule.

Example :

- A molecule of sulphuric acid is represented by the formula H_2SO_4.
- The elements present in it are hydrogen, sulphur and oxygen.
- One molecule of sulphuric acid has two atoms of hydrogen, one atom of sulphur and four atoms of oxygen. The ratio in which atoms of hydrogen, sulphur and oxygen are present is 2 : 1 : 4.
- If the masses of all the atoms present in the molecule are added, the molecular mass of sulphuric acid is obtained.

Note : We can represent the number of molecules of a compound by writing a number before the formula. *For example:* $2H_2SO_4$ represents two molecules of sulphuric acid.
5NaCl represents five molecules of sodium chloride.

Table 4.8 : Molecular formulae, the common names and the state of some common compounds

	Name of Compounds	*Formula*	*State*
1.	Sodium chloride [common salt]	$NaCl$	Solid
2.	Sugar	$C_{12}H_{22}O_{11}$	Solid
3.	Glucose	$C_6H_{12}O_6$	Solid
4.	Sodium bicarbonate [baking soda]	$NaHCO_3$	Solid
5.	Washing soda [sodium carbonate, decahydrate]	$Na_2CO_3 \cdot 10H_2O$	Solid
6.	Marble & chalk [calcium carbonate]	$CaCO_3$	Solid
7.	Sand [silica]	SiO_2	Solid
8.	Calcium hydroxide [slaked lime]	$Ca(OH)_2$	Solid
9.	Sodium hydroxide [caustic soda]	$NaOH$	Solid
10.	Copper sulphate [blue vitriol]	$CuSO_4$	Solid
11.	Water	H_2O	Liquid
12.	Acetic acid [vinegar]	CH_3COOH	Liquid
13.	Hydrochloric acid	HCl	Liquid
14.	Sulphuric acid	H_2SO_4	Liquid
15.	Nitric acid	HNO_3	Liquid
16.	Carbon dioxide	CO_2	Gas
17.	Carbon monoxide	CO	Gas
18.	Sulphur dioxide	SO_2	Gas
19.	Sulphur trioxide	SO_3	Gas
20.	Ammonia	NH_3	Gas
21.	Hydrogen sulphide	H_2S	Gas
22.	Nitrogen dioxide	NO_2	Gas
23.	Nitric oxide [nitrogen monoxide]	NO	Gas
24.	Nitrous oxide [laughing gas]	N_2O	Gas
25.	Phosphorous pentoxide	P_2O_5	Solid

RECAPITULATION

- Matter is made up of tiny particles called atoms and molecules.
- Atoms may or may not have independent existence.
- Atoms are the smallest particles of elements.
- Molecules have independent existence. They are the smallest particles of compounds.
- Radicals are charged ions consisting of an atom or group of atoms of different elements. Radicals can be positive or negative.
- Valency is the combining capacity of an atom of an element. The number of hydrogen atoms that combines with an atom of another element determines the valency of that element.
- Some elements exhibit variable valency like iron, copper, etc.
- Periodic table represents the tabular arrangement of elements in horizontal rows called periods and vertical columns called groups in order to classify the elements and their systematic study.
- The valency of elements corresponds to the group number of the table upto 4 and then decreases to one and finally zero. This shows the similar behaviour of the elements present in the same group.
- Molecular formula is the representation of molecules with the help of symbols and the valencies of its constituting atoms.

EXERCISE

1. Define the following terms :
   (a) Atoms (b) Molecules
   (c) Radicals (d) Valency
   (e) Periodic table
2. Write the names of the elements present in the following compounds.
   (a) Common salt (b) Ammonia
   (c) Sulphuric acid (d) Glucose
   (e) Sodium hydroxide (f) Acetic acid
3. What does each of the following represent ?
   (a) $2CO_2$ (b) $2H_2S$
   (c) $5H_2SO_4$ (d) $6NaNO_3$
4. Write the symbols and valencies of the following radicals :
   (a) Magnesium ion (b) Ammonium
   (c) Carbonate (d) Nitrate
   (e) Oxide (f) Bisulphate
   (g) Aluminium ion
5. Name the following radicals :
   (a) SO_4^{2-} (b) HCO_3^-
   (c) OH^- (d) $Cr_2O_7^{2-}$
6. (a) Name one ion for each of the valencies +1, +2 and +3.
   (b) Name one ion for each of the valencies –1, –2 and –3.
7. The valency of calcium is 2. Write the valencies of other radicals in the following compounds :
   (a) CaO (b) $Ca(OH)_2$
   (c) $CaCO_3$ (d) $CaCl_2$
8. Write the names of the following compounds :
   (a) $(NH_4)_2SO_4$ (b) $Ca(NO_3)_2$
   (c) FeS (d) Na_3PO_4
   (e) NH_4OH (f) $CuCO_3$
   (g) HgO (h) $ZnCl_2$
   (i) ZnS (j) H_2S.
9. Write the molecular formulae of :
   (a) Sodium sulphide
   (b) Magnesium oxide
   (c) Calcium hydroxide
   (d) Hydrogen chloride
   (e) Sulphuric acid
   (f) Iron (II) sulphide

(g) Iron (III) sulphate
(h) Nitric acid
(i) Calcium phosphate
(j) Aluminium sulphate
(k) Magnesium nitride

10. The valency of sodium is one. Write the molecular formula for the following compounds of sodium.
(a) sodium oxide (b) sodium sulphate
(c) sodium carbonate (d) sodium hydroxide
(e) sodium nitrate

11. What is variable valency ? Give two examples of elements showing variable valency.

12. Give the group number of the following elements present in periodic table
(a) Magnesium (b) Carbon
(c) Sulphur (d) Neon

13. An element belongs to group VA. What would be its valency? Name two such elements.

14. An element belongs to group II. What would be its valency ? Write the formulae of molecules of compounds it will form with elements in VA, VIA and VII A groups.

OBJECTIVE TYPE QUESTIONS

1. Fill in the blanks :
(a) Atoms are ....
(b) An ion with positive charge is called ....
(c) An ion with negative charge is called ....
(d) $2H_2$ means two .... of hydrogen.
(e) .... is a triatomic molecule.
(f) Metals have .... valency.
(g) Chemical name of caustic soda is ....

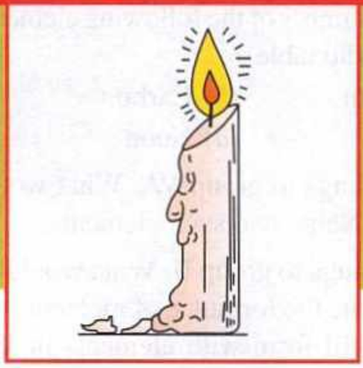
2. Tick (√) the correct answer.
(a) The valency of iron in Fe_2O_3 is
(i) 1 (ii) 2
(iii) 3 (iv) 6
(b) Which of the following has valency 4 ?
(i) aluminium (ii) oxygen
(iii) carbon (iv) phosphorus
(c) The sulphate radical is written as SO_4^{2-}. What is the formula of calcium sulphate?
(i) $Ca(SO_4)_2$ (ii) $Ca_2(SO_4)$
(iii) $Ca(SO_4)_3$ (iv) $CaSO_4$
(d) Which of the following exhibits variable valency ?
(i) calcium (ii) copper
(iii) carbon (iv) chlorine

3. State the term for the following :
(a) The number of atoms present in a molecule of an element. ....
(b) The symbolic representation of a molecule. ....
(c) A group of atoms that react as a single unit. ....
(d) The combining capacity of an element. ....
(e) The tabular arrangement of elements in horizontal rows and vertical columns. ....

Project

- Play a game for writing the formulae of compounds.

Example : Make placards with symbols and valencies of the elements separately. Each student should hold two placards, one with the symbol in the right hand and the other with the valency in the left hand. Keeping the symbols in place, students should criss-cross their valencies to form the formula of a compound.



Language of Chemistry

5

Theme : Chemistry involves the study of a large number of elements and compounds that also have been learnt earlier with their representation by their short hand notations *i.e.* symbols and formulae. As it is not convenient to write full names of the elements and compounds, the use of symbols has made the job of the chemists very easy. Chemistry also involves the occurrence of a large number of chemical reactions that are written in the form of equations known as chemical equations. The writing of chemical equations involves writing of reactants and products as their symbols and formulae. Thus symbols and formulae have also made writing of chemical equations in Chemistry very convenient.

In this chapter you will learn :

- *Chemical reactions*
- *A chemical reaction may take place when two or more reactants come in contact with one another and transfer of energy takes place.*
- *Characteristics of occurrence of a chemical reaction:*

  Change of:
  - *Colour*
  - *State*
  - *Smell*
  - *Evolution of gas*
  - *Precipitate formed*
  - *Heat evolved / released*
- *Chemical Equations:*
  - *Writing word equations for chemical reactions and emphasize on the observational skills and the names of products formed*
- *Some examples of word equations for practice.*

LEARNING OUTCOMES

The children will be able to :

- identify the names of reactants and products of different chemical reactions;
- write a chemical reaction in the form of a chemical word equation;
- recognize the usefulness of a word equation.

CHEMICAL REACTIONS

Any chemical change in matter which involves its transformation into one or more new substances is called a chemical reaction. It also involves transfer of energy.

The substances that undergo chemical change are called ***reactants****, and the new substances thus formed are called* ***products****.*

$$\text{Reactants} \xrightarrow[\text{Change}]{\text{Chemical}} \text{Products}$$

Both reactants and products are pure substances, *i.e.*, elements and compounds.

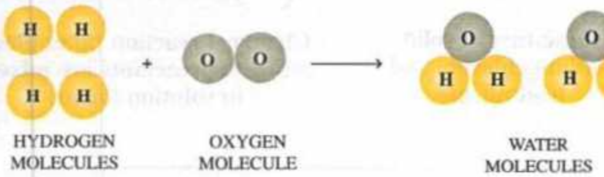
When we write the names of reactants and products to express a chemical reaction, it is called a 'word equation.'

Example 1 : Hydrogen + Oxygen ⟶ Water
[Reactants] [Product]

In the above reaction, hydrogen and oxygen are the elements that undergo chemical change to form a new substance water, a compound which is completely different from hydrogen and oxygen in its properties.

But what happens to hydrogen and oxygen molecules during the reaction?

The atoms of oxygen and hydrogen in their molecules rearrange themselves to form water molecules. One molecule of water contains two atoms of hydrogen and one atom of oxygen.



- It has been observed that, total mass of the reactants together is equal to the total mass of the products *i.e.* mass of the substances before and after a chemical change remains same.
- This is possible only when the total number of atoms of each kind remains the same before and after a chemical reaction.
- This is supported by the **law of conservation of matter** which states that,

"Matter can neither be created nor be destroyed. It can only be transformed from one form to another."

Example 2 : Sodium oxide + Water ⟶ Sodium hydroxide

The above word equation shows that two compounds, sodium oxide and water, react chemically to give a new compound sodium hydroxide.

Example 3 :

$$\text{Potassium chlorate} \xrightarrow[MnO_2]{\text{heat}} \text{Potassium chloride} + \text{Oxygen}$$

In this reaction potassium chlorate, a compound, on heating, changes into two new substances; a compound potassium chloride and an element oxygen.

Thus, a chemical reaction may involve a combination of two or more elements or compounds reacting with each other to form new compound(s) or it may involve splitting of a compound into two or more elements or compounds. It also involves reaction between an element and a compound or two compounds to give more than one product.

So whenever a chemical change occurs, we can say that a chemical reaction has taken place.

Activity 1

To be demonstrated by the teacher.

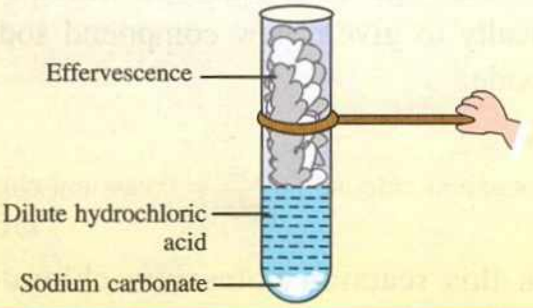
Take a small amount of sodium carbonate, a white solid in a dry test tube. Add 2-3 ml of dilute hydrochloric acid to it.

What do you observe ?

A brisk effervescence* indicating evolution of a gas, which is a new substance carbon dioxide. At the same time heat energy is also given out as the test tube becomes warm.

This indicates that a chemical reaction has taken place between sodium carbonate and dilute hydrochloric acid to produce new substances.

Sodium carbonate + Hydrochloric acid (dil.)
→ Sodium chloride + Water + Carbon dioxide



CONDITIONS NECESSARY FOR CHEMICAL REACTIONS

A chemical reaction takes place when one or more of the following conditions are fulfilled.

1. **Close contact :** For a chemical reaction to take place, the reactants must come into close contact, *i.e.*, they should be mixed.

   For example : Sodium reacts with water violently when they come in contact with each other to produce two new substances, sodium hydroxide and hydrogen.

   Sodium + Water ⟶ Sodium hydroxide + Hydrogen

   Without contact, no reaction takes place. Therefore in the laboratory, sodium is stored in kerosene oil to prevent its contact even with moisture.

2. **Solution form :** Some substances react with each other only when they are mixed in the solution form.

   For example : When sodium chloride solution is added to silver nitrate solution, a white precipitate* of silver chloride and a soluble sodium nitrate are formed.

   Silver nitrate (aqueous solution) + Sodium chloride ⟶ Silver chloride (white ppt.) + Sodium nitrate (solution)

   If solid sodium chloride and silver nitrate are mixed together, no change takes place.

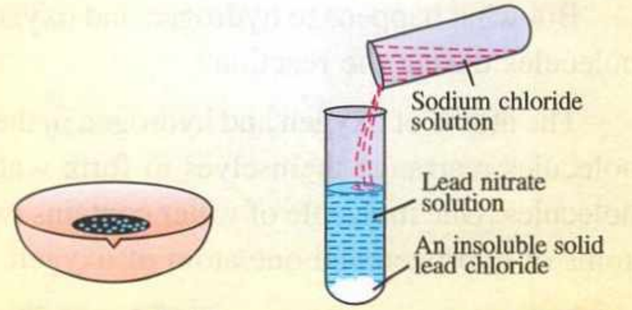
Activity 2

To be demonstrated by the teacher.

Take some solid sodium chloride and solid lead nitrate and mix them. They are now in contact of each other. Keep the mixture undisturbed for some time.

Do you observe any change ? **No.**

Now take aqueous solutions of sodium



A mixture of solid sodium chloride and lead nitrate

Chemical reaction takes place when the reactants are mixed in solution forms.

* *Effervescence : It is the bubble formation due to evolution of a gas during a chemical reaction.*

* *Precipitate : An insoluble solid formed on reaction of two solutions is called a precipitate.*

chloride and lead nitrate in two separate test tubes. Add the solution of sodium chloride to lead nitrate solution. What do you observe ?

A white insoluble solid (precipitate) is formed immediately which is a new substance known as lead chloride.

This shows that some substances react when they are mixed only in solution form.

Now think, why the contents of 'Eno*' powder do not react inside the packet, but give effervescence on pouring in water.

3. **Heat :** Some reactants need to be heated to undergo a chemical change.

   For example : Iron and sulphur when heated together react to produce iron sulphide. Without heating, they do not react even if they are in contact with each other.

$$\text{Iron} + \text{Sulphur} \xrightarrow{\text{heat}} \text{Iron sulphide}$$

4. **Light :** Some reactions take place in the presence of light.

   For example : In photosynthesis, carbon dioxide and water react in presence of chlorophyll and light to produce glucose and oxygen.

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

5. **Catalyst :** Some reactions need a catalyst to speed up or slow down the reaction.

   For example : Manganese dioxide acts as a catalyst for the decomposition of potassium chlorate into potassium chloride and oxygen at a lower temperature.

$$\text{Potassium chlorate} \xrightarrow{\text{Manganese dioxide}} \text{Potassium chloride} + \text{Oxygen}$$

   Manganese dioxide does not undergo any change in its chemical composition during the reaction.

CATALYST : *A catalyst is a substance which changes the rate of a chemical reaction without itself undergoing any chemical change.* Different chemical substances are used as catalysts for different chemical reactions.

* *Eno : It is a mixture of sodium bicarbonate, sodium carbonate and citric acid. It is used as a medicine.*

Characteristics of chemical reactions

Chemical reactions are characterized by certain changes that can be easily observed. They help to recognize the changes in the reactants and formation of new products. Some of these are as follows :

1. **Change of colour :** In some chemical reactions, change of colour takes place when reactants form the products.

   Example : When a few pieces of iron are dropped into a blue solution of copper sulphate, its blue colour slowly changes into light green and also a red substance is formed. The reaction can be represented as,

$$\underset{}{\text{Iron}} + \underset{\text{(blue solution)}}{\text{Copper sulphate}} \longrightarrow \underset{\text{(light green solution)}}{\text{Iron sulphate}} + \underset{\text{(reddish brown solid)}}{\text{Copper}}$$

Activity 3

To be demonstrated by the teacher.

Take some sugar in a porcelain dish. Keep it over a tripod stand and heat it for some time.

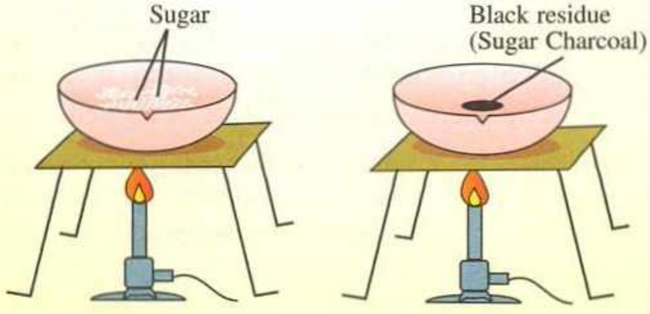
What do you observe ?

Sugar first melts and then gets charred into a black residue which is a new substance charcoal. It no more tastes sweet. Some water vapour is also formed which escapes in air.

This shows that a chemical reaction may involve a change in colour.

This reaction can be represented as,

$$\underset{\text{(white solid)}}{\text{Sugar}} \xrightarrow{\text{heat}} \underset{\text{(black solid mass)}}{\text{Charcoal}} + \text{Water vapour}$$



2. Evolution of a gas : In some reactions one of the products is a gas, which can be recognised by the effervescence (bubbles), smell or colour.

Example : When dilute hydrochloric acid is added to solid sodium carbonate, a strong effervescence is observed indicating evolution of carbon dioxide gas.

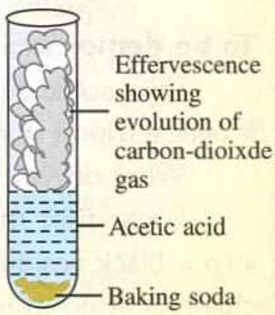
Sodium carbonate (solid) + Dilute hydrochloric acid ⟶ Sodium chloride + Water + Carbon dioxide (gas)

Activity 4

To be demonstrated by the teacher.

Take some baking soda in a test tube. Add some dilute acetic acid (vinegar) to it.

What do you observe ?



Strong effervescence (bubbles) indicating evolution of a gas. The gas evolved is carbon dioxide.

This shows that during a chemical reaction a gas may be evolved.

3. Formation of a precipitate : In some chemical reactions, when two solutions are mixed, an insoluble solid known as a precipitate is formed.

Example : When barium chloride solution is added to sodium sulphate solution, a white precipitate of barium sulphate is formed.

Barium chloride (solution) + Sodium sulphate (solution) ⟶ Barium sulphate↓ (white precipitate) + Sodium chloride (solution)

Activity 5

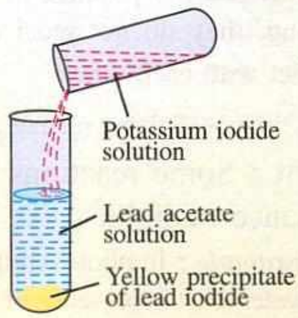
To be demonstrated by the teacher.

Take aqueous solutions of potassium iodide and lead acetate in two separate test tubes. Add potassium iodide solution to lead acetate solution.

What do you observe ?

A yellow precipitate is formed immediately which is a new substance lead iodide.

This shows that, during a chemical reaction an insoluble solid *i.e.* a precipitate can be formed and also a colour change may take place.



Potassium iodide (solution) + Lead acetate (solution) → Lead iodide (yellow precipitate) + Potassium acetate (solution)

4. Change of state : Change of state is observed in many chemical reactions. The reactant may be a solid or a liquid which changes into a gaseous product or vice versa.

Example : • When hydrogen gas is burnt in oxygen gas it results in the formation of water which is a liquid under normal conditions.

Hydrogen (gas) + Oxygen (gas) $\xrightarrow{heat}$ Water (liquid)

• Copper carbonate is a green solid. On heating, it produces copper oxide which is a black solid and carbon dioxide, a gas.

Copper carbonate (green solid) $\xrightarrow{heat}$ Copper oxide (black solid) + Carbon dioxide (gas)

5. **Change of smell :** During some chemical reactions a strong smell is experienced.

Example **:** • When solid ammonium chloride is heated with sodium hydroxide solution, a gas ammonia is evolved which is recognized by its *strong pungent smell.*

Ammonium chloride (solid)	+	Sodium hydroxide (solution)	$\xrightarrow{\text{heat}}$	Sodium chloride (solution)	+	Water	+	Ammonia↑ (gas) (pungent smell)

• When dilute hydrochloric acid is heated with iron sulphide, a gas hydrogen sulphide with a *rotten egg smell* is evolved.

Iron sulphide (solid)	+	dil. hydrochloric acid (solution)	$\longrightarrow$	Iron chloride (solution)	+	Hydrogen↑ sulphide (gas) (rotten egg smell)

6. **Heat is released or evolved :** During many chemical reactions heat is evolved, indicating the formation of products.

Example **:** • When water is added to quick lime, a large amount of heat energy is evolved.

Calcium oxide (solid)	+	Water	$\longrightarrow$	Calcium hydroxide	+	Heat

• When dilute hydrochloric acid reacts with sodium hydroxide, some heat is released.

Sodium hydroxide	+	dil. hydrochloric acid	$\longrightarrow$	Sodium chloride	+	Water	+	Heat

Note : In a chemical reaction transfer of energy takes place during the formation of products from the reactants in the form of heat and light and sometimes in the form of sound and electricity too. This is because every substance has a fixed amount of energy stored in it, in the form of chemical energy. The amount of energy stored is different in different substances.

During a chemical reaction, if the reactants have more chemical energy than the products formed, the energy is released as heat, light or sound or vice versa.

CHEMICAL EQUATIONS

A chemical equation is the symbolic representation of a chemical reaction using symbols and formulae of the reactants involved and the product(s) formed in the reaction.

Example **:** Burning of coal in air is a chemical reaction in which a new substance, carbon dioxide, is formed.

This reaction can be represented by either a word equation or a chemical equation (using formulae and symbols), as shown below :

$$\text{Carbon} + \text{Oxygen} \xrightarrow{\text{heat}} \text{Carbon dioxide}$$

$$\underset{\text{(reactants)}}{C + O_2} \xrightarrow{\text{heat}} \underset{\text{(product)}}{CO_2}$$

In this reaction, carbon and oxygen are the reactants and carbon dioxide is the product.

In fact a chemical equation is a short hand description of a chemical reaction. It saves space, time and energy.

The steps involved in writing a chemical equation :

(i) Write the symbols or the formulae of the reactant(s) on the left hand side, with a (+) sign between them if they are two or more than two.

(ii) Write the symbols or the formulae of the product(s) on the right hand side, with a (+) sign between them if they are two or more than two.

(iii) Put the sign of an arrow (→) in between the reactant side and the product side.

(iv) Represent the reactants and the products in their molecular forms. Atomic forms are usually neither stable nor capable of independent existence.

Now consider the following chemical reactions :

(i) Reaction of zinc oxide with carbon to form zinc and carbon monoxide.

Zinc oxide + Carbon ⟶ Zinc + Carbon monoxide [word equation]

$ZnO + C \longrightarrow Zn + CO$ [symbolic equation]

The total number of atoms on the reactant side as well as product side are equal in this case. Such an equation is a balanced equation.

(ii) Reaction between hydrogen and chlorine to form hydrogen chloride.

Hydrogen + Chlorine ⟶ Hydrogen chloride [word equation]

$H_2 + Cl_2 \longrightarrow HCl$ [skeletal equation]

Note **:** We cannot write the equation as $H + Cl \rightarrow HCl$, because H and Cl represent the atoms of hydrogen and chlorine, which have no independent existence. The two reactants should be written as H_2 and Cl_2, *i.e.*, in their molecular form. Molecules have independent existence.

In this reaction the numbers of hydrogen and chlorine atoms on the left hand side are not equal to their numbers on the right hand side.

Such an equation is an unbalanced one and it is known as a ***skeletal equation***.

Some more examples of skeletal equations are :

$$H_2 + O_2 \longrightarrow H_2O$$
$$Mg + O_2 \longrightarrow MgO$$
$$N_2 + H_2 \longrightarrow NH_3$$

Activity : Identify the reactants and products in the above three equations and also write their word equations.

Remember, all chemical equations must be balanced in order to follow the law of conservation of matter or mass.

Note : Word equations do not require balancing.

The need for balancing a chemical equation

A chemical equation needs to be balanced so as to make the number of atoms of the reactants equal to the number of atoms of the products. *This is because a chemical reaction is just a rearrangement of atoms. The atoms themselves are neither created nor destroyed during the course of a chemical reaction. [Law of conservation of matter].*

Therefore, the balanced chemical equation for the reaction between hydrogen and chlorine is written as :

$$H_2 + Cl_2 \rightarrow 2HCl.$$

A balanced chemical reaction *is the one in which the number of atoms of each element on the reactant side is equal to the number of atoms of that element on the product side.*

The significance of a balanced chemical equation

A balanced chemical equation is a wonderful way of representing a lot of information in a concise manner.

1. It shows which substances are taking part in a chemical reaction and what products are obtained as a result of it (qualitative).
2. It shows both the number of molecules and the number of atoms involved in the reaction (quantitative).
3. It makes the study of chemistry universally standardized.

Example : $2Mg + O_2 \rightarrow 2MgO$

This chemical equation indicates that :

(i) magnesium reacts with oxygen to form magnesium oxide.

(ii) two monoatomic molecules of magnesium combine with one diatomic molecule of oxygen to produce two molecules of magnesium oxide.

HOW TO BALANCE A CHEMICAL EQUATION?

A chemical equation is balanced by taking the following steps in the given examples :

Example* 1 : *Burning of magnesium in the presence of oxygen.

Magnesium burns in oxygen to give magnesium oxide.

∴ The word equation is :

Magnesium + Oxygen → Magnesium oxide

Formulae for the reactants are Mg and O_2.

Formula for the product is MgO.

∴ The skeletal equation is :

$$Mg + O_2 \rightarrow MgO$$

Steps for balancing the equation

Step I : *Count the number of atoms of each element on either side. It is convenient to start balancing with the molecule that contains the maximum number of atoms.*

Number of atoms of each element on the	
Reactant side	**Product side**
Mg = 1 O = 2	Mg = 1 O = 1

Therefore, we can see that there is an extra oxygen atom present on the reactant side.

Step II : *Multiply the product side by 2, because there are two atoms of oxygen present on the reactant side.*

$$Mg + O_2 \rightarrow \boxed{2} MgO$$

Now we have :

Number of atoms of each element on the	
Reactant side	**Product side**
Mg = 1 O = 2	Mg = 2 O = 2

But this means that there is now one extra atom of magnesium present on the right hand side (product side).

Step III : *Multiply the magnesium atom on the left hand side by 2.*

$$\boxed{2} Mg + O_2 \rightarrow 2MgO$$

Number of atoms of each element on the	
Reactant side	**Product side**
Mg = 2 O = 2	Mg = 2 O = 2

This equation is now balanced and can be written as $2Mg + O_2 = 2MgO$

Note : Please note that whatever number you are writing to balance the atoms of a molecule, you are neither supposed to insert the number in between the formula nor by changing the formula. *e.g.*

$$Mg + O_2 \rightarrow MgO$$

This equation cannot be balanced in the following ways :

$Mg + O_2 \rightarrow Mg2O$ } × Wrong

$Mg + O_2 \rightarrow MgO_2$ } × Wrong

Example* 2 : *Reaction of hydrogen with oxygen to produce water.

The word equation is :

Hydrogen + Oxygen → Water

The skeletal equation is :

$$H_2 + O_2 \rightarrow H_2O$$

Steps for balancing the equation :

Step I : Count the number of atoms of each element on either side.

Number of atoms of each element on the	
Reactant side	**Product side**
H = 2 O = 2	H = 2 O = 1

There is an extra oxygen atom on the reactant side.

Step II : Multiply the product side by 2.

∴ The equation now becomes,

$$H_2 + O_2 \rightarrow \boxed{2} H_2O$$

Now we have :

Number of atoms of each element on the	
Reactant side	**Product side**
H = 2 O = 2	H = 4 O = 2

That means there are two extra hydrogen atoms on product side.

Step III : Multiply hydrogen on the left hand side by 2.

$$\boxed{2} H_2 + O_2 \rightarrow 2H_2O$$

This equation is now balanced and can be written as

$$2H_2 + O_2 \rightarrow 2H_2O$$

Example 3 :

Reaction of Iron (II) sulphide with sulphuric acid.

The word equation is :

Iron (II) sulphide + Sulphuric acid →
Iron (II) sulphate + Hydrogen sulphide

The skeletal equation is :

$$FeS + H_2SO_4 \rightarrow FeSO_4 + H_2S$$

Let us examine the number of atoms of different elements on both sides of the arrow. In this equation, sulphur is at two places on reactant as well as product side. So when you count atoms to balance the equation, sum of each side is to be considered.

The following table will make this point clear.

Number of atoms of each element on the	
Reactant side	**Product side**
Fe = 1 S = (1 + 1) = 2 H = 2 O = 4	Fe = 1 S = (1 + 1) = 2 H = 2 O = 4

As the number of atoms of each element is the same on both sides of the arrow, hence the above equation is a balanced chemical equation.

Note **:** The physical states of the reactants and the products of a chemical equation are shown using the symbols *(g)* for gas, *(l)* for liquid and *(s)* for solid and (aq.) for aqueous. The word aqueous (aq.) is written if the reactant or the product is present as a solution in water.

For example,

$$\underset{(s)}{NH_4Cl} + \underset{(aq.)}{NaOH} \xrightarrow{\text{heat}} \underset{(aq.)}{NaCl} + \underset{(l)}{H_2O} + \underset{(g)}{NH_3}$$

Sometimes the pressure, temperature and catalyst used in the reaction are also shown, they are mentioned above or below the arrow sign.

$$N_2 + 3H_2 \xrightarrow[\text{200 – 900 atm (pressure)}]{\text{Fe(catalyst)/Mo (promoter)} \; 450°C} 2NH_3 + \text{heat}$$

Intext Questions

1. Define the term catalyst. Write one example where it is used.
2. Name the reactants and products in the following skeletal equations and balance them.
   (i) $Na + Cl_2 \rightarrow NaCl$ (ii) $N_2 + H_2 \rightarrow NH_3$ (iii) $Na + O_2 \rightarrow Na_2O$
   (iv) $Fe + H_2O \rightarrow Fe_3O_4 + H_2$ (v) $Na + H_2O \rightarrow NaOH + H_2$

RECAPITULATION

- A chemical reaction involves the transformation of an original substance into an altogether new substance(s).
- A chemical reaction can be represented with the help of the symbols or the formulae of the elements and the compounds taking part in that reaction. This gives a chemical equation.
- Certain necessary conditions for a chemical reaction to happen are — close contact, solution form, heat, light and catalyst.
- Characteristics of chemical reactions are — change of colour, evolution of a gas, formation of a precipitate, change of state, change of smell and evolution/absorption of heat.
- The substances that react with each other are called reactants and they are represented on the left hand side of the equation. The substances that are formed as a result of the reaction are called products. They are represented on the right hand side of the equation.
- A complete chemical equation symbolically represents the reactants, products and their physical states.
- A chemical equation needs to be balanced to make it follow the law of conservation of mass.
- The law of conservation of mass states that mass can neither be created nor destroyed, it can only be transformed from one form to another.

EXERCISE

1. (a) Define a chemical reaction.
   (b) What is a chemical equation ?
   (c) Why do we need to balance chemical equations?
2. State four conditions necessary for chemical reactions to take place.
3. Differentiate between :
   (a) Reactants and products
   (b) Chemical reaction and chemical equation
   (c) A balanced and a skeletal chemical equation.
4. Write word equations for the following skeletal equations :
   (a) $KClO_3 \rightarrow KCl + O_2$
   (b) $Zn + HCl \rightarrow ZnCl_2 + H_2$
   (c) $FeCl_2 + Cl_2 \rightarrow FeCl_3$
   (d) $CO + O_2 \rightarrow CO_2$
   (e) $Ca + O_2 \rightarrow CaO$
   (f) $Na + O_2 \rightarrow Na_2O$
   (g) $NaOH + H_2SO_4 \rightarrow Na_2SO_4 + H_2O$
   (h) $AgBr \rightarrow Ag + Br_2$
   (i) $KNO_3 \rightarrow KNO_2 + O_2$
5. Balance the following chemical equations :
   (a) $FeS + 2HCl \rightarrow FeCl_2 + H_2S$
   (b) $Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$
   (c) $2H_2 + O_2 \rightarrow 2H_2O$
   (d) $Na_2O + H_2O \rightarrow 2NaOH$
6. What information do you get from the equation
   $$H_2 + Cl_2 \rightarrow 2HCl \ ?$$
7. Write your observations for the following chemical reactions and name the products formed :
   (a) When sugar is heated.
   (b) When manganese dioxide is added to potassium chlorate and heated.
   (c) When dilute acetic acid is poured on baking soda.
   (d) When an aqueous solution of sodium chloride is mixed with an aqueous solution of silver nitrate.

(e) When ammonium chloride is heated with sodium hydroxide.

(f) When water is added to quick lime.

8. Write symbolic representation for the following word equations and balance them :

(a) Calcium carbonate → Calcium oxide + Carbon dioxide

(b) Carbon + Oxygen → Carbon dioxide

(c) Calcium oxide + Water → Calcium hydroxide

(d) Aluminium + Chlorine → Aluminium chloride

(e) Iron + Sulphur → Iron sulphide

(f) Sodium carbonate + Hydrochloric acid (dil) → Sodium chloride + Water + Carbon dioxide

(g) Barium chloride + Sodium sulphate → Barium sulphate + Sodium chloride

(h) Iron sulphide + Hydrochloric acid (dil) → Iron (II) chloride + Hydrogen sulphide

(i) Calcium + Water → Calcium hydroxide

OBJECTIVE TYPE QUESTIONS

1. Fill in the blanks :

(a) The substances which undergo chemical change are called ....

(b) The substances formed as a result of a chemical reaction are called ....

(c) During a chemical reaction, transfer of .... takes place.

(d) The basic condition necessary for a chemical reaction is ....

(e) In some chemical reactions, an insoluble .... is formed when two solutions are mixed.

2. Write **'true'** or **'false'** for the following statements:

(a) No new substance is formed during a chemical reaction. ....

(b) Hydrogen sulphide has rotten egg smell. ....

(c) When potassium iodide solution is added to lead acetate solution, a red precipitate is formed. ....

(d) A black residue is formed when sugar is heated. ....

(e) When iron and sulphur are heated together a grey mass is formed which is attracted by a magnet. ....

MULTIPLE CHOICE QUESTIONS

1. A chemical equation is a statement that describes a chemical change in terms of

(a) Symbols and formulae (b) Energy

(c) Number of atoms (d) Colours

2. Balancing a chemical equation is based on

(a) Law of conservation of mass

(b) Mass of reactants and products

(c) Symbols and formulae

(d) None of the above

3. Copper carbonate when heated, turns :

(a) Blue (b) Green

(c) Black (d) Yellow

4. When lead acetate solution is added to potassium iodide solution, a precipitate is formed which is

(a) Red (b) Yellow

(c) White (d) Black

5. This gas has a rotten egg smell

(a) Ammonia (b) Hydrogen

(c) Hydrogen sulphide (d) Oxygen

6. When sodium carbonate reacts with dilute hydrochloric acid, the gas evolved is

(a) Carbon dioxide (b) Nitrogen

(c) Oxygen (d) Hydrogen

Project

Invisible writing

- Take some pure sodium hydrogen carbonate (baking soda). Make a thick paste using water in a container. Insert an ear bud in the paste and write your name on a plane sheet of paper. Do you manage to read your name written on the paper ? **No.** Now expose the paper with name written, to sunlight for a few minutes and watch. You will be able to read your name now. Discuss it with your teacher.

Metals and Non-metals

6

Theme : In day- to- day life many elements are commonly found such as iron, aluminium, zinc, lead, chlorine, carbon, sulphur, etc. and their compounds. The elements have been classified in two classes, namely metals and non-metals. Children will learn the classification of elements as metals and non-metals on the basis of their properties.

In this chapter you will learn :

Metals, non-metals

- *Properties*
- *Distinguish between metals and non-metals with the general properties (lustre, conduction of electricity, heat, malleability, ductility, sonority, melting point, boiling point, density, strength)*
- *Classification of elements as metals & non metals*
- *Corrosion of iron (rusting); ways to prevent rusting (oiling, painting, chrome plating, galvanization, tinning) (avoiding contact with air and water vapour)*
- *Uses of certain metals (iron, gold, copper, aluminium, zinc, lead, magnesium)*
- *Metalloids: elements that show the properties of both metals and non-metals – e.g. silicon, germanium, tungsten, antimony); uses.*

LEARNING OUTCOMES

The children will be able to :

- differentiate between metals and non-metals on the basis of their physical properties such as lustre, conduction of electricity and heat, malleability, ductility, sonority, melting point, boiling point, density, strength;
- describe common uses of some of the metals and non-metals;
- describe the cause of corrosion of iron and other metals;
- list different ways of preventing corrosion of metallic articles used in daily life;
- list some properties and uses of metalloids.

INTRODUCTION

There are millions of substances in this world, but they are all made up of a limited number of basic substances called **elements**. You have already studied about elements as pure substances which are made up of one kind of atoms only. These elements can be represented by symbols and formulae.

For convenience of study, these elements are divided into two broad classes : **metals and non-metals**. This division of elements is based on the fact that there are certain properties which are found only in metals and certain other properties found only in non-metals.

But there are also some elements that show the properties of both metals and non-metals. They are known as **metalloids**. Some common metalloids are boron, silicon, arsenic and antimony. The **noble (inert) gases** form the fourth category of elements.

Elements

- **Metals** *e.g. :* gold, tin
- **Non-metals** *e.g. :* oxygen, sulphur
- **Metalloids** *e.g. :* boron, silicon
- **Inert gases** *e.g. :* helium, neon

METALS

Most of the elements known to us are metals.

For example : Gold, silver, platinum, aluminium, iron, zinc, tin, nickel, calcium, magnesium, etc.

The knowledge of metals is very old to mankind. Copper was perhaps the first metal to be used by man for making utensils, weapons and other objects. Most metals have a significant role in our daily life. They constitute the mineral wealth of a country.

OCCURRENCE OF METALS

Metals occur in nature in both free and combined states.

Gold and platinum are exclusively found in free state because they are not reactive. Copper, silver and mercury are also found in free state to some extent due to their low reactivity.

But most metals occur in a combined state since they are very reactive.

Sea water is also a source of metals such as sodium, potassium, magnesium and calcium in the form of their salts.

Table 6.1 : Shows the relative abundance of metals in earth's crust

Metal	*Percentage*	*Metal*	*Percentage*
Aluminium	8%	Sodium	2·5%
Iron	6%	Potassium	1·5%
Calcium	5%	Other metals	2%
Magnesium	3%		

From the above table it is clear that aluminium is the most abundant metal.

Activity 1

To show that metals are malleable while non-metals are brittle.

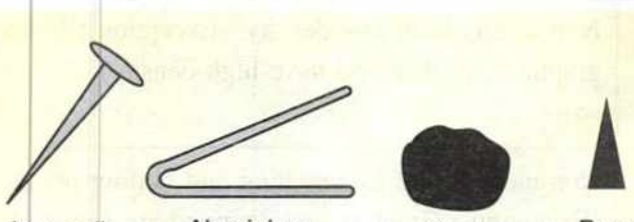
Take a small iron nail, an aluminium wire, a coal piece and a pencil lead.

Now hammer each of them separately for sometime.

What do you observe ?

You will notice that iron nail and aluminium wire have slightly become flat, their shapes have changed, while coal piece and pencil lead are broken into pieces.

This proves that metals are malleable while non-metals are brittle.



Changed shapes of iron nail and aluminium wire

Coal and pencil lead broken into pieces

Note : Have you noticed the silvery foil coated over sweets ? What is it made of ? Is it really silver ? Yes, it is a very thin sheet of silver as silver is highly malleable.

NON-METALS

Non-metals are very less in number in comparison to metals. Excluding inert gases, there are only eleven non-metals known to us. They are hydrogen, oxygen, nitrogen, carbon, fluorine, chlorine, bromine, iodine, sulphur, phosphorus and astatine.

Non-metals too play a vital role in everyday life. We need oxygen to breathe and for respiration. Plants need carbon dioxide for photosynthesis. Proteins, carbohydrates and fats, which are important food nutrients, are made mostly of non-metals carbon, hydrogen, oxygen and nitrogen.

OCCURRENCE OF NON-METALS

- Non-metals occur in earth's crust in a combined state as oxides, carbonates, sulphates, nitrates, etc.
- In atmosphere, non-metals occur both in free state as oxygen and nitrogen and in combined state as carbon dioxide and water.
- The most abundant non-metal in earth's crust is oxygen.
- Nitrogen forms 78% of air in free state and is the most abundant element of air. It also forms an important food nutrient, protein.

COMPARISON OF GENERAL PROPERTIES OF METALS AND NON-METALS TO DISTINGUISH THEM

To recognise metals and non-metals, it is necessary to study and compare their genreal properties.

Table 6.2 : The following table shows the general properties of metals and non-metals

Properties	*Metals*	*Non-metals*
Physical state	All metals are solids at room temperature. (*Exception :* Mercury is a liquid while gallium changes into liquid above 30°C, *i.e.* even when placed on palm of the hand).	Non-metals exist in all the three states. Oxygen, nitrogen, chlorine, etc. are gases. Bromine is a liquid while phosphorus, sulphur, and carbon are solids.
Lustre	Metals are lustrous, *i.e.* they shine and can be polished (Exception : Lead is a dull metal).	Non-metals are non-lustrous, *i.e.* they have dull surfaces (except graphite and iodine which are lustrous solids.)
Hardness	Most of the metals are hard. (Exception : Sodium and potassium are soft metals and can be cut with a knife).	Solid non-metals sulphur and phosphorus are soft, (whereas carbon in the form of diamond is the naturally occuring hardest substance.)

Density	Metals have high density (sodium and potassium have low density, they are lighter than water).	Non-metals have low density. (Exception : Iodine, graphite and diamond have high density).
Melting and boiling points	Metals have high melting and boiling points. (Sodium, potassium, gallium, caesium and mercury have low melting and boiling points).	Non-metals have low melting and boiling points. (Exception : Graphite and diamond are forms of carbon that have high melting points).
Ductility	Metals are ductile, *i.e.* they can be drawn into wires. Gold, silver, copper, aluminium and tungsten are the most ductile metals.	Non-metals are not ductile. (*Exception :* Carbon fibre)
Malleability	Metals are mostly malleable, *i.e.* they can be beaten into thin sheets without breaking. Gold is the most malleable metal. (Zinc is brittle, on beating it breaks into pieces).	Non-metals are brittle. They are not malleable.
Thermal and electrical conductivity	Metals are good conductors of heat and electricity. Silver and copper are excellent conductors.	Non-metals are bad conductors of heat and electricity. (Carbon in the form of graphite and gas carbon conducts electricity).
Sonority	Metals are sonorous, *i.e.* they produce a specific sound when struck with a hard object.	Non-metals are non-sonorous. They do not produce any sound when struck.
Tensile strength	Metals have high tensile strength, *i.e.* they can bear a lot of strain. (*except* zinc).	Non-metals have low tensile strength. (*except* carbon fibre).
Alloy formation	Metals combine with other metals to form useful homogeneous mixtures called alloys.	Non-metals do not form alloys. (Carbon forms an alloy with iron called steel).
Solubility	Metals are insoluble in water and other organic solvents.	Non-metals can be soluble or insoluble in water or other solvents.

Activity 2

To show that metals are lustrous.

Take small pieces of copper and sulphur powder in two separate watch glasses.

Observe them carefully.

You will notice that copper shines but sulphur does not shine. That means copper is **lustrous** but sulphur is **not lustrous**. Copper is a metal and sulphur is a non-metal.

Activity 3

To compare the sonority of metals and non-metals.

Take a copper spoon and a coal piece.

Drop them one by one on the floor.

You will hear a specific sound when copper spoon is dropped but no sound will be heard on dropping a coal piece.

Hence, copper is sonorous and coal is not.

Activity 4

To show that metals are hard.

Take small pieces of iron, copper, aluminium and magnesium. Try to cut these metals with a sharp knife.

What do you observe?

You will find that metals are hard and cannot be cut with a knife.

Activity 5

To show that metals are good conductors of electricity.

Take a battery, a bulb, a switch, aluminium wires, an iron nail and a piece of coal.

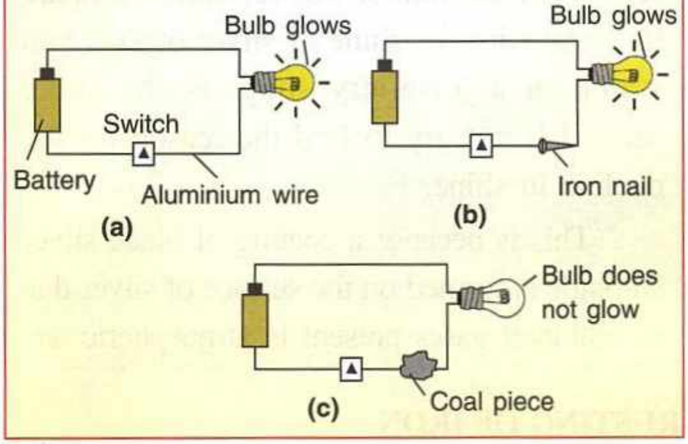
Make electric circuits as shown in Fig. (a), (b) and (c).

In the first case (a), battery, bulb and switch are connected with the aluminium wires. When the switch is on, the bulb glows. This indicates that aluminium, a metal, is a good conductor of electricity.

In the second case (b), an iron nail is connected to the wire and placed in the circuit. When the switch is on the bulb glows indicating that iron being a metal is a good conductor of electricity.

In the third case (c), a coal piece is placed in the circuit connected to the wires. You will observe that the bulb does not glow when the switch is on indicating that no current is passing through the circuit. This is because coal, a form of non-metal carbon, is a bad conductor of electricity.

Hence, it is proved that metals are good conductors while non-metals are bad conductors of electricity.



CORROSION IN METALS

Most of the metals when exposed to the atmosphere react with moist air and get corroded due to which their properties are destroyed and their use as metals diminishes.

This happens because metals are reactive and due to their reaction with moist air, they change into more stable compounds.

Iron gets easily corroded and forms a reddish brown layer known as rust ($Fe_2O_3 \cdot xH_2O$) on its surface. It slowly destroys iron.

Aluminium also reacts with air to produce its oxide (Al_2O_3) because it has a strong affinity for oxygen.

Copper forms a green deposit of basic copper carbonate when exposed to moist air. If you have copper articles at home, you can notice the green deposit on their surfaces after some days.

When metal lead gets exposed to moist air, it forms a white deposit on its surface which is basic lead carbonate.

> Look at a silver object at your home. It could be the silver trophy you have won in a school competition or a silver coin. Compare its shine with the shine of silver objects you watch in a jewellery shop. Is the shine same ? If not, try to find the reason for the decline in shine.
>
> This is because a coating of black silver sulphide is formed on the surface of silver due to pollutant gases present in atmospheric air.

RUSTING OF IRON

Rusting is a slow oxidation process in which iron slowly reacts with oxygen of the 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 reddish brown coating over iron. It is flaky and easily crumbles off from the surface of the metal, thus exposing the free iron surface for further rusting.

Fig. 6.1

$$\text{Iron} + \text{Oxygen} \xrightarrow[\text{slow process}]{\text{Atmospheric moisture}} \text{Hydrated ferric oxide (rust)}$$

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

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

Activity 6

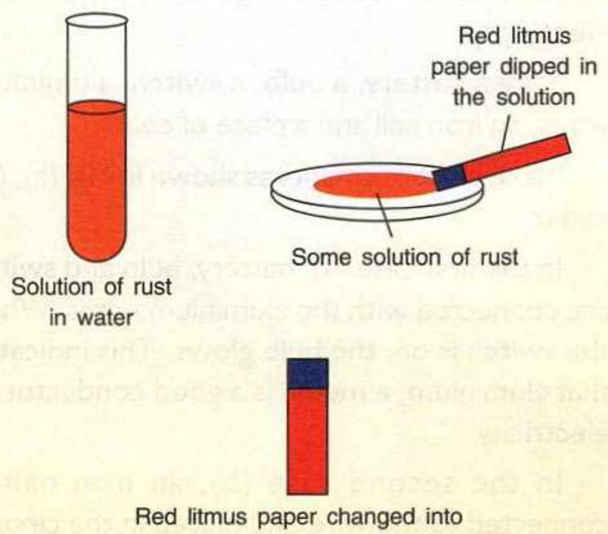
To show the basic nature of rust.

Take some rust from the surface of a rusted iron nail. Crush it into powder. Take this powder in a test tube, add some water and shake the test tube properly.

Now introduce blue litmus paper and red litmus paper in the mixture of water and rust, one by one.

You will observe that red litmus turns into blue.

This proves that rust ($Fe_2O_3 \cdot xH_2O$) is basic in nature.



* *x may vary in number*

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 in the air increases the rate of rusting of iron.

Activity 7

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 expels 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.

After a few days, it is observed that only 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.

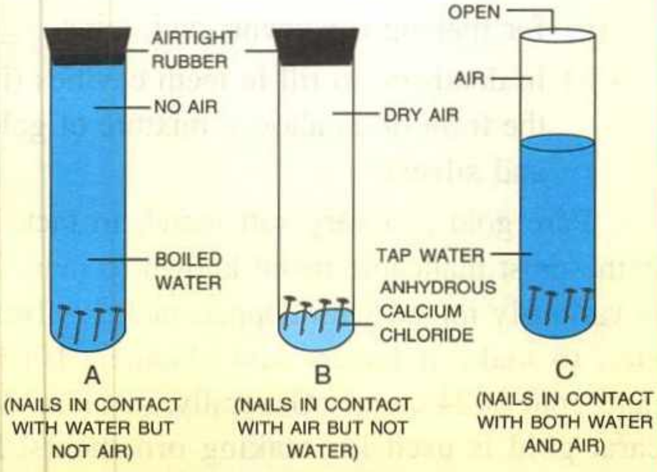


Fig. 6.2

PREVENTION FROM RUSTING

Iron is one the most useful metals to 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 the wastage of metal. Thus, the prevention of rusting of iron is essential.

Iron can be protected from rusting if the surface of iron is prevented from coming in contact with moist air. This is done by the following methods :

By painting

1. (a) ***Painting with red lead*** **:** This coating is put on the heavy iron parts of vehicles, machinery and materials such as grills, gates, etc. used in buildings.

   (b) ***Oil paint*** **:** This paint is applied on doors and windows made up of iron which already have a base coating of red lead.

   (c) ***Enamel coating*** : Enamel is a mixture of iron or steel with silicates. It is used to coat cooking appliances, refrigerators, *etc*.

   (d) ***Coal tar*** **:** It is used for coating the lower parts of ships and bridges.

   (e) ***Plastic coating*** **:** It is used to cover steel pipelines, hangers, stands, etc.

2. ***Grease or oil*** **:** Metallic tools and machine parts are protected from rusting by applying a thin film of grease or oil that also lubricates them.

3. Metallic coating

(i) *Galvanization* : In this process, iron articles 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 after galvanization are known as G.I. (galvanized iron) pipes.

> Galvanized steel is not used for food containers, since acids present in food react with zinc to form poisonous compounds.

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

(iii) *Aluminium painting* : This process protects iron bridges, iron furniture, car bodies, telephone poles, *etc*. from rusting.

(iv) *Alloy formation* : By this process, iron is fused with nickel, chromium, carbon, *etc*. to form stainless steel, which is a lustrous, corrosion-resistant substance. It is used for making cutlery, surgical instruments, *etc*.

(v) *Electroplating* : Iron articles are electroplated with copper, chromium, tin, nickel, *etc*. for decorative purposes in jewellery, and for the durability of cutlery, cooking gas stoves, motor parts, etc. But it is a costly process.

> The iron pillar near Qutub Minar is notable for its rust-resistant composition. It is made up of iron mixed with high percentage of phosphorous which has prevented it from corrosion.
>
> It has not rusted for the last eight hundred years. It highlights the achievements of ancient India in chemical engineering.

USES OF SOME METALS

Metals are very useful to us. They are used on the basis of their properties. A brief description of some important metals and their uses are given below.

1. **Gold (Au) :** Gold is a shiny yellow metal. It is considered as a very precious substance for its beauty, scarcity and chemical stability. Due to its chemical stability, it does not react easily with other substances. Therefore, gold is a durable substance. Gold is highly malleable and resistant to corrosion, and it is also a very good conductor of electricity. Therefore, it is used :

   (i) in the manufacture of electronic devices, like computers, telephones, home appliances, *etc*.

   (ii) for making ornaments and coins.

   (iii) in dentistry, to fill in teeth cavities (in the form of an alloy, a mixture of gold and silver).

Pure gold is a very soft metal. In fact, it is the most malleable metal known to man. It is variously mixed with copper, nickel, silver, *etc*., to make it harder and cheaper. 100% pure gold is 24 carat*. Generally, in India, 22 carat gold is used for making ornaments. It

** CARAT is the measure of the purity of precious substances.*

means that 22 parts of pure gold is alloyed with 2 parts of either copper or silver.

2. **Silver (Ag) :** Silver is a greyish white, lustrous metal. It is one of the highly malleable and ductile metals and also the best known conductor of electricity. Its chemical reactivity is more than that of gold. It is used :
   (i) for making jewellery.
   (ii) for filling in teeth cavities (in the form of a gold-mixed alloy).
   (iii) as a purifier of water.
   (iv) as an electrode metal, and in electroplating.
   (v) in photography in the form of silver bromide and silver nitrate.
   (vi) for making thin sheets to decorate sweets. It increases the immunity of the body.

Silver is not used for making electric wires, because it is a costly metal.

3. **Iron (Fe) :** Iron is the most useful metal of all. It is known to man since ancient times. It is a reactive metal and is found in combined states. Iron is used :
   (i) to make pipes, tanks, cylinders, agricultural tools, nails, wire meshes, railings, furniture, *etc*.
   (ii) to make bridges, ships, machine parts, buildings, *etc*. in the form of *steel,* an alloy containing carbon.
   (iii) in the construction of power transmission towers.
   (iv) for making utensils, cutlery and surgical instruments from its alloy stainless steel, which is steel with chromium or nickel.

4. **Copper (Cu) :** Copper is a reddish brown metal. It is highly ductile and a very good conductor of heat and electricity. It finds applications in :
   (i) making electric wires, coils and cables, utensils, and even semi-precious ornaments.
   (ii) making coins and statues in the form of its alloys called bronze and brass.
   (iii) electronic devices.

Activity : • Consider some metals such as iron, copper, aluminium, lead, etc.

• Which of the above metals are available in the form of wires ?

Do You Know ?

The ability of metals to be drawn into thin wires is called ductility. Gold is the most ductile metal. You will be surprised to know that a wire of about 2 km length can be drawn from one gram of gold.

Activity 8

To show that metals are good conductors of heat.

Procedure : On a cold day, touch a metal rod and a wooden rod. Metal rod appears to be much more colder than the wooden rod though both are at the same temperature. This is due to the fact that metals are good conductors of heat and conduct heat from our body quickly, while wood being bad conductor of heat, does not conduct heat so quickly.

5. **Aluminium (Al) :** Aluminium is the most abundant metal found in the earth's crust, and the second most useful metal after iron. It is silvery white in colour. It is malleable and ductile, and it is a very good conductor of heat and electricity.

Therefore, it is used :

(i) as a substitute for copper to make electric cables and wires, because it is cheaper.

(ii) to make utensils, cans for drinks, furniture, window frames, *etc*.

(iii) for packaging foodstuffs and wrappers of medicines in the form of aluminium foil.

(iv) as a paint to prevent rust in the form of a powder foil on telephone poles.

> Aluminium is a light and shiny metal but it is a very soft metal. To make it stronger, it is mixed with other metals and then it is used to make alloys such as duralumin (Al, Cu, Mg, Mn) which is used to make the bodies of aircrafts, automobiles, machine parts, tools, etc.

6. Zinc (Zn) : Zinc is a bluish-white metal. It is neither malleable nor ductile; rather it is brittle. It is used :

(i) as an electrode metal.

(ii) for making alloys like brass and bronze.

(iii) to make dry cells.

(iv) to coat iron sheets through the process of *galvanization,* which protects iron from rusting.

7. Mercury (Hg) : Mercury is a silvery white, liquid metal. It does not moisten glass, and it expands or contracts even on little heating or cooling. Therefore, it is used in :

(i) thermometers as thermometric liquid.

(ii) barometers and other scientific apparatus.

(iii) dentistry, for filling up cavities in teeth in the form of alloys known as *silver amalgam* and *gold amalgam*. (An alloy of metal with mercury is called amalgam).

8. Tin (Sn) : It is a silvery white metal. It is highly malleable but not ductile. It does not rust. It is used :

(i) for making cans to keep foodstuffs, especially grains.

(ii) for tinning of food cans and utensils made of other metals.

(iii) Tin coated iron sheets are used to make boxes and big containers.

9. Magnesium (Mg) : It is available in the form of ribbons. It is used :

(i) in fireworks, because it burns with a dazzling light.

(ii) for making alloys called magnalium and duralumin.

Do You Know ?

The various colours we see in fireworks are mainly produced by compounds of metals like magnesium, strontium and barium. Magnesium produces a brilliant white light, strontium compounds produce crimson and barium compounds produce green colour

> ***Note :*** Magnesium is very vital for life. The green pigment chlorophyll, present in the plants contains magnesium compounds which help to capture the solar energy for photosynthesis.

Fig. 6.3 : Articles made of metals

10. **Lead (Pb) :** Lead is a very heavy, silvery grey metal. It is used for :
   (i) making storage batteries.
   (ii) making sanitary pipes, tips of bullets, tin roofs, and fusible alloy (solder — a mixture of 50% tin and 50% lead).

Do You Know ?

Gold and platinum are known as noble metals because they are chemically inert. They are unaffected by air, water, acid or alkali. They are found in free state and they retain metallic lustre for a long time.

11. **Platinum (Pt) :** Platinum is lustrous and a very precious metal. Like gold, platinum too does not react easily with other substances. Platinum is also an excellent catalyst. It is used :
   (i) for making electrodes and electrolytic cells.
   (ii) for making expensive ornaments and watches.
   (iii) as a catalyst in hydrogenation of unsaturated oil to prepare vanaspati *ghee*, in the manufacture of acids, *etc*.

12. **Tungsten (W) :** It is a shiny grey metal, occurring in solid state at room temperature. It can withstand high temperature because it has highest melting point among metals. It is highly resistant to acids. It is used in :
   - making electrodes.
   - heating elements.
   - electric bulbs as filaments and cathode ray tubes.
   - making heavy metal alloys used to make cutting tools.
   - mining industries, etc.

Activity : Identify the metals from which following articles are made :

(i) Nail	(ii) Electric wire
(iii) Ornaments	(iv) Food cans
(v) Chocolate wrapper	(vi) Sanitary pipes

USES OF SOME NON-METALS

The non-metals important to us are oxygen, nitrogen, hydrogen, carbon, iodine, chlorine, etc. They give us many useful products. Some of the non-metals and their uses are discussed below :

1. **Oxygen (O_2) :**
   (i) Human beings and animals use oxygen for breathing and respiration.
   (ii) In hospitals, oxygen cylinders are available for serious patients.
   (iii) It has many industrial uses.
   (iv) It is important for combustion.

2. Nitrogen (N_2) :

(i) It is used in food canning such as in packaging of potato chips and in electrical bulbs.

(ii) It is used for producing compounds which are used as fertilizers like urea.

3. Carbon (C) : Carbon is one of the most important and widely distributed elements. It mainly occurs as coal, graphite and diamond in *free state*, while in a *combined state* it is present in all living organisms as food nutrients like carbohydrates, proteins, vitamins, *etc*. In the atmosphere, it is present as carbon dioxide.

(a) Coal : Coal is mostly used as a fuel in homes and industries. Many trains still run on coal. It is used in the pharmaceutical and textile sectors as a source of synthetic chemicals and textiles.

(b) Graphite : It is a crystalline, black, lustrous substance. It is soft and slippery, and marks paper black. Graphite is used :

(i) in the leads of pencils.

(ii) as electrode material in electrolytic cells because it is a good conductor of electricity.

(iii) as a solid lubricant (*e.g.* in grease) for machine parts.

(iv) for making heat resistant crucibles for keeping molten metals because of its high melting point and good conductivity of heat.

(v) in nuclear reactors to control the speed of nuclear reactions.

(c) Diamond : It is one of the crystalline forms of carbon. It shines brilliantly and is the hardest naturally occurring substance known to us.

(i) Pure diamond is used as a precious gem in jewellery.

(ii) Impure diamond is used for cutting glass and grinding hard substances, and in drilling heads.

(d) Charcoal : (i) It is used as a decolourising agent in sugar industry.

(ii) It is used to purify water as it removes the colour and smell if present in water.

4. Iodine (I_2) : Iodine is a dark grey, crystalline solid, with a metallic lustre. It is insoluble in water but soluble in alcohol and potassium iodide solutions. It is used :

(i) in a very small quantity in the form of iodized salt for the healthy growth of the human body. Iodine deficiency causes goitre.

(ii) in photographic films in the form of potassium iodide.

(iii) to make *tincture of iodine* and *iodex*, which are used as an antiseptic and pain reliever (analgesic), respectively. Tincture of iodine is solution of iodine in alcohol.

5. Chlorine (Cl_2) : It is a greenish yellow gas with a pungent, suffocating smell. It is fairly soluble in water, forming a pale yellow solution, called chlorine water. Chlorine is used :

(i) as a bleaching agent for rough and hard fibres like jute and cotton.

(ii) as a disinfectant for sterilizing both drinking water and swimming pool water.

(iii) in the manufacture of chemicals like D.D.T., B.H.C. and bleaching powder, which are used as insecticide, pesticide and disinfectant, respectively.

1. **DDT** — Dichlorodiphenyl trichloro ethane.

2. **BHC** — Benzene hexachloride.

(iv) in the manufacture of mineral acids like hydrochloric acid.

6. Hydrogen (H_2) :

(i) It is used as a reducing agent.

(ii) It is used for converting vegetable oils into ghee (hydrogenation of oils).

(iii) It is used to make ammonia which is used to prepare fertilizers.

7. Sulphur (S_8) :

(i) It is used as fungicide and insecticide.

(ii) It is used in the manufacture of sulphuric acid.

(iii) It is widely used in the manufacture of sulphur drugs used as antibiotics.

(iv) It is used in match box industry for making striking heads of the match sticks (Phosphorous sulphide).

(v) It is used to vulcanize rubber (a process of converting rubber latex to hard rubber).

METALLOIDS

Metalloids are the elements which show some properties of metals and some properties of non-metals. They all are solids. They are silicon, boron, arsenic, antimony, germanium, tellurium and polonium. Some of them are discussed below :

1. Silicon (Si) : Silicon is one of the most useful metalloids available to mankind. It does not occur in free state in nature. In combined state as **sand**, it is the second most abundant element of the earth's crust (next only to oxygen). Sand is chemically known as silicon dioxide (SiO_2), also called as silica.

- Highly pure silicon is used in making microchips for computers, transistors, solar cells, rectifiers and other solid state devices that are used extensively in the electronic and present age space industries.
- It is used in the manufacture of a waterproof material called "silicone". Silicone is used to make bags, umbrellas, raincoats, etc.
- It is used to prepare a substance called silicon carbide which is the hardest compound prepared by man. It is used in various kinds of grinding tools.
- In the form of sand, it is used to prepare concrete, bricks and cement. Sand is the principal ingredient of glass.
- In the form of silcates, silicon is used in enamel, pottery, etc. and for preserving eggs.
- It is also used to make electrical steel (silicon steel), an alloy of iron in which magnetic properties are retained.

2. Germanium (Ge) : It is a hard, lustrous, greyish white metalloid. It is chemically similar to tin and silicon.

- Germanium is used as a semiconductor.
- It is used as a transistor in many electronic appliances when mixed with arsenic, gallium, antimony, etc.

- Germanium is also used to form alloys and as a phosphor in fluorescent lamps.

3. Antimony (Sb) : It is a lustrous grey metalloid.

- Antimony is used in electric industry to make semiconductor devices.
- It is alloyed with lead to improve its hardness and strength and is used in batteries.
- It is also used in printing presses as type metal.
- Antimony compounds are used to make paints, enamels, glass pottery, etc.

INERT GASES

They are chemically inert, non-metallic, gaseous elements. They are found only in traces in air. They are six in number : Helium (He), Neon (Ne), Argon (Ar), Krypton (Kr), Xenon (Xe) and Radon (Rn). Uses of these elements are given below :

Uses :

(i) **Helium (He) :** It is the second lightest element known to man. It is used for filling up weather observation balloons.

(ii) **Argon (Ar) :** It is used for filling into electric bulbs so as to provide an inert atmosphere to the heating filament. It improves the quality and life of the bulb (but commonly nitrogen is used because of its easy availability).

(iii) **Neon (Ne) :** It is used in making advertising signboards and tubelights. It emits a coloured light when a high voltage current is passed through it.

(iv) **Radon (Rn) :** It is the only radioactive inert gas used for cancer treatment.

(v) **Xenon (Xe) and Krypton (Kr) :** They find application in photography.

RECAPITULATION

- Elements are broadly classified into metals and non-metals.
- Metals are lustrous, hard, mostly solids, have high density, high melting point, high boiling point, malleable, ductile, good thermal and electrical conductors, have high tensile strength and are sonorous while non-metals are not.
- Metals and non-metals are very important and useful to mankind.
- The properties of reactive metals are degraded due to exposure to moist air. The most easily corroded metal is iron due to the formation of rust ($Fe_2O_3 \cdot xH_2O$).
- Rusting of iron can be prevented by different methods.
- Metalloids are the elements showing some properties of metals and some properties of non-metals.
- Inert gases are non-reactive non-metals like helium, neon, argon, etc.

EXERCISE

1. Name a metal :
   (*a*) that is the most malleable,
   (*b*) that is brittle,
   (*c*) as precious as gold,
   (*d*) that can be cut with knife,
   (*e*) used in making electric cables,
   (*f*) used as a thermometric liquid,
   (*g*) that is the best conductor of electricity.
2. Name a non-metal that is :
   (*a*) a good conductor of heat and electricity,
   (*b*) hardest naturally occurring substance,
   (*c*) used to kill germs in water,
   (*d*) lustrous,
   (*e*) used for filling into electric bulbs,
   (*f*) used for cancer therapy,
   (*g*) liquid at room temperature.
3. Mention *two* uses of the following metals and non-metals :
   (*a*) Iron (*b*) Aluminium
   (*c*) Gold (*d*) Oxygen
   (*e*) Iodine
4. Give reasons :
   (*a*) Magnesium is used in fireworks.
   (*b*) Aluminium is used in making aircrafts.
   (*c*) Copper is used in making electric cables.
   (*d*) Graphite is used in the leads of pencils.
   (*e*) Impure diamond is used to cut glass.
   (*f*) Gold is mixed with copper and nickel.
   (*g*) Tungsten is used in electric bulbs.
5. Name the metals present in the following alloys:
   (*a*) Brass (*b*) Bronze
   (*c*) Duralumin (*d*) Stainless steel
6. Give *four* differences between metals and non-metals with reference to their :
   (*a*) Melting point and boiling point,
   (*b*) Conductivity of heat and electricity,
   (*c*) Malleability
   (*d*) Solubility in water
7. What are metalloids ?
8. Give *two* uses of :
   (*a*) Silicon (*b*) Antimony
   (*c*) Tungsten (*d*) Germanium

OBJECTIVE TYPE QUESTIONS

1. Fill in the blanks :
   (*a*) The most ductile metal is ....
   (*b*) A metal stored in kerosene oil is ....
   (*c*) Tungsten metal is a good conductor of ....
   (*d*) .... is a soft metal.
   (*e*) .... is the hardest compound known to us.
   (f) A non-metal used to purify water is ....
   (g) A metal that gives dazzling effect to crackers when they explode is ....
   (h) A chemical compound that makes up the striking heads of match sticks is ....
2. Match the following :

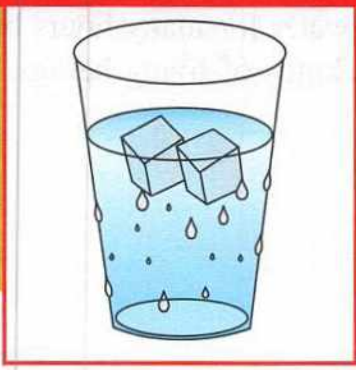
Column A	Column B
(a) Helium	(1) Electric bulb
(b) Neon	(2) Thermometer
(c) Argon	(3) Semiconductor
(d) Germanium	(4) Weather observation balloons
(e) Mercury	(5) Advertising signboards

3. Write ***'true'*** or ***'false'*** for the following statements :
   (a) Silver is used to make electric cables.

(b) Iodine acts as an antiseptic in the form of tincture of iodine.
(c) Sodium can be cut with a knife.
(d) Antimony is a metal.
(e) Sand is an oxide of silicon.

MULTIPLE CHOICE QUESTIONS

1. The noble gas used in advertising signboards is :
   (a) Helium (b) Neon
   (c) Argon (d) Krypton
2. A metal with melting point less than 50°C is :
   (a) Gallium (b) Iron
   (c) Gold (d) Aluminium
3. A metal which is neither ductile nor malleable is :
   (a) Copper (b) Silver
   (c) Zinc (d) Aluminium
4. Rust is a hydrated oxide of iron which is :
   (a) Reddish brown (b) Green
   (c) White (d) Black
5. Aluminium is not used to make :
   (a) Foils (b) Wires
   (c) Fireworks (d) Utensils
6. A metalloid used in the manufacture of microchips used in computer is :
   (a) Antimony (b) Germanium
   (c) Silicon (d) Arsenic
7. A metalloid used to make glass :
   (a) Sulphur (b) Germanium
   (c) Silicon (d) Antimony



Air And Atmosphere

7

Theme : Air is a mixture of some gaseous components which have wide use in daily life. For example, nitrogen is an important constituent of fertilizers and oxygen is essential for our body for sustenance of life. These gases have important physical and chemical properties and uses.

In this chapter you will learn :

- *Air a mixture of gases.*
- *Composition of air and uses of its components.*
- *Oxygen is needed for combustion.*
- *Mass change during burning (burning of magnesium and candle)*
- *Word equations for reactions of metals and non-metals (S, C, P, Na, K, Ca, Mg) with O.*
- *Products formed in acid rain; effects of acid rain.*
- *Air quality*
- *Study the properties of oxygen (physical properties to include colour, odour)*
- *Distinguish between:*
  - *Respiration and combustion,*
  - *Combustion and rusting*

LEARNING OUTCOMES

The children will be able to :

- review that air is a mixture of gases.
- recall the components of air.
- discuss the use of oxygen and nitrogen in different life processes.
- explain from an activity that mass change takes place during combustion.
- express the reaction in the form of word equation.
- describe the preparation of oxygen in the laboratory using potassium chlorate/hydrogen peroxide and manganese dioxide as a calalyst.
- understand the concept of catalyst.

INTRODUCTION

- You know that among food, water and air, the most essential substance for the survival of life is ***air***. A person can live without food for many days, without water for many hours but without air not even five minutes. 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 300 km above its surface.
- Air also occurs in water in a dissolved state which helps aquatic plants and animals to survive.

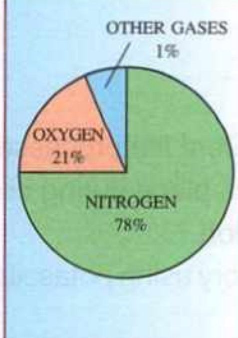
(A.) AIR : A Mixture of Gases

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 small amounts in air.

Apart from these gases, air also contains some other gases, like sulphur dioxide, hydrogen sulphide and nitrogen dioxide. Some impurities like dust particles, smoke and germs are also present in air.

Table 7.1 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.

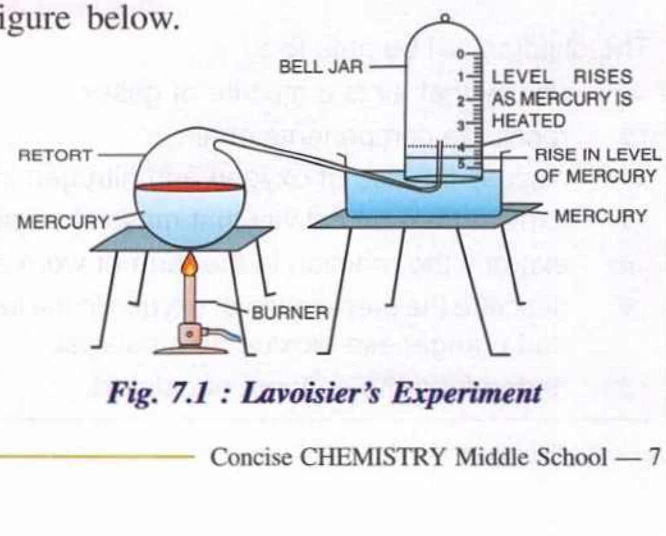


Fig. 7.1 : Lavoisier's Experiment

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 bell jar rose by $\frac{1}{5}$th of the total volume of the bell jar.

The following were his conclusions :

1. $\frac{1}{5}$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 on strongly re-heating the red substance. This gas supported burning better than air and also supported life. Lavoisier named this active air as ***"oxygen"***.

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

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

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

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

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 combustion. The gas was named as **azote** meaning unsuitable for life. Later on Lavoisier named it as ***"nitrogen"***.

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

Activity 1

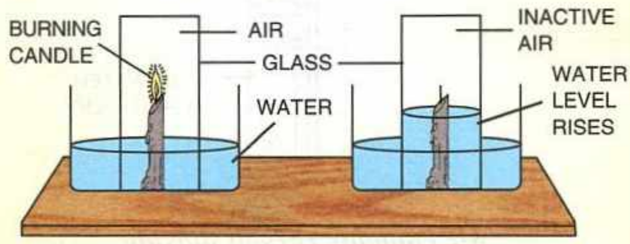
To show that air contains oxygen (an active part) and nitrogen (an inactive part).

Fix a candle in the middle of a shallow container. Fill the container with some water. Cover it with an empty inverted glass jar and mark the level of water inside the jar.

Lift the jar and light the candle, then cover it with the inverted glass jar.

Observe carefully.

Does the candle continue to burn or gets extinguished ? Does the level of water inside remains the same or not ?



Air contains oxygen and nitrogen

You will notice that the candle continues to burn for sometime and then gets extinguished. The water level rises slightly *i.e.*, upto 1/5th part of the jar containing air. This part is **active air** *i.e.* oxygen which helps candle to burn. When it is used up, candle stops burning. This 4/5th part of air still present in the jar is **inactive air** that does not support burning and it is nitrogen.

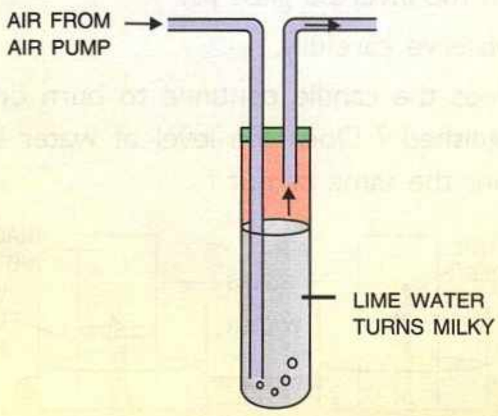
Activity 2

To show that air contains carbon dioxide.

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

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

This shows that *air contains carbon-dioxide*.



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 due to which lime water turns milky.

Lime water + Carbon dioxide → Calcium carbonate + Water

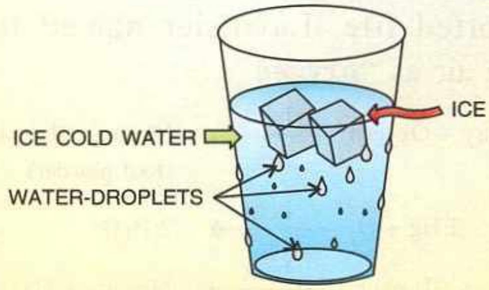
Activity 3

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

This proves that *air contains water vapour.*



Air contains water vapour

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

1. The composition of air is not fixed. It 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. It involves their liquefaction followed by fractional distillation.

6. Air is not represented by any chemical formula as it is a mixture.

THE IMPORTANCE OF THE VARIOUS COMPONENTS OF AIR

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 had not been present in the atmosphere, then even small sparks would have 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 neither combustible nor a supporter of combustion.
4. It is non-poisonous but animals die because of suffocation created by the 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 that are necessary for the growth of plants, animals and human beings.
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. They release huge volumes of gases quickly with lots of energy. *e.g. :* trinitrotoluene (T.N.T.), nitroglycerine, etc. Therefore, a commercial ban has been imposed on the sale of glycerine in open market.

Do You Know ?

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

6. **For flushing food packages :** 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. The packaged potato chips that you purchase from market are filled with nitrogen.

IMPORTANCE OF NITROGEN FOR PLANTS, ANIMALS AND HUMAN BEINGS

Nitrogen is of vital importance to the plants, animals and human beings as it provides a vital nutrient **protein** to all living beings essential for their growth and development. When we breathe, nitrogen is exhaled out as such. We cannot use nitrogen from the air to make protein.

It is the plants which convert nitrogen into protein while human beings and animals get it from plants. But nitrogen also cannot be absorbed directly in free form by the plants. It is first fixed up in the soil as nitrogenous compounds, nitrates and nitrites, and then absorbed by plants in soluble form. This is done by the phenomenon called **nitrogen fixation**.

When plants and animals die, they decay and nitrogen is returned to the soil. In this way, the amount of nitrogen is balanced in soil and the gas can be used again and again by plants.

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.

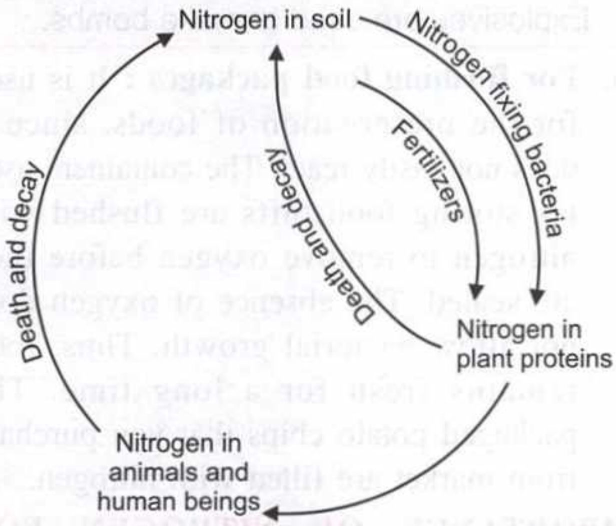


Fig. : 7.2 Nitrogen cycle.

Nitrogen fixation : The phenomenon by which nitrogen is converted into nitrates and nitrites and get fixed in the soil or directly due to some bacterial action is known as nitrogen fixation. Following are the two natural ways of nitrogen fixation.

1. Biological fixation :

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 them into proteins. Some non-leguminous plants like *Ginkgo* can also fix nitrogen.

Fig. 7.3 : Root nodules in leguminous plants

Leguminous plants

1. Root nodules (containing symbiotic bacteria) —convert→ 2. Free nitrogen (in air and soil)
↓ to
3. Soluble nitrates [in soil]
→ 4. Proteins

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 oxides of nitrogen.

$$\underset{\text{(Nitrogen)}}{N_2} + \underset{\text{(Oxygen)}}{O_2} \xrightarrow{\text{Temp.} > 2500°C} \underset{\text{(Nitric oxide)}}{2NO}$$

$$\underset{\text{(Nitric oxide)}}{2NO} + \underset{\text{(Oxygen)}}{O_2} \longrightarrow \underset{\text{(Nitrogen dioxide)}}{2NO_2}$$

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

These acids, so formed, reach the earth along with rainwater, and react with metal carbonates present in the soil to form metal nitrates which are absorbed by the plants from the soil and get converted into proteins.

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

Lightning discharge

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

$$\text{Nitrogen dioxide} \xrightarrow{H_2O\ \text{(air)}} \text{Nitric acid and nitrous acid}$$

$$\text{Soluble nitrate} \xleftarrow[\text{Soil}]{\text{Minerals}} \text{Nitric acid and nitrous acid}$$

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

Oxygen

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

Uses :

1. It supports life on 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 Chapter 7B).

* Respiration is a chemical process in which oxygen in the air is used by all living organisms to oxidise their food and gain energy.
$\underset{\text{(glucose)}}{C_6H_{12}O_6} + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{Energy}$

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

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

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 compounds).

CNG is compressed natural gas. It contains methane gas.

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 human activities.

Uses :

1. It is essential for the process of photosynthesis, by which green plants prepare their food.
2. Carbon dioxide minimizes heat loss by radiation, by reflecting heat back to the earth's surface, particularly at night. Thus, it acts as a green house gas and balances the temperature of the earth.
3. Carbon dioxide dissolved in water helps in the 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.

Water vapour

Water vapour in air is also known as moisture. The amount of moisture present in the air is known as **humidity**. But the percentage proportion of water vapour in air varies. The more is the amount of water vapour present in the air, the higher is the humidity.

Uses **:** 1. It determines the earth's climatic conditions. The presence of water vapour in air causes rain. At low temperatures, water vapour condenses 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.

Water cycle : The change of water from one form to another in nature, which results in continuous circulation of water from earth's surface to the atmosphere and from the atmosphere back to the earth's surface is called water cycle.

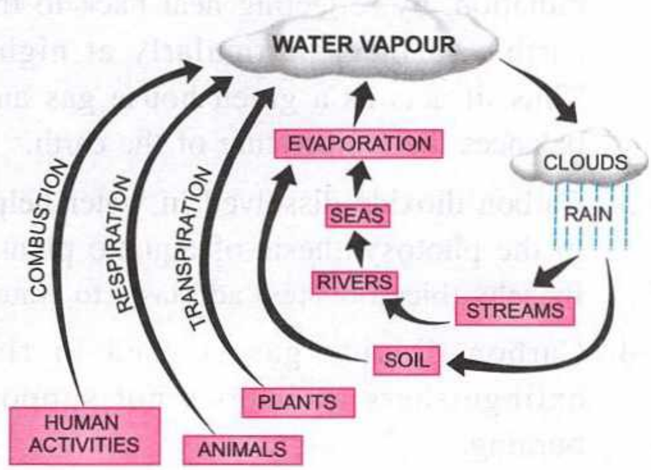


Fig. 7.4 : Water Cycle

Different forms, other than rain, in which water vapour present in air precipitates on the earth are —

Fog : They are the tiny droplets of water formed near the ground when water vapour in air condenses.

Mist : Tiny droplets of water which remain suspended in air are called mist.

Dew : Dew is formed when water vapour condenses on cold objects. They are tiny droplets of water often seen on grass, leaves, flowers, etc. in winter mornings.

Frost : Frozen dew is called frost.

Snow : Water vapour frozen into ice which falls on the ground as light white flakes covering the surface where it falls is called snow.

Hail : They are small, hard balls of ice which fall on the ground just like rain.

Sleet : Rain and snow mixed together which fall on the ground is called sleet.

Inert (noble) gases

About 0·96% of air, by volume, is made up of inert gases. Inert gases are six in number : Helium, Neon, Argon, Krypton, Xenon and Radon. These gases do not react with any substance. Argon is the most abundant inert gas.

Dust particles

These are solid, minute soil particles present in the air. Water vapours condense around dust particles to form clouds and cause rains. An excess of dust particles in the air also causes 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 and diffuse easily in the available space.

AIR QUALITY

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. The harmful substances in air are called *air pollutants*. Air pollution is a major problem created by humans.

Some common pollutants in air are smoke, dust, soot, oxides of carbon, sulphur and nitrogen. Other pollutants are chlorofluorocarbons (CFCs), methane and ammonia (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 (deforestation),
- 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, nuclear explosions, 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 suspended particulate matter (SPM) that cause serious respiratory problems, like *asthma* and *bronchitis*. Smoke makes the atmosphere dense and reduces the visibility leading to many road accidents.

(i) Particles of lead oxide present in the automobile exhaust can cause brain damage in children. Lead compounds formed due to burning of leaded petrol obstruct development of blood cells.

(ii) Particles of dust, cement, ash and carbon particles (soot) in smoke may cause bronchitis, while asbestos fibres can cause a disease called silicosis.

(iii) 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. This gas causes suffocation and death. That is why one should not sleep in a room with all windows and doors closed with a burning coal stove.

2. Oxides of carbon : Due to incomplete combustion of fossil fuels, 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* from which haemoglobin cannot be recovered back by any method. Thus it prevents the blood to carry oxygen for respiration. Breathing in carbon monoxide rich air causes headache, dizziness and might even lead to death.

Carbon dioxide is non-poisonous but excess of it in the atmosphere adds 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 and nitrogen dioxide are produced. These gases are present in variable amounts in the air around big cities and industries. SO_2 and SO_3 are highly poisonous and cause serious respiratory problems. H_2S is highly obnoxious and causes headache. 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.

4. Other pollutants (CFCs) : Pollutants like chlorofluorocarbons (used as 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-violet (UV) rays from the sun reach directly to the earth. The UV rays of the sun cause skin tanning and skin cancer.

> Today, the number of people suffering from cataract and snow blindness has increased because of an increase in the percentage of UV-rays reaching the earth's surface.

Acid rain : Gases like sulphur dioxide, nitrogen dioxide, *etc.* react with the water present in the air to form sulphurous acid, sulphuric acid, nitrous acid and nitric acid respectively. These acids fall on the earth along with rain making it acidic and become a part of the water cycle.

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

Equations for the chemical reactions to form acid rain :

sulphur dioxide + water → sulphurous acid

$SO_2 + H_2O \rightarrow H_2SO_3$

sulphur trioxide + water → sulphuric acid

$SO_3 + H_2O \rightarrow H_2SO_4$

sulphurous acid + oxygen → sulphuric acid

$2H_2SO_3 + O_2 \rightarrow 2H_2SO_4$

nitrogen dioxide + water → nitrous acid + nitric acid

$2NO_2 + H_2O \rightarrow HNO_2 + HNO_3$

nitrogen pentoxide + water → nitric acid

$N_2O_5 + H_2O \rightarrow 2HNO_3$

Acid rain has many harmful effects.

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

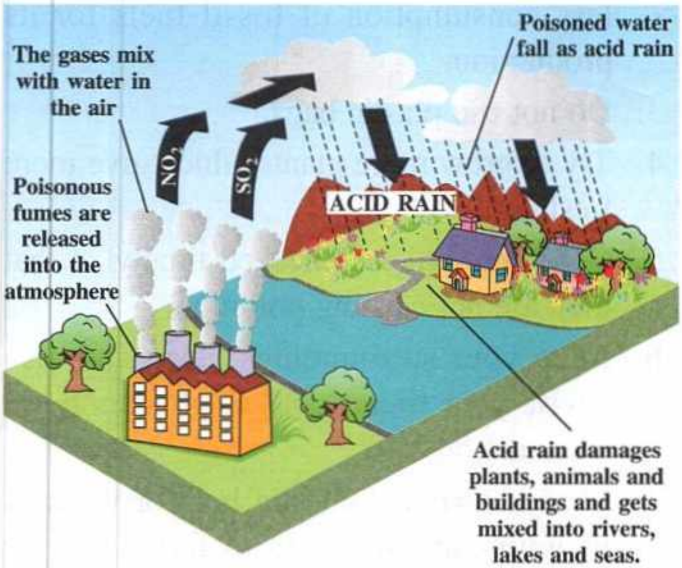


Fig. 7.5 : Acid rain

The Taj Mahal at Agra is said to be suffering from marble cancer. Why ?

Do You Know ?

Rain water has always been slightly acidic as carbon dioxide in the air dissolves in rain water to form carbonic acid. $H_2O + CO_2 \rightarrow H_2CO_3$.

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

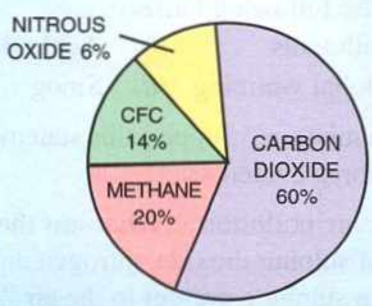


Fig. 7.6 : Contribution of different gases to global warming

You can understand the effect of global warming by comparing the temperatures of the inside of a parked car and the air outside it.

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 air pollutants released into the air to protect life on earth. Air pollution can be prevented by taking the following steps :

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 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 with more solid particles depositing on the filter inside the chimney walls.
3. *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. The installation of catalytic convertors has been recommended in vehicles to reduce air pollution.

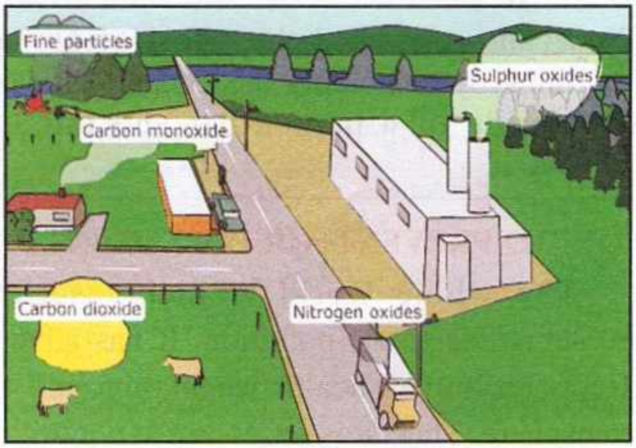


Fig. 7.7 : The common agents of air pollution in most cities.

HOW CAN YOU CONTRIBUTE TO CONTROL AIR POLLUTION ?

1. 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 them.
2. Do not misuse electricity and try to conserve it. This will ultimately lead to less consumption of fossil fuels for its production.
3. Do not use plastic bags.
4. Try to grow more plants which give more fresh air.
5. Get your vehicles checked timely so that they are not causing pollution.
6. Keep your surroundings clean and also advise your friends and neighbours to do the same.
7. Motivate your domestic help or workers in your surroundings to use LPG for cooking instead of other materials which pollute the environment.

Activity 4

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 or travelling by car pool. Discuss in your class the impact of each of these options on the quality of air.

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 is no carbon dioxide in air." Support this statement with relevant facts.

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

3. Define the following terms :

(*a*) Pollutants (*b*) Acid rain
(*c*) Global warming (*d*) Smog

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.

B. Oxygen

Symbol : O; *molecular formula* : O_2; *atomicity* : 2; *valency* : 2.

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 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.

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) About 89% (by mass) of water is oxygen.

(b) The human body has 65% oxygen (by mass).

(c) Plants contain 60% oxygen (by mass).

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

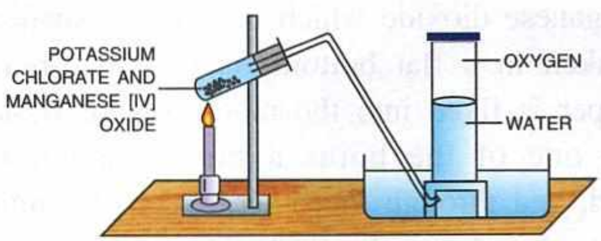
(e) It is also an essential component of carbohydrates, proteins, fats and nucleic acids.

Some common compounds containing oxygen

1. Oxides	:	Silica (sand : SiO_2) Haematite (iron ore : Fe_2O_3) Bauxite (aluminium ore : $Al_2O_3 \cdot 2H_2O$)
2. Carbonate	:	Limestone (calcium carbonate : $CaCO_3$)
3. Sulphate	:	Gypsum (calcium sulphate : $CaSO_4 \cdot 2H_2O$)

Laboratory preparation of oxygen

1. *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 oxygen gas. Potassium chlorate needs heating for quite some time (to a high temperature) before it decomposes.



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

Fig. 7.8(a) : Preparation of oxygen from potassium chlorate, using manganese dioxide as catalyst

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

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

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

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.

2. *From hydrogen peroxide :*

Chemicals required :

(i) A dilute solution of hydrogen peroxide

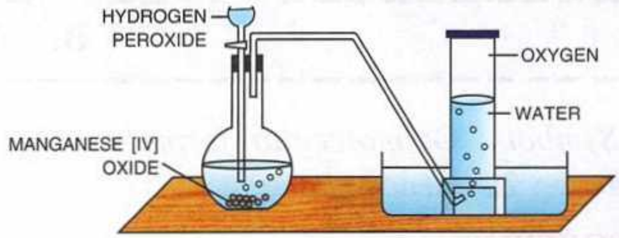
(ii) Manganese dioxide powder, which acts as a catalyst.

Chemical equation for the reaction :

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

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

Procedure : A small quantity of manganese dioxide which is a black powder, is taken in a flat bottom flask. A two-bore stopper is fixed into the mouth of the flask. Into one of the bores a thistle funnel is fitted, and through the other, a delivery 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 as shown in Fig. 7.8(a).



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

Fig. 7.8(b) : Preparation of oxygen from hydrogen peroxide, using manganese dioxide as catalyst

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 (0·7% of only). Therefore, it can be collected over water without fear of excessive dissolution.
2. Oxygen is slightly heavier than air, so it cannot be collected over air.

Why hydrogen peroxide is preferred to potassium chlorate for the preparation of oxygen in the laboratory ?

In the laboratory, oxygen can be prepared by heating potassium chlorate with manganese dioxide but hydrogen peroxide is preferred for the following reasons :

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, also called oxygenated water.

To prepare oxygen gas from potassium chlorate, heating to a high temperature is required which may cause

(i) cracking of glass apparatus being used.

(ii) accidents and burn injuries.

Therefore, the use of potassium chlorate is avoided for safety reasons.

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.
4. It is only slightly soluble in water (0·7%). Oxygen dissolved in water is used by aquatic plants and animals for respiration.
5. It is liquefied into a bluish liquid at –183°C by applying a high pressure. Liquid oxygen has its boiling point at –183°C and its freezing point is –218.4°C.

Activity 5

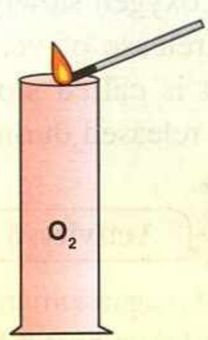
Test for oxygen

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 either 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.
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.



The glowing splinter relights

Litmus : Litmus is a substance used as an indicator to know the nature of a solution. There are two types of litmus papers or solutions – *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 or basic 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.

Chemical properties of oxygen

Oxygen is chemically an active gaseous element. It supports burning, therefore metals, non-metals and a large number of compounds react with oxygen to produce new products which essentially contain oxygen in them along with other elements. The new compounds so formed are called **oxides** and the process is called **oxidation**.

There are two types of oxidation.

1. Fast oxidation – Burning/combustion
2. Slow oxidation – Rusting, respiration

1. Burning : When a substance combines with oxygen with the release of heat and light energy, the process is called burning or combustion.

2. Slow oxidation : When a substance combines with oxygen slowly over a period of time with the release of very less amount of heat energy, it is called slow oxidation. No light energy is released during such oxidation.

Activity 6

Take a piece of magnesium in a crucible with a lid. Weigh it and then heat it by opening the lid after short intervals to let the air enter the crucible. When the whole of the magnesium is burnt, cool the crucible and weigh it again.

What do you observe ?

Does the weight increase or decrease ?

You will find that the weight is increased after heating. This is due to the gain of oxygen from the air to form magnesium oxide. Hence, mass is increased after burning.

Burning of elements in oxygen

For a substance to burn, it needs to be heated to attain a minimum temperature known as ignition temperature. At this temperature, the substance combines chemically with oxygen to produce its respective oxide.

***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.*

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

(A) ***Action with non-metals :*** Non-metals like carbon, sulphur and phosphorus burn in

Table 7.1 : The products and observations of the reactions between non-metals and oxygen.

Non-metal	*Reaction with oxygen*	*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.
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.
3. Phosphorus	(a) Phosphorus + Oxygen $\xrightarrow{\text{heat}}$ Phosphorus + heat pentoxide $4P + 5O_2 \xrightarrow{\text{heat}} 2P_2O_5$ + heat energy	***Flame*** : Phosphorus burns with a dazzling flame, producing dense white fumes of P_2O_5.

Note : When oxygen supply is insufficient, carbon reacts with it to produce carbon monoxide gas.

$$2C + O_2 \xrightarrow{\Delta} 2CO$$
(insufficient)

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 the activity given ahead.

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

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

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

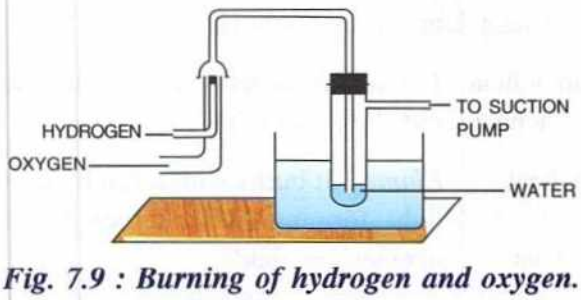


Fig. 7.9 : Burning of hydrogen and oxygen.

Activity 7

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. Insert the moist blue litmus paper in each of them. Blue litmus paper turns red. This shows that oxides of carbon, sulphur and phosphorus are acidic in nature.

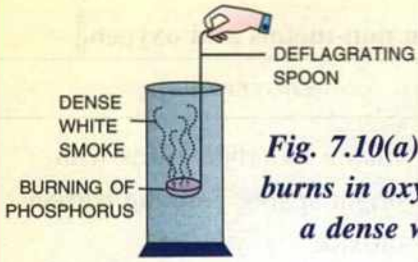
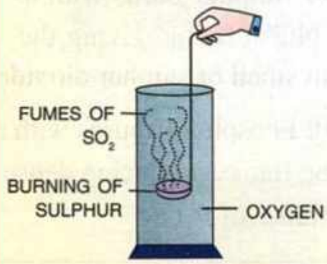


Fig. 7.10(a) : Phosphorus burns in oxygen giving off a dense white smoke



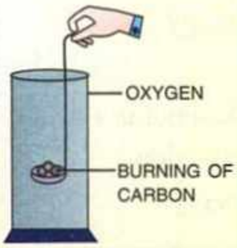


Fig. 7.10(b) : Burning of sulphur in oxygen

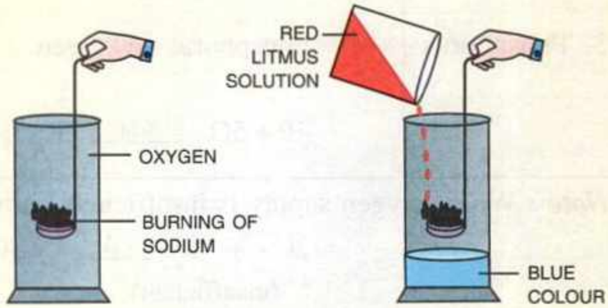
Fig. 7.10(c) : Burning of carbon in oxygen

(B) *Action with 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.

Activity 8

Take a piece of sodium in a deflagrating spoon. It starts burning on its own. Now, lower it into a jar of oxygen. It burns more 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.



Basic nature of metals

Repeat the same activity with metals like calcium and potassium and observe the respective processes. Each time red litmus changes into blue.

This shows that oxides of metals are basic in nature.

Note : This test is shown only by the metals which make soluble oxides.

Table 7.2 : The products and observations of the reactions between metals and oxygen.

Metal	*Chemical reaction with oxygen*	*Observations*
1. Sodium	(a) Sodium + Oxygen → Sodium oxide + heat $4Na + O_2 \rightarrow 2Na_2O$ + heat	***Flame :*** It burns brightly, with a brilliant yellow flame.
2. Calcium	(a) Calcium + Oxygen → Calcium oxide + heat $2Ca + O_2 \rightarrow 2CaO$ + heat	***Flame :*** It burns with a bright brick red flame, forming a white solid.
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.
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.

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

Wax + Oxygen ⟶ Carbon dioxide + Water vapour + Energy

Do You Know ?

Food can go bad on 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. Onions, garlic, tomatoes and turmeric are good sources of antioxidants.

RUSTING

Rusting of iron is a case of action of oxygen on metals.

Rusting is a slow process in which oxygen from the air, in presence of moisture, reacts with iron and produces a brownish red coating over the metal. It easily crumbles off from the surface of iron thus exposing the free surface for further rusting.

Rust is hydrated ferric oxide ($Fe_2O_3 . x\, H_2O$).

The equation of the reaction is :

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

Air and moisture are necessary for rusting. The presence of acidic gases like CO_2, SO_2, etc. increases the rate of rusting of iron.

Since iron is a very useful metal, it is essential to prevent rusting of iron. If we protect iron from coming into contact with moisture/moist air, rusting will not occur. This is done by painting, greasing, metallic coating, etc.

COMPARISON OF RUSTING AND BURNING

Rusting	***Burning (combustion)***
Similarities :	
1. Rusting needs oxygen.	1. Burning too needs oxygen.
2. The process forms oxides.	2. The process also forms oxides.
Differences :	
1. Rusting is slow oxidation.	1. Burning is fast oxidation.
2. Small amount of heat is released but not light.	2. Large amount of heat is released with light.
3. Both air and moisture are necessary for rusting.	3. Only air is necessary for burning.
4. Ignition is not required.	4. Ignition is required to initiate the process.

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.

USES OF OXYGEN

(1) 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.

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 the roots of the plants.

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

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

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

Differences between burning/combustion and respiration

Burning	*Respiration*
1. Burning is a fast oxidation process.	1. Respiration is a slow oxidation process.
2. It occurs at a high (ignition) temperature.	2. It occurs at body temperature.
3. Large amount of energy is released in the form of heat and light.	3. Small amount of energy is released in the form of heat only.
4. Burning is an artificial process and needs initiation.	4. Respiration is a natural process.

(3) Uses in medicine :

- Oxygen cylinders are provided for patients 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.

(4) 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 oxy-hydrogen 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 purer forms of iron metal.
- *In chemical industries* : Purer 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 spacecrafts* : Liquid oxygen (LOX) is carried by rockets that burn liquid hydrogen as fuel to propel the rocket at high speed.

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 photosynthesis. This circulation of oxygen is called the oxygen cycle. The rate of photosynthesis is much faster than respiration, that is why we can say that oxygen is a '*gift from plants*' to all other living beings.

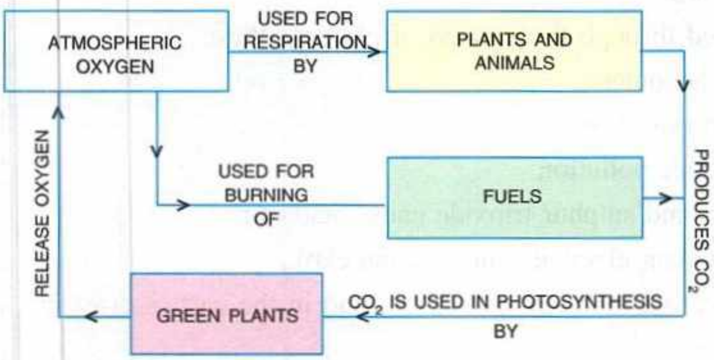


Fig. 7.11 Oxygen cycle

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.

Release of oxygen during photosynthesis

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

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

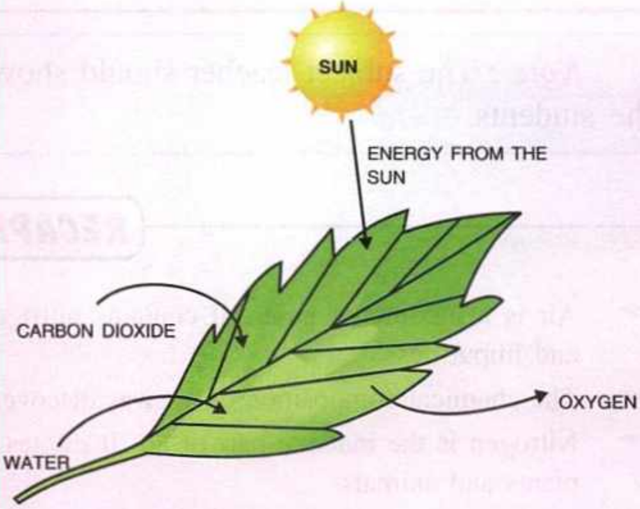
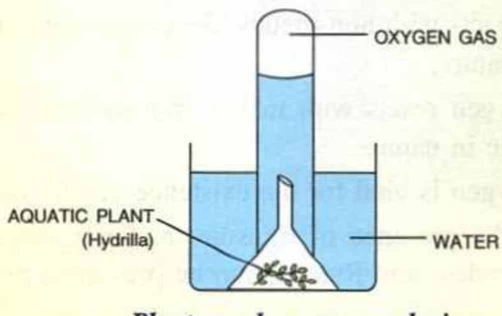


Fig. 7.12 : Release of oxygen in air by green plants during photosynthesis

Activity 9

To show that plants produce oxygen during photosynthesis.

Place a small aquatic plant like hydrilla in a beaker full of water and cover the plant with a funnel. Fill a test tube with water and



Plants produce oxygen during photosynthesis

invert it over the stem of the funnel. Place the apparatus in the sun. After some time, bubbles of a gas 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 the dark or at night, since photosynthesis cannot take place in the absence of light.

Note : The subject teacher should show burning of wood and rusting of iron objects to the students.

RECAPITULATION

- Air is a mixture of gases. It contains nitrogen, oxygen, carbon dioxide, water vapour, noble gases and impurities.
- The chemical composition of air was discovered by Lavoisier.
- Nitrogen is the inactive part of air. It dilutes the effect of 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 vapour is responsible for most climatic phenomena.
- Dust helps in condensation of water vapour into rain drops.
- Harmful gaseous substances present in air cause air pollution.
- Impurities like nitrogen dioxide, sulphur dioxide and sulphur trioxide cause acid rain.
- 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 oxidises food to release energy.
- In the presence of moisture and oxygen, iron 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*) A chemical called oxygenated water.
   (*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 on 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 produced ?
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.

   $KNO_3 \xrightarrow{heat} KNO_2 + \ldots\ldots\ldots\ldots\ldots$

   $KClO_3 \xrightarrow{heat} \ldots\ldots\ldots + O_2$

   $HgO \xrightarrow{heat} \ldots\ldots\ldots + \ldots\ldots\ldots\ldots\ldots$

   $CaO + H_2O \rightarrow \ldots\ldots\ldots\ldots\ldots$
8. (*a*) Give four uses of oxygen.
   (*b*) How is oxygen naturally renewed in air ?
9. State two differences between : Rusting and burning.

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.

2. 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)	Methane
(e)	Photosynthesis	(v)	Nitrogen dioxide

MULTIPLE CHOICE QUESTIONS

1. A fuel that releases the least amount of pollutants in the air when used.

   (a) sulphur dioxide
   (b) chlorofluorocarbon
   (c) smoke
   (d) CNG

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

   (a) photosynthesis
   (b) respiration
   (c) burning
   (d) dissolution

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

   (a) a stainless steel cup-board
   (b) a galvanised iron bucket
   (c) an iron hammer
   (d) a tin plated iron box

Project

- Prepare a list of harmful effects of acid rain on bridges, cars, machines, coral reef, aquatic organisms, agriculture and discuss them in the class.

GLOSSARY

1. *Alloy :* A homogeneous solid mixture of two or more metals.
2. *Anion :* A negatively charged ion.
3. *Atom :* The smallest particle of an element, which can take part in a chemical reaction. It exhibits the essential properties of an element. It is electrically neutral and may or may not exist independently in nature.
4. *Atomicity :* The total number of atoms present in one molecule of an element.
5. *Catalyst :* A substance that alters the rate of a chemical reaction without itsef undergoing any chemical change.
6. *Cation :* A positively charged ion.
7. *Chemical change :* A change in which a substance loses its identity or changes its composition. Further, it is a change which is not reversible.
8. *Chemical equation :* A statement that describes a chemical change in terms of symbols and formulae with the reactants on left hand side and the products on right hand side of an arrow.
9. *Chemical formula :* Represents the composition of the molecule of a substance in terms of symbols of the atoms present in the molecule.
10. *Chemical reaction :* Involves the change of matter into a new substance or substances which take place during a chemical change.
11. *Chromotography :* The process of separating closely related but different dissolved constituents of a mxiture by their absorption on an appropriate material.
12. *Compound :* A substance formed by the chemical union of two or more elements, united in a definite proportion by mass.
13. *Distillation :* A process of getting a pure liquid from a crude liquid by boiling it and then condensing the vapours.
14. *Ductility :* The ability of metals to be drawn into thin wires.
15. *Element :* A pure substance which cannot be decomposed into simpler substances by ordinary chemical means.
16. *Fertilizers :* Artificially prepared chemicals which are rich in plant nutrients. They help in healthy growth of crops and increase the yield.
17. *Freezing point :* It is a temperature at which a liquid changes from liquid to solid state.
18. *Galvanisation :* The process of coating molten zinc over iron articles to protect them from rusting.
19. *Glass :* A supercooled liquid formed from molten silicates of sodium and calcium.
20. *Green house effect :* The trapping of solar heat energy in earth's atmosphere due to the presence of carbon dioxide, methane, water vapour, etc.
21. *Ignition temperature :* The minimum temperature to which a substance must be heated to make it burn is called its ignition temperature.
22. *Ions :* Electrically charged atoms or group of atoms formed by losing or gaining electrons.
23. *Malleability :* The property due to which metals can be beaten into sheets.
24. *Metalloid :* Elements which show some properties of metals and some properties of non-metals.
25. *Metals :* Elements which show metallic properties, a class of elements electropositive in nature. Their atoms tend to lose electrons during chemical reactions to form positive ions.
26. *Mixture :* Made up of two or more elements or compounds mechanically mixed together in any proportion, such that it retains the properties of those of its constituents.
27. *Molecular formula :* A chemical formula which gives the number of atoms of its constituent elements in one molecule of a compound or an element.

28. *Molecule :* The smallest particle of a substance (an element or a compound) which can exist independently in nature and retains all the properties of that substance.

29. *Negative valency :* The valency of all non-metals and acid radicals.

30. *Neutron :* The neutral subatomic particle found in the nucleus of an atom with mass almost equal to that of a proton.

31. *Noble gases :* A class of elements which are chemically inert.

32. *Non-metals :* A class of elements which are electronegative in nature. Their atoms tend to gain electrons during chemical reactions to form negative ions.

33. *Physical change :* It is a temporary change in which no new substance is formed and the composition of the substance is not altered. It undergoes only change in physical behaviour. It is reversible.

34. *Positive valency :* The valency of all metals, hydrogen and ammonium ion.

35. *Precipitate :* An insoluble solid formed on reaction of two solutions.

36. *Products :* The substances formed as a result of a chemical change.

37. *Proton :* A positively charged subatomic particle found in the atoms of all elements.

38. *Radicals :* An atom or a group of atoms of different elements behaving as a single charged unit.

39. *Reactants :* The substances which take part in a chemical reaction.

40. *Rust :* The brown powdery mass of hydrated ferric oxide formed in the presence of moist air.

41. *Rusting :* The slow oxidation of iron into hydrated ferric oxide, in the presence of moist air.

42. *Silicones :* A compound of silicon used to prepare waterproof materials, electrical insulators and non-stick pans.

43. *Smog :* A noxious mixture of particulates and gases causing air pollution.

44. *Solute :* The dissolved substance in a liquid.

45. *Solution :* A homogeneous mixture containing a substance (solid, liquid or a gas) in dissolved state in a liquid.

46. *Solvent :* A liquid or a medium in which the solute is dissolved.

47. *Sublimation :* The changing of a solid substance directly into its vapours without passing through liquid stage.

48. *Symbol :* A short form for the full name of an element which represents an atom of that element.

49. *Syrup :* A supersaturated solution containing maximum amount of solute in a given volume of a solvent.

50. *Valency :* The combining capacity of the atom of an element to form chemical bonds.