Preface

'*Concise Chemistry Middle School*' meant for class VI 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 VI 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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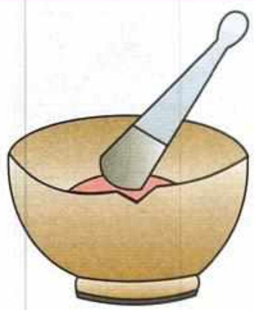


Introduction to Chemistry

1

Theme : Chemistry finds applications in day- to- day life as well as in industries. Chemicals from simple to complex, are used in medicines, cosmetics, textile industry, agriculture, cleansing agents, etc. This theme will help children understand applications of Chemistry in their lives.

In this chapter you will learn :

- *Chemistry — meaning and importance.*
- *Development of Chemistry — A historical perspective.*
- *Notable chemists/scientists and their contributions to Chemistry (at least 3 scientists)*
- *Food and Chemistry*
- *Cosmetics and Chemistry*
- *Clothing and Chemistry*
- *Chemicals as Medicines*
- *Chemicals in Industries*

LEARNING OBJECTIVES

The children will be able to :

- discuss the importance of chemistry in daily life and its role in different industries and life processes.
- list important applications of chemistry in day to day life.
- list some industrial applications of chemistry.
- discuss the bio-sketches of some great scientists and their works.
- appreciate the patience, perseverance, sacrifices and ethical conduct of scientists.

INTRODUCTION

All of us are familiar with the word **'Science'**. But, what is science ? How has it been developed ? And why is it so important ?

All these questions and many more such questions need to be answered to satisfy our curiosity and to enhance our knowledge.

Since ancient times, humans have always been curious to know about nature and the fascinating world around them. In this process of learning, human beings started observing natural phenomena carefully and came out with some conclusions. This effort further led to new ideas and concepts. These organised human discoveries were later on given the name **Science**.

This scientific knowledge gained importance and it was passed on from one generation to another, for the development of mankind. With the passage of time, the sum total of this human knowledge brought about vast changes in human behaviour and people started enjoying the 'miracles' of science.

In olden days, probably a casually picked up branch of a tree or a stone became a tool for human search. With the help of such tools, early men could get their food easily and could protect themselves too. With time, these tools improved and tools made of metals came into existence.

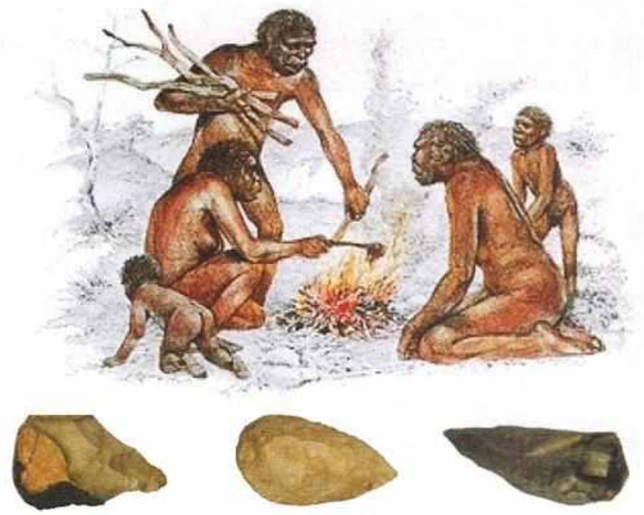


Fig. 1.1 Primitive human beings used stone tools

This fact can be further explained by the following examples :

While using stones as tools, an ancient man probably rubbed them together which made the stones so hot that a fire was produced. The fire gave them warmth and also kept the wild animals away from them.

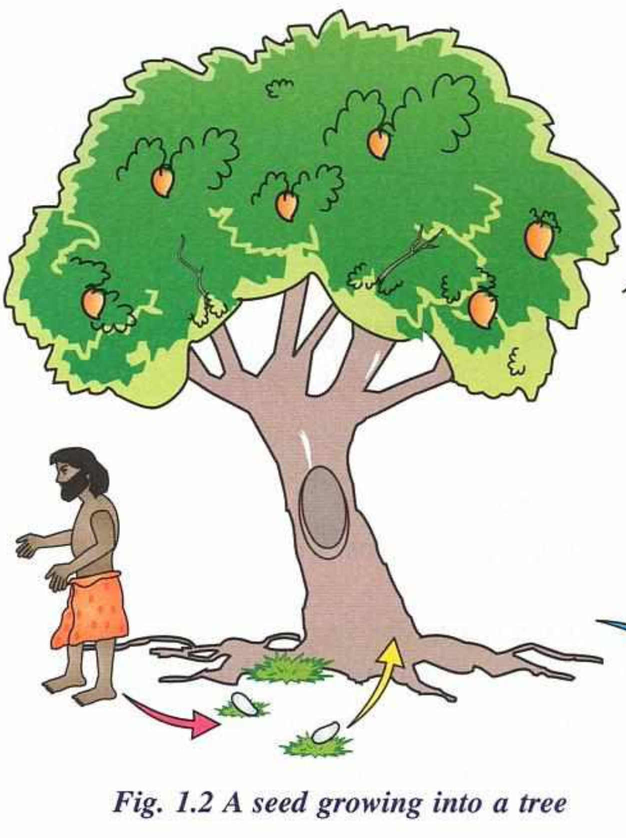


Fig. 1.2 A seed growing into a tree

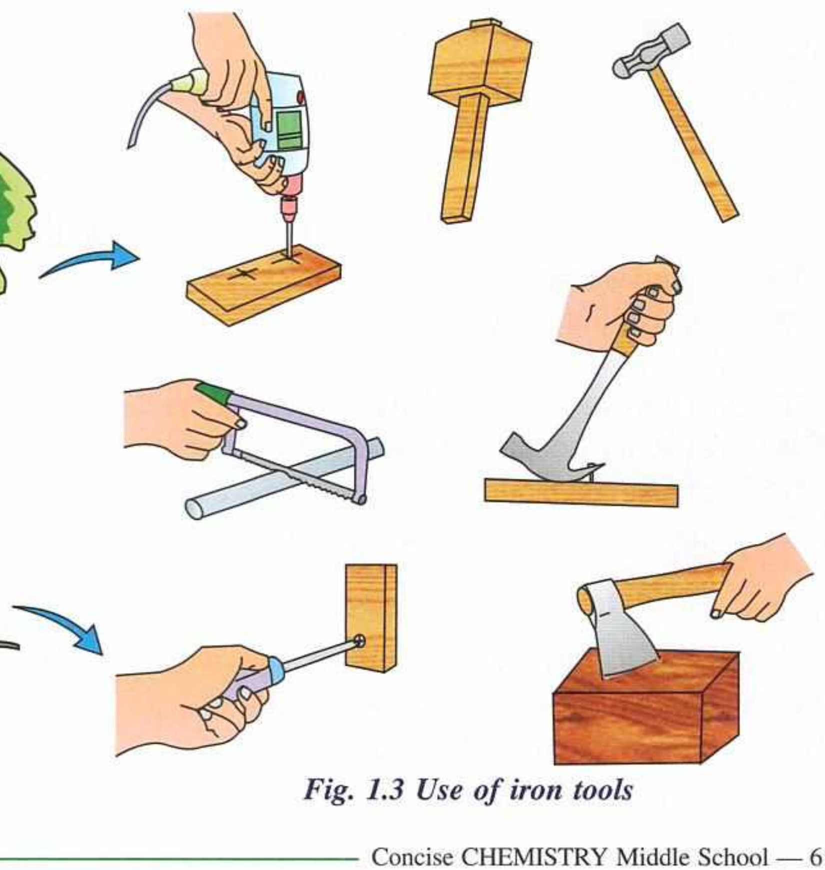


Fig. 1.3 Use of iron tools

Accidently, a piece of meat fell into the fire, when that piece was taken out and eaten, it was tastier and easier to chew. Men now learnt to cook food and protect themselves from the cold weather and wild animals. They were also able to ignite fire with the help of wood.

Similarly, early man plucked a fruit from a tree, ate it and threw its seeds on the soil. After sometime, he saw that a plant had grown which further grew into a tree, bearing the same kind of fruits. This gave mankind an idea to grow plants and produce fruits.

Thus, slowly and gradually, the basic knowledge of science developed.

If today we know many advanced techniques of growing crops, it is only possible because of proper observations and efforts that early man had made and passed on to us.

Thus, we can now say that :

Science is the systematic, ongoing effort by human beings to study, understand and utilise nature for meaningful purposes. This understanding is slowly developed by careful observations and experiments.

CHEMISTRY — A BRANCH OF SCIENCE

Science is broadly classified into *three* main branches.

(i) Physics, (ii) Chemistry and (iii) Biology.

Nature is a large reservoir of different kinds of substances. They need to be minutely studied in order to understand and appreciate,

- What are they made up of ?
- How are they made ?
- Will they remain in the same form forever or will they change ?
- How can they become useful ?
- Can they be prepared by man ?

Make a list of products which you use daily from morning to night and share your knowledge about these substances with your classmates and ask your teacher about it.

A detailed study of all these substances is done under the branch *'Chemistry'*.

The branch of science that deals with the study of the composition and the physical and chemical properties of various forms of matter is called ***Chemistry***.

Development of chemistry — A historical perspective.

ALCHEMY

It is necessary to mention 'alchemy', an ancient practice, which has played an important role in the development and growth of chemistry. It has contributed to an incredible number of future uses of chemicals, metals, ink, paints, cosmetics, medicines, porcelain, etc.

The people practising alchemy were considered to be early chemists and were known as 'Alchemists'. They used all general techniques of chemistry in healing humans. Their contribution proved valuable to the society and in the advancement of civilization.

The word **"Alchemy"** has its origin in a Greek word 'Khemeia' which means "art of transmuting metals". It was partly based on experimentations and partly on spiritual discipline.

The goal of alchemy was to find a mythical and magical substance called "philosopher's stone" (not a literal stone but wax, liquid or powder) with magical powers, which on heating with a base metal iron or copper would turn into **gold**, the purest form of matter which would bring wealth, health and immortality.

However they could not succeed in finding this magical substance, but they were successful to some extent in developing processes to extract metals and make alloys. They were the first to isolate zinc and phosphorous.

The iron pillar near Qutab Minar is notable for the rust resistant composition of metal used in its construction. It is 7 metres high. It is made up of iron mixed with high percentage of phosphorous.

Alchemy had initially developed in Egypt and China. In the 8^{th} century, it appeared in Europe. In India, it was mainly practised for medicines now known as Ayurvedic medicines.

Alchemy was both scientific and spiritual. Alchemists never separated the two. It also lacked a common language for its concepts and processes *i.e.* there was no standardized scientific practice.

By the 18^{th} century, the field of 'chemistry' was completely separated from ancient traditional alchemy. Still, modern chemistry in general owes a great deal to alchemy.

IMPORTANCE OF CHEMISTRY

Chemistry has played a vital role in the progress of mankind. Directly or indirectly, all human activities depend upon the knowledge of chemistry. Chemistry finds many applications in our daily life. It also plays an important role in industries. Everything from our food, cosmetics, medicines, fuels, soaps and detergents to the various industries, like textile, paper, etc. incorporates chemistry.

Thousands of useful substances are produced through chemical processes such as soap, detergents, toothpaste, shoe polish, clothes, dyes, plastics, paints, etc. They are all gifts of chemistry. They in turn help in improving our national economy. Let us now discuss the applications and uses of chemistry in some of the major fields.

1. **Food and agriculture :** Food supply to any society entirely depends on agriculture. Along with the quality of food, it is also important to increase its production with increasing population. This has been made possible by the development and application of advanced techniques and methods of agriculture.

Chemistry has helped farmers by providing them with agro-chemicals like fertilisers, pesticides, insecticides and fungicides. They are described below :

(i) **Fertilisers :** Fertilisers are the chemicals which provide essential nutrients to crops and increase their yield. They are obtained through various chemical processes. The well-known fertilisers are urea, sodium nitrate, potash, ammonium phosphate, calcium nitrate, *etc*.

(ii) **Pesticides :** Pesticides are the chemicals used to kill pests which affect the yield of crops and fruits. The main pesticides are malathion, parathion, aldrin, *etc*.

(iii) **Insecticides :** Insecticides (such as D.D.T. and B.H.C.) are chemicals used to kill insects.

(iv) **Fungicides :** Bordeaux mixture and sulphur act as ***fungicides***. They protect crops from harmful fungi.

(v) **Preservatives :** Preservatives like sodium benzoate, sodium meta-bisulphate and salicylic acid are used for better preservation of food and to check its spoilage.

2. **Food processing and processed food :** Food processing is the transformation of raw food materials by physical or chemical means into marketable food products that can be easily prepared and served to the consumers, such as cheese, tinned vegetables, bread, jams, jelly, butter, snacks, soft drinks, etc.

3. **Minerals and Petroleum :** Knowledge gained through chemistry has helped us in developing methods for the extraction of different metals from their ores and minerals. These metals are used to manufacture different kinds of machines and tools.

   Petroleum products like petrol, diesel, kerosene, wax, paraffin, *etc.* are separated from crude oil with the help of chemical techniques.

4. **Industry :** Chemistry has helped in the growth of different industries. It has enabled us to improve the efficiency of industrial processes. Industries are set up to produce a large number of consumer products like dyes, drugs, paints, plastics, synthetic fibres, petrochemicals, pharmaceuticals, steel, alloys, textiles, paper, pencil, glass, cleaning agents-soaps and detergents.

   The development of the above products and many more, naturally or artificially, has made human survival possible on the earth since ages. Preparation of common salt from sea water and sugar from cane sugar juice is possible only through different physical and chemical processes.

5. **Medicines :** Extensive research by chemists have led to the discovery of a number of medicinal drugs. These drugs help in fighting diseases and have thus increased the life span of human beings. *Examples :* aspirin, paracetamol, antibiotics like penicillin, tetracycline, antiseptics and various other medicines used to kill germs and cure diseases.

6. **Cosmetics :** Cosmetics are products used to cleanse, protect and change the appearance of external parts of human bodies. *Example :* talcum powder, skincare creams, lipsticks, eyes and facial make up, deodorants, lotions, perfumes, soaps, bathing oil, body butter, baby products, etc.

   It is possible to convert various ingredients into usable cosmetics due to knowledge of chemistry.

Do You Know ?

Talcum powder is made up of a mineral called talc which contains elements like magnesium, silicon and oxygen.

7. **Clothings :** Chemistry is widely used in textile industry which manufactures clothing for us. Clothes guard our body from external environment.

   Cloth manufacturing begins with the knowledge of conversion of fibres into fabrics. Fibres can be natural or synthetic. Earlier only natural fibres (such as cotton, jute, silk, wool, etc.) were known to man which were used to proudce dress materials, sarees, bags, sweaters, shawls, etc. With more development, synthetic

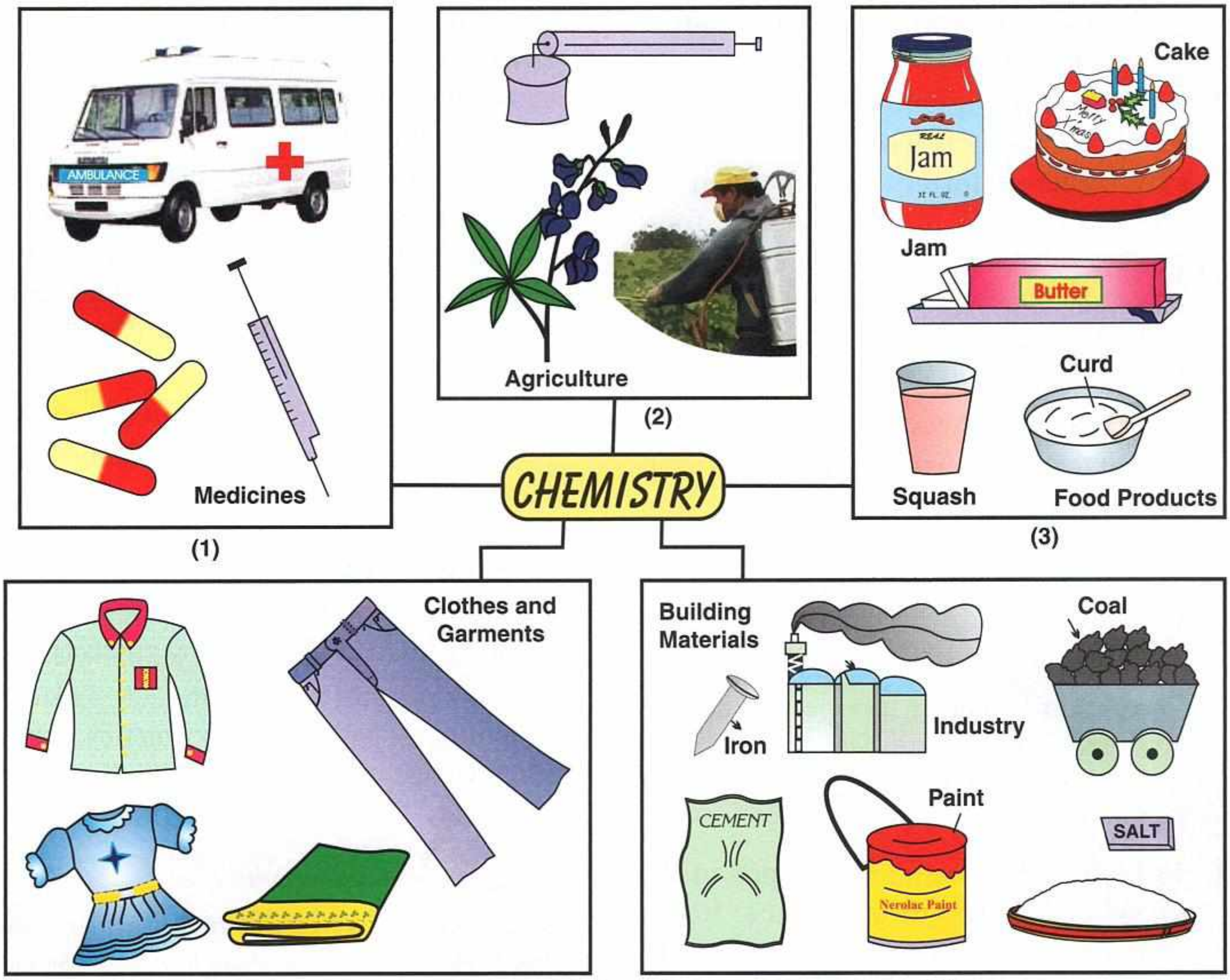


Fig. 1.4

fibres were also made such as nylon, spandex, polyester, etc. These fibres are strong, wrinkle resistant and dry quickly. They are used to make towels, bed sheets, bags, curtains, carpets, blankets, dress materials, etc.

8. **Building Materials :** Basic raw materials such as cement, mortar, steel, glass, paints, varnishes, *etc*. used for the construction of buildings, bridges, roads, *etc*., are manufactured by chemical processes. All these materials help us in making strong infrastructures.

9. **Transport :** Trains, buses, scooters, cars, aeroplanes and ships are common means of transport. They completely depend upon the fuel made available through the knowledge of chemistry.

> Fuels are substances which on combustion produce a large amount of heat energy that can be used. *Example*: Cooking gas (LPG), petrol, diesel, *etc*. Compressed Natural Gas or CNG can be used in automobiles and also for cooking purposes.

10. **Communication devices :** Synthetic chemicals, metallic wires and plastics used in telephones, mobile phones, radios, transistors, tape recorders, *etc.* are all gifts of chemistry.

11. **National Defence :** Substances like gunpowder, T.N.T. (trinitrotoluene), phosgene, chemical weapons, laughing gas, *etc.* are all products of chemistry which contribute to the national defence.

12. **Recreation :** Chemistry plays a vital role in any mode of recreation. Sports goods are made from rubber, leather, plastics, metals and fibres. Substances for photographic films are the gifts of chemistry. The use of adhesives such as glue and tapes also incorporates chemistry.

13. **Chemistry and energy resources :** The energy resources of the world are mainly petroleum, coal, wood and nuclear fuels. To conserve the fast depleting reserves of coal and petroleum, attempts are being made by chemists to utilize alternative sources of energy. Solar energy, ocean energy and biogas, which are inexhaustible sources, are being studied under chemistry for future energy needs.

Thus, the progress of the human race is dependent on chemistry. It involves a lot of chemical research and its utility in industries. In other words, due to chemistry, the world economy has improved which, in turn, has raised the living standards of the people.

DARK SIDE OF CHEMISTRY

Chemistry, misused by unscrupulous people, has also been endangering human society. It has given rise to the menace of harmful drugs and their bulk processing like LSD, cocaine, brown sugar, heroin, angel dust, etc. that cripple the society. Chemistry has also developed deadly explosives such as TNT, RDX and the atomic and hydrogen bombs. The increasing use of certain compounds such as polythene and styrofoam is also a major source of environmental pollution today.

Full form of

1. TNT — Trinitro-toluene.
2. DDT — Dichlorodiphenyl trichloro ethane.
3. BHC — Benzene hexachloride.
4. LSD — Lysergic acid diethylamide
5. RDX — Rapid detonating explosive

[Chemically RDX is cyclo trimethylene trinitramine]

6. LPG — Liquified Petroleum Gas

Do You Know ?

- Our body is a mobile chemical factory which uses food, water and oxygen as raw materials. These substances undergo a series of changes with the help of chemicals called **enzymes** that are secreted by our body.
- **Hormones** are another group of chemicals secreted in our body to control various activities.
- A strong acid called hydrochloric acid is produced in our stomach which helps in the digestion of food.
- There are more chemicals in the food we eat than we find elsewhere. Some of them are carbohydrates, proteins, vitamins, fats, minerals, *etc.* These are vital to life.

Some Great Chemists/Scientists and their contributions to chemistry

- **Robert William Boyle (1627-1691)** is known as the "Father of Modern Chemistry". He was an Anglo Irish scientist born in Ireland. He was the first to perform experiments under controlled conditions and publish his researches with elaborate details of procedure, apparatus and observations. Robert Boyle put chemistry on a firm scientific footing, transforming it from alchemy into one based on measurements. He defined elements, compounds and mixtures.
- **Antoine Lavoisier (1743-1794)** was a French nobleman. He revolutionized chemistry. Lavoisier named the elements carbon, hydrogen and oxygen and discovered the role of oxygen in combustion and respiration for which he is most noted. He established that water is a compound and helped to continue the transformation of chemistry from a qualitative science to a quantitative one.
- **John Dalton (1766-1844)** was a British chemist and physicist. He proved that matter consists of small indivisible particles called **'atoms'**. For this, he proposed the atomic theory which was later on called "Dalton's atomic theory".
- **Dmitri Mendeleev (1834-1907)** was a Russian chemist, best known for his discovery of "Periodic Law" in 1869 and formulation of "Periodic Table of elements". He was passionate about chemistry. His deepest wish was to find a better way for organizing the substances.
- **Acharya P.C. Ray (1861-1944)** was an Indian scientist who did useful work in the development of mercury compounds. He was a pioneer in the field of medical industry in India.
- **Alfred Nobel (1833-1896)** was a Swedish Chemist who invented dynamite. He had 350 patents to his name, and was nicknamed "Merchant of Death" because he made a fortune through the manufacture of explosives. The "Nobel Prizes" are awarded for outstanding achievements in the fields Physics, Chemistry, Medicine, Literature, Economics and Peace after his name. These awards are given every year on his death anniversary *i.e.* 10th December.
- **Marie Curie (1867-1934)** was a physicist as well as a chemist. She was a pioneer in the study of "Nuclear Chemistry". She discovered the radioactive metal radium. She was the first woman who won the "Nobel Prize" for Physics in 1903. She was also the first person and the only lady who received the "Nobel Prize" for Chemistry a second time in 1911 in recognition of her work in radioactivity. She also developed a portable X-ray machine which saved many lives during World War I.

The names of some of the noted scientists and their discoveries are given in the followig table:

Name of Chemists/Scientists	Discovery
• Joseph Priestly	Oxygen.
• Daniel Rutherford	Nitrogen, worked on radioactivity.
• Sir Humphry Davy	Isolated potassium and sodium and devised a safety lamp.
• William Ramsay	Helium, Argon, Krypton and Xenon (inert gases).
• Michael Faraday	Laws of electrolysis.
• Henry Cavendish	Hydrogen.

RECAPITULATION

- Science is the sum of systematic efforts by human beings to control nature through experiments and observations for their own use.
- Development of science is an ongoing process.
- Chemistry is the branch of science which deals with the study of substances and the various changes that they undergo.
- Contributions of chemistry in everyday life fulfill man's basic needs.
- Chemistry helps in modifying natural materials into synthetic materials for the use of mankind.
- Fuels are substances which burn to produce a large amount of heat energy that can be used.
- Chemistry plays an important role in improving our *national economy.*
- Contributions of eminent scientists like Boyle, Lavoisier, John Dalton, etc. are outstanding.

EXERCISE

1. Give two examples for each of the following substances :
   (a) food preservatives *(b)* fuels
   (c) fungicides *(d)* medicines
   (e) building materials
   (f) chemical war weapons

2. Give short answers :
   (a) What is science ?
   (b) What is chemistry ?
   (c) What is a fuel ?
   (d) How is chemistry helpful in improving the health of human beings ?
   (e) What is alchemy ?
   (f) What kind of experiments did Alchemists do ?
   (g) What is 'Philosopher's stone' ?
   (h) What is the main difference between alchemy and chemistry ?
   (i) Name the chemicals which help in increasing food production.
   (j) Name six chemical products which we use daily.

3. What is the contribution of chemistry in the following fields ?
   (a) Industry *(b)* Clothing
   (c) Cosmetics *(d)* National Defence
   (e) Medicines

4. Who is known as the 'Father of Chemistry' ? Why ?

5. Name the scientists who discovered the following.
   (a) Atoms *(b)* Oxygen
   (c) Safety lamp *(d)* Elements

OBJECTIVE TYPE QUESTIONS

1. Fill in the blanks :
   (a) .... deals with the study of matter and the changes it undergoes.
   (b) .... help to increase the production of food.
   (c) Food items like jams and pickles are protected by using ....
   (d) L.P.G. is used for ....
   (e) Inert gases were discovered by ....

2. Match the following words in column *A* with those in column *B* :

Column A	Column B
(*a*) Clothing	(*i*) toothpaste, cosmetics
(*b*) Green revolution	(*ii*) nylon, wool
(*c*) Building materials	(*iii*) agriculture
(*d*) Commodities of daily use	(*iv*) mortar, cement

3. Write ***"True"*** or ***"False"*** against each of the following statements.

(*a*) Chemistry plays an important role in our national economy. ....

(*b*) Antibiotics are used as preservatives. ....

(*c*) D.D.T. is an important fertiliser. ....

(*d*) Gunpowder is an insecticide. ....

(*e*) Enzymes secreted by our body are chemicals. ....

4. Choose the correct alternative from the choices given below for the following statements :

(*a*) Trinitrotoluene is used as
(*i*) a preservative (*ii*) a fertiliser
(*iii*) a fuel (*iv*) an explosive

(*b*) Which one of the following is a pesticide?
(*i*) benzoic acid (*ii*) aldrin
(*iii*) sugar (*iv*) gun powder

(*c*) Mortar is used as a
(*i*) plastic material
(*ii*) a building material
(*iii*) an insecticide
(*iv*) as medicine

(*d*) Urea is an important
(*i*) fuel (*ii*) preservative
(*iii*) fertiliser (*iv*) food item

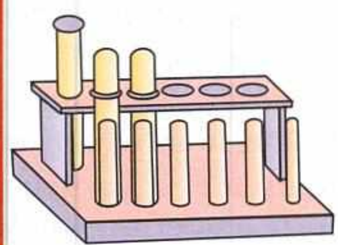
(*e*) The chemicals prescribed by a doctor in treatment of infectious diseases are called
(*i*) antigens (*ii*) lotions
(*iii*) antibiotics (*iv*) creams

5. Match the following scientists in column A with their discoveries or contributions in column B.

Column A	Column B
(*a*) Marie Curie	(*i*) Safety lamp
(*b*) John Dalton	(*ii*) Helium
(*c*) William Ramsey	(*iii*) Nobel Prize Winner (two times)
(*d*) Sir Humphry Davy	(*iv*) Atomic theory

Project

1. Make a list of five products of daily use and their starting material.
2. Visit a nearby chemical industry and describe your experience in the class.



Common Laboratory Apparatus And Equipments

Theme : Chemistry laboratory is a place where experiments are done carefully with the help of various apparatus and equipments. The changes are observed and conclusions drawn.

In this chapter you will learn :

- *The importance of 'observation' and 'experiment' in chemistry*
- *The importance of a chemistry laboratory*
- *Names, descriptions and uses of apparatus and equipments*
- *Precautions to be taken in a chemistry laboratory.*

LEARNING OBJECTIVES

The children will be able to :

- discuss about the arrangement of chemistry laboratory and its wise use.
- list apparatus and equipments used in a chemistry laboratory.
- understand the importance of experiments and observations.
- discuss the precautions to be taken once in the chemistry laboratory.

INTRODUCTION

Our knowledge of chemistry would be incomplete if we do not utilise our ability to observe a natural phenomenon, then put it to an experiment and finally, draw our own conclusions to verify the facts.

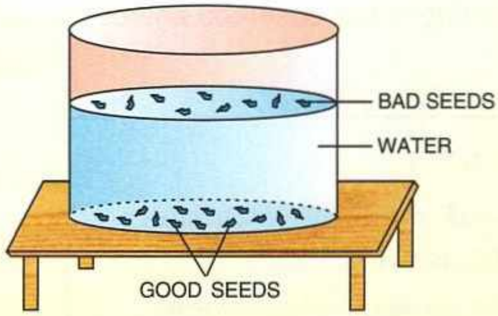
Observation :

Our everyday experiences arise from what we see, hear, touch, taste and smell. We observe that the sun rises from the east and sets in the west. A ball when thrown up comes down. Such observations help us to draw scientific conclusions.

Note : All observations cannot be considered to be scientific. *For example*, a poet's observations about nature.

Activity 1

A farmer puts some seeds into a beaker full of water. He observes that most of the seeds sink and a few seeds stay afloat. It is believed that the seeds that remain afloat are bad ones and those which sink to the bottom are the good seeds. This method helps farmers to separate the good seeds from the bad ones. Such separation is possible only because of proper and careful observation.



GOOD SEEDS SINK BUT BAD SEEDS FLOAT

Experiment :

Chemistry is the branch of science which is mostly based on experiments. An experiment performed under controlled conditions is an activity where we observe a natural or an artificially created phenomenon.

Activity 2

Take three glasses, A, B and C. Glass A contains hot water, glass B has lukewarm water and glass C contains cold water. Put one of your fingers in glass A and a finger of the other hand in glass C for sometime. Now, put both fingers in glass B.

What do you feel ?

You will feel different sensations in your two fingers. The water in glass B feels warmer to the finger kept in cold water in glass C, whereas it feels cooler to the finger kept in hot water in glass A. This is an experiment carried out to understand a particular phenomenon. This simple activity helps us to draw the scientific conclusion that the hotness or coldness of a substance is a relative term.

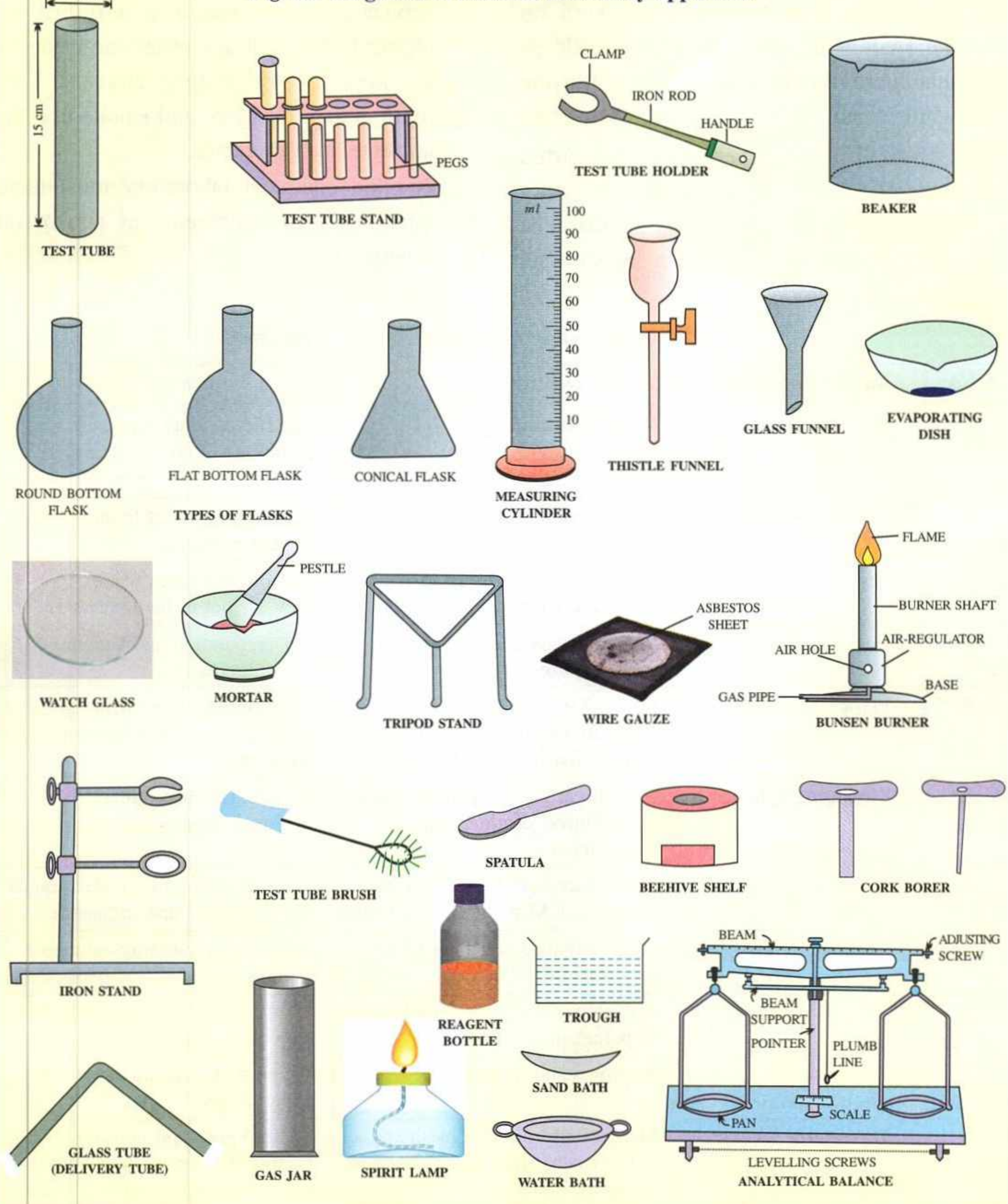
LABORATORY

A chemical laboratory (or a chemistry laboratory) is a place to perform experiments, observe chemical processes and to analyse results.

The following facilities should be provided to perform experiments.

1. **Working Table :** A chemical laboratory has special kinds of tables. Each table is fitted with a gas burner, a sink with a tap, a reagent shelf and a waste-paper basket. There is also a side shelf for keeping glassware apparatus and a fume closet.

Fig. 2.1 **Diagrams of common laboratory apparatus**



2. **Reagent Shelf :** All reagents and chemicals should be properly kept on the shelf with labels on every bottle so that there should not be any confusion while using the reagents.

3. **Exhaust Fan :** These fans are fitted near the roof of the walls to expel poisonous gases and fumes so that one can comfortably work for a longer time in the laboratory.

4. **Balance Room :** Every laboratory has a separate room where a number of physical, chemical and electronic balances are kept for weighing chemicals. This room is kept dust-free and smoke-free for accurate measurements.

A good chemical laboratory must have the apparatus and equipments as shown on the previous page.

Table 2.1 : Names, descriptions and uses of apparatus

S.No.	*Name of apparatus*	*Description*	*Use*
1.	Test tube	Made of hard or pyrex glass.	Used to conduct tests with small quantities of chemicals, for heating and boiling purposes.
2.	Test tube stand	A rack made of wood or plastic.	To keep test tubes in an organised manner.
3.	Test tube holder	Metallic rod with a clamp at one end and a handle at another end.	To hold test tubes while they are hot or being heated.
4.	Beaker	Made of glass and available in different sizes.	For preparation and keeping of solutions.
5.	Flask	Made of glass. Three types of flasks are the most common : round-bottom, flat bottom and conical.	Used during experiments to hold sufficient quantities of solutions.
6.	Measuring cylinder	Cylindrical glass apparatus graded in millilitres, decilitres and centilitres.	To measure the volume of liquid substances.
7.	Funnel	Cone shaped with a stem at its narrow end. Made of glass or plastic.	Used to filter and transfer liquids from one container to another.
8.	Evaporating dish	A bowl-shaped container made of porcelain.	Used for evaporating solutions/ liquids.
9.	Mortar and pestle	A container and a hand-tool made of porcelain.	Used to grind and crush solid substances into a powder.
10.	Tripod stand	An iron stand having three legs.	Supports the apparatus during experiments.
11.	Wire gauze	Made of an iron wire mesh and a thin asbestos sheet that is fixed at its centre.	To keep glass apparatus on it while heating is in progress and also for the uniform distribution of heat.

12.	Spirit lamp	A type of burner made of glass, brass or steel containing a wick. Spirit is used as fuel.	To heat up substances.
13.	Bunsen Burner	A burner that uses gas as fuel.	For heating purposes.
14.	Reagent bottle	Made of white or coloured glass.	For storing chemicals.
15.	Gas jar	Glass cylinder.	For collecting gases.
16.	Analytical balance	A horizontal metal beam with pans suspended on both sides of it.	To measure the weight of substances.
17.	Glass tube or delivery tube	Hollow tube made of glass.	To transfer fluids or gases from one vessel to another.
18.	Glass rod	Solid glass stick.	To stir chemical solutions.
19.	Watch glass	It is made up of glass.	It is used like an evaporating dish for very small amount of liquid. It is also used to cover beakers.
20.	Crucible and cover	It is made up of porcelain.	It is used when a substance requires strong and direct heating.
21.	Pair of tongs	Made up of metal.	It is used for picking up hot apparatus like crucible.
22.	Water trough	Made up of metal or glass. It is big and bowl shaped.	It is used during collection of a gas.
23.	Water bath	Made up of metal.	It is used when a substance can not be heated directly on the flame.
24.	Thistle funnel	A bulb shaped reservoir with a stem and a stopper.	Used to transfer liquids in a controlled manner.

Note :

1. *Apart from these equipments, there are many others like spatula, cork-borer, file and beehive shelf that are also used in the chemistry laboratory.*
2. *Most of the laboratory apparatus are made of glass because :*
   - (a) *glass is a transparent material and we can see through it clearly.*
   - (b) *glass can withstand high temperatures.*
   - (c) *glass is easy to clean.*
   - (d) *glass does not react with most of the chemicals used in experiments.*
   - (e) *Pyrex glass or Borosil glass is a special type of glass which hardly expands on heating. Such glasses do not break even at high temperatures.*

PRECAUTIONS TO BE TAKEN IN A CHEMISTRY LABORATORY

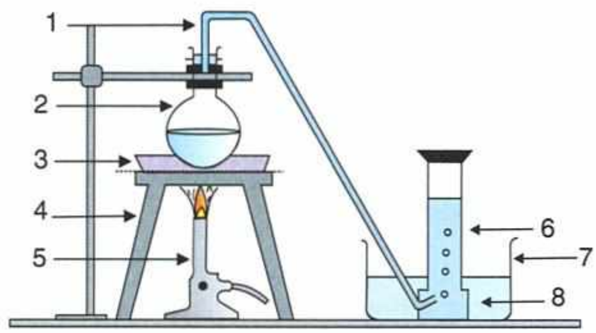
1. Do not work alone in the laboratory.
2. Always wear a lab coat in the laboratory. It protects your clothes.
3. The apparatus to be used in an experiment should be arranged neatly before beginning an experiment.
4. Carefully follow your teacher's instructions whenever you perform an experiment.
5. Only small quantities of chemicals should be used to carry out experiments.
6. Hot objects should be handled with attention and care.
7. Do not touch or taste any unknown substance or inhale any unknown gas directly.
8. After the experiment is completed, the apparatus should be properly washed, cleaned, dried and put back in their respective places in the laboratory.
9. Do not throw hot concentrated acids into the sink directly. Make sure that water is running into the sink so that when you throw away anything into it, it is safely washed away.
10. In case of accidental burns or skin contact with a corrosive chemical, immediately wash the affected area with cold running water and report it to your teacher.
11. When you have finished doing an experiment, wash your hands with soap and dry them with a clean towel.
12. Maintain silence and discipline in the laboratory and concentrate on your experiment.
13. When using test tube for heating, avoid pointing its mouth towards your fellow classmates.
14. Do not throw broken glass apparatus or used filter paper in the sink. Throw them in a dustbin.

RECAPITULATION

- Chemistry is the branch of science mostly based on experiments.
- Knowledge of chemistry is also based on observations.
- Experiments are artificially created situations to make observations.
- A laboratory is a place to perform chemical experiments and observe chemical processes.
- Various kinds of apparatus and equipments are required to perform experiments. They are made of glass, metals or porcelain to withstand high temperatures.
- Necessary precautions should be taken while doing experiments.

EXERCISE

1. Mention one use of each of the following equipments :
   (*a*) Spirit lamp (*b*) Test tube
   (*c*) Conical flask (*d*) Evaporating dish
   (*e*) Wire gauze (*f*) Beaker
   (*g*) Mortar and pestle (*h*) Measuring cylinder
   (*i*) Glass tube (*j*) Gas jar
   (*k*) Reagent bottle.
2. From what materials are the following made up of ?
   (a) Test tube rack (b) Test tube holder
   (c) Measuring cylinder (d) Wire gauze
   (e) Mortar and pestle
3. List any *five* precautions to be taken while performing an experiment in a chemistry laboratory.
4. Answer the following questions in brief :
   (a) Why is chemistry known as an experimental science ?
   (b) Why are most of the apparatus made of glass?
5. Label the marked equipments and apparatus in the diagram given below.



OBJECTIVE TYPE QUESTIONS

1. Fill in the blanks :
   (*a*) Experiment and .... are the two important basics of chemistry.
   (*b*) A porcelain dish is used ....
   (*c*) .... is used to hold the test tube while it is hot or being heated.
   (*d*) .... is used for grinding and crushing solid substances into a powder.
   (*e*) Glass apparatus is made of .... or .... glass.
2. Match the items in Column A with their respective functions in Column B.

Column *A*	Column *B*
(*a*) Iron stand	(*i*) To boil chemicals
(*b*) Test tube	(*ii*) To keep solutions
(*c*) Funnel	(*iii*) To stir solutions
(*d*) Beaker	(*iv*) To support apparatus
(*e*) Glass rod	(*v*) To transfer liquids

3. Choose the correct alternative from the options given for each of the following statements.
   (*a*) Evaporating dish is made of
      (*i*) porcelain
      (*ii*) glass
      (*iii*) metal
      (*iv*) plastic
   (*b*) Spirit lamp is made of
      (*i*) glass
      (*ii*) brass
      (*iii*) steel
      (*iv*) all of the above
   (*c*) The apparatus to measure an accurate volume of a liquid is
      (*i*) beaker
      (*ii*) conical flask
      (*iii*) measuring cylinder
      (*iv*) test tube

(d) To pass a gas from one vessel to another, you will use

   (i) gas jar
   (ii) delivery tube
   (iii) glass rod
   (iv) test tube

(e) To prevent the escape of a gas from a gas jar, you will cover its mouth with

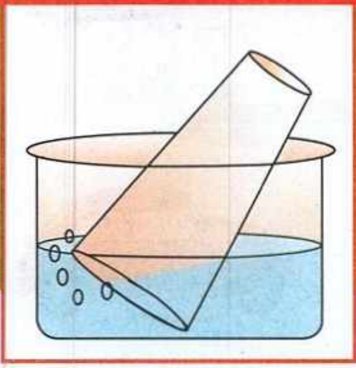
   (i) watch glass (ii) crucible
   (iii) beaker (iv) round bottom flask

4. Write ***true*** or ***false*** against the following statements and correct the false ones.

(a) A glass funnel is used to pour off liquids. ....
(b) A test tube is used to test liquid chemicals. ....
(c) A mortar and pestle is used for evaporation. ....
(d) A glass rod is used to stir solutions. ....
(e) A round-bottom flask is used to store chemicals. ....

Project

Visit your school chemistry laboratory with your teacher. Observe the arrangements carefully. Know about different apparatus and equipments and their use, make a list of those and draw the arrangement of your laboratory.



Matter

3

Theme : Matter exists in different physical forms *i.e.* solids, liquids and gases. One form can be converted into another. Matter expands on heating and contracts on cooling. Besides the physical changes, matter can also undergo chemical changes on heating.

In this chapter you will learn :

- *States of matter : Classification of matter into solid, liquid and gas on the basis of properties (shape, volume). Factors responsible for the existence of matter in different states.*
- *Arrangement of atoms/molecules in solids, liquids and gases — intermolecular space, cohesive forces).*
- *There is space between the particles of matter.*
- *Effect of heat on matter (expansion, change of state and chemical change).*

LEARNING OBJECTIVES

The children will be able to :

- discuss the properties of solids, liquids and gases.
- classify the matter into solid, liquid and gas.
- discuss the interconversion of one state of matter into another.
- explain the effect of heat on matter showing change of state, expansion and chemical change.

INTRODUCTION

When we look around us, we see many things like plants, animals, land, water, rocks, different objects like desk, chair, book, pen, pencil, bag, shoes, houses, cars, etc. They are of different shapes and sizes. Some are living while others are non-living. Some are natural while others are man-made. All these things are part of our environment.

But what makes up plants and animals? What makes up land and water? What makes up desk and chair? The answer to all these questions is ***matter***. In fact everything we can think of from the book which we read, the

Fig. 3.1

chair on which we sit, the water that we drink, etc. is all made up of matter.

Matter is not only what we can see or touch but, it also includes the air we breathe in, the sun, the stars and the planets in the universe.

Therefore, we can say that **all substances whether living or non-living are composed of matter.**

Creation of Matter : Most scientists believe that all the matter in the Universe was created in an explosion called the **Big Bang**. Great amount of energy was released. Then after just a few seconds, some bundles of energy turned into tiny particles of matter that made up the universe in which we live today.

- The different forms of energy are heat, light, sound, electricity, magnetism, chemical energy, nuclear energy, solar energy, *etc.*

MATTER

- **LIVING**
  - **PLANTS** — Lotus, banyan tree
  - **ANIMALS** — Dog, cat, humans
- **NON-LIVING**
  - **NATURAL** — Air, water, stars
  - **MAN-MADE** (Artificial) — Plastic, cement

(i) LIVING MATTER : Earth is home to all kinds of plants and animals. They can grow, move and reproduce on their own.

(ii) NON-LIVING MATTER : Most of the matter in the universe is non-living. It means that it does not grow, move or reproduce on its own. It can be natural or man-made.

(a) NATURAL MATTER : It occurs in nature and can be used to make more useful substances, *e.g., wood, coal, silk, water, stone, cotton, jute, cereals, fruits, etc.*

(b) MAN-MADE MATTER : It is produced artificially from natural matter, *e.g., plastics, soaps, detergents, medicines, glass, nylon, steel, ceramic, etc.*

Does matter of only one kind exist ? No, there are different kinds of matter.

Different substances are made up of different kinds of matter, like chair is made up of wood, bucket is made up of plastic, book is made up of paper, *etc.* Even a single material* can be used to make different objects.

* ***The word material is derived from matter.***

Activity 1

List five objects made by using each of the following materials:

1. Wood	2. Paper	3. Plastic
4. Metals	5. Leather	6. Cloth

NATURE OF MATTER

From the above it is clear that there are different kinds of matter with different properties. It is observed that all forms of matter **occupy space*** and **have a definite mass**.

* *The space occupied by matter is called its volume.*

"Matter can also be perceived by our senses". *For example*, we cannot see air but we can feel its presence.

Matter offers resistance too. *For example*, if you try to swim in fast flowing water or you try to walk during an air storm, you will experience resistance.

Hence matter is something that we can see, touch, taste, smell or feel.

Anything that has mass and occupies space is called **matter**.

EXERCISE – I

1. Define matter.
2. What are the two main types of matter ? Give two examples for each type.
3. Differentiate between living and non-living matter.
4. Select natural and man-made matter from the following list :

   Wood, plastic, silk, medicines, detergents, coal, water, ceramic, cotton, glass, nylon, fruits.

COMPOSITION OF MATTER [ATOMS AND MOLECULES]

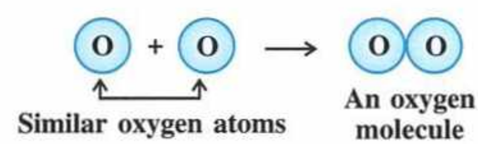
Now, you know that all substances are made up of matter. But, what is matter made of ? Matter is made up of extremely small particles called **atoms**. **"An atom is the smallest possible unit of matter that exhibits all the properties of matter"**. Atoms usually do not have an independent existence, therefore, they combine with one another. Two or more atoms combine together to form a minute particle called **molecule**. **"A molecule is the smallest unit of matter which exhibits all the properties of that kind of matter and is capable of independent existence."**

However, atoms and molecules are so small that they cannot be seen through naked eyes or even with an ordinary microscope.

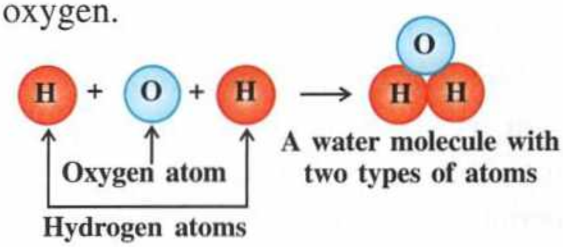
A molecule can be formed of atoms of one kind or different kinds.

Example :

(a) A molecule of oxygen is made up of two atoms of oxygen.



(b) A water molecule is made up of two atoms of hydrogen and one atom of oxygen.



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

CHARACTERISTICS OF PARTICLES/ MOLECULES OF MATTER

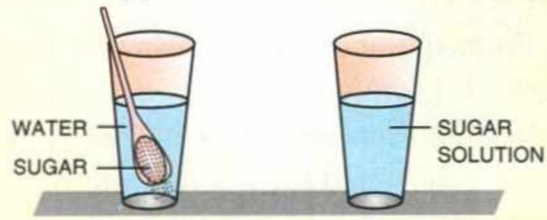
Properties of matter can be explained on the basis of the following characteristics of its particles.

- Particles of matter are held together by a force of attraction that exists between them. This force is known as **intermolecular force of attraction**. The force of attraction between particles of the same substance is known as "Cohesion". The force of attraction is different for different kinds of particles.
- Particles of matter are always in **random motion**, because they possess **kinetic energy**. It increases with increase in temperature and vice-versa.
- Particles of matter have space between them which is called **interparticular or intermolecular space or gap**. This is due to random motion of particles which sometimes brings them close to each other and sometimes keeps them apart.

Intermolecular gaps between the molecules can further be shown by the following activities.

Activity 2

Take half a glass of water. Add one teaspoon of sugar to it and stir. The sugar disappears but the level of water in the glass does not rise. It means the volume of water did not increase. But where did the sugar particles disappear ?

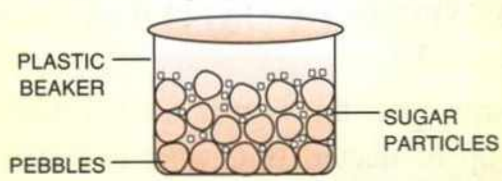


No change in the level of water

The sugar particles are adjusted between the water molecules. *This shows that there are intermolecular gaps between water molecules*.

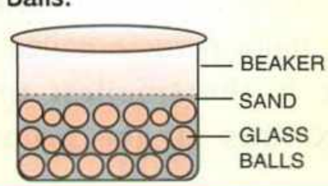
Activity 3

Take a plastic beaker and put some pebbles in it. Now add sugar or powdered table salt to it. Shake the beaker gently. You will observe that sugar particles get adjusted in the gaps between the pebbles.



Activity 4

Take a plastic beaker and put some glass balls in it. Now add sand to the beaker. You will observe that sand particles occupy the gaps between glass balls.



The above activities prove that **smaller particles can occupy the space between bigger particles.**

STATES OF MATTER

Intermolecular force of attraction and intermolecular space are two important properties of matter.

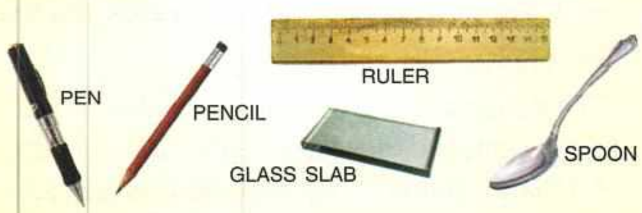
If the intermolecular force of attraction increases, the molecules come closer and thus intermolecular space decreases; but if the intermolecular force of attraction decreases, the molecules tend to move away and the intermolecular space increases. This fact accounts for the different states of matter.

Matter exists in three different states *i.e.* solid, liquid and gas.

Solid State : A solid has a definite shape and a definite volume. Molecules in the solid state are packed very close to each other. Intermolecular space is almost negligible while the intermolecular force of attraction between the molecules is very strong in solids.

Activity 5

Take objects like pen, pencil, ruler, glass-slab and spoon. Keep them in different containers. Now take them out and look at them. You will find that there is no change in the shape and size of these objects at room temperature.



This shows that solid objects have a definite shape.

Properties of solids

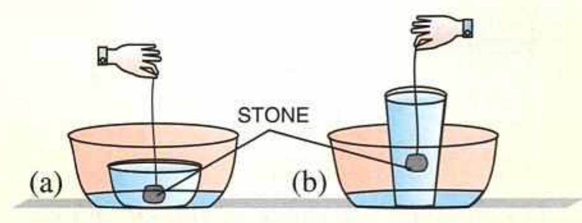
1. Solids are rigid.
2. They have a definite volume.
3. They retain their shape.
4. They are almost incompressible.
5. They can have any number of free surfaces.

Examples : Wood, stone, iron, diamond, gold, salt, sugar, sand, etc.

Note : Effect of pressure on solids depends upon the type of solids, *i.e.* hard or soft and also on conditions. **Hard solids** are incompressible while **soft solids** are slightly compressible.

Activity 6

Take a cup and a glass, both fully filled with water. Keep them separately in two troughs carefully. Take a piece of stone, tie it with a thread and dip it into each of them, one by one. Measure the volume of water which flows out in either case. The volume of overflown water is the same in each case.



A piece of stone has fixed volume

This shows that solid objects have a definite volume.

Liquid State : A liquid has a definite volume but no definite shape. The molecules in liquids are less closely packed than solids. The intermolecular space is greater than solids. The molecules have weaker intermolecular force of attraction, therefore, the liquid molecules have greater movement than solids and hence a liquid flows.

Properties of liquids

1. Liquids have no definite shape, they take the shape of the container in which they are kept.
2. They have a definite volume.
3. They can flow from a higher to lower level.
4. They have only one free surface.

Examples : Water, milk, fruit juice, kerosene, mustard oil, petrol, alcohol, *etc*.

Activity 7

Take a glass tumbler and fill it half with water. Observe the shape of the water in the glass [Fig. (A)]. Now, pour the water into a bowl. It fills the bowl up to two-third and takes the shape of the bowl [Fig. (B)]. Now pour the water into a cup [Fig. (C)]. The cup is completely filled but now the water takes the shape of the cup. Pour the water once again, this time from the cup to the glass tumbler.

(A) (B) (C)

Liquids take the shape of the container in which they are kept

Does the volume change ?

There is no change in the volume. This shows that water, when poured from one container to another, changes its shape, but its volume remains constant.

In each case, the top surface of the water remains free (exposed to air).

This proves that liquids can flow. They have a definite volume but no definite shape. They have only one free surface.

Gaseous state : A gas has neither a definite shape nor a definite volume. The molecules in a gas are far apart. The intermolecular force of attraction between the molecules is very weak and intermolecular space is large.

Properties of gases

1. Gases have no definite volume.
2. They do not have any definite shape.
3. They can flow and move in any direction.
4. They can be compressed inside a small container and can also spread into a large area, if available.
5. Gases exert equal pressure in all directions.

For example, air, when pumped into a football, takes the shape of the football. Similarly, the fragrance of an incense stick spreads into the whole room rapidly because of the gas coming out of it.

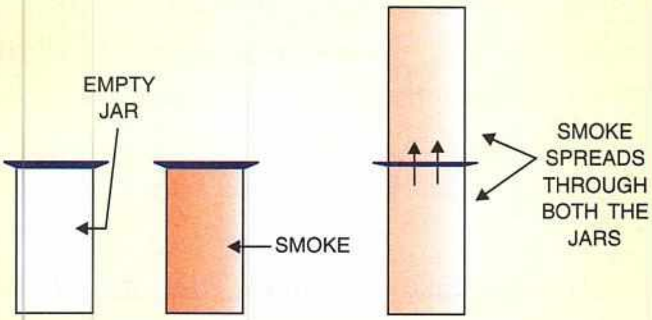
Examples :

Hydrogen, nitrogen, oxygen, carbon dioxide, sulphur dioxide, *etc*. Air is a mixture of gases.

Activity 8

Take two jars. Light an incense stick and allow its smoke to collect in one jar. Invert another jar over it. We observe that the gas spreads into the upper jar, as well.

This shows that gases can fill up all the space that they get, and they have neither a fixed shape nor a fixed volume. They have no free surfaces, either.



Gas fills up all the space available to it

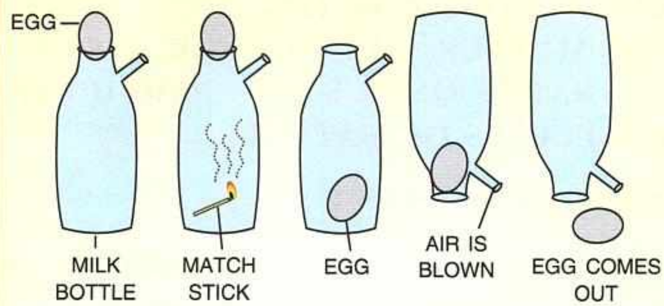
All substances that can flow are called **fluids**. Both gases and liquids are fluids.

Activity 9

To show that air exerts pressure

Take a narrow necked bottle with a side opening, a peeled hard boiled egg and a matchstick.

Set the egg on the top of the bottle. The egg won't go into the bottle. It is too large to fall inside the bottle. Since pressure is equal both inside and outside of the bottle, so no extra force is acting on it.



Now strike a match stick and drop it into the bottle and quickly set the egg on the top of the bottle as before. The match stick flame heats the bottle inside due to which air in the bottle expands and some of it escapes out of the side opening of the bottle. Now close the side opening. The match stick gets extinguished and air in the bottle cools again and gets contracted creating a low pressure inside the bottle. The egg is now forced by the outside air pressure to get sucked into the bottle.

Now invert the bottle and blow air into the bottle through the side opening. This creates high pressure inside the bottle and the egg is kicked out of the bottle.

Table 3.1 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 very loosely packed; have large intermolecular spaces.
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; almost incompressible.	Effect of pressure is higher than on a solid, can be compressed slightly.	Effect of pressure is very high; can be greatly compressed.

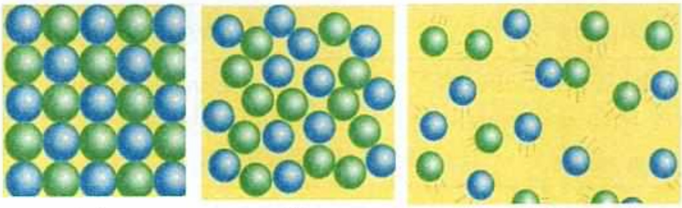
EXPLANATION FOR THE THREE STATES OF MATTER ON THE BASIS OF CHARACTERISTICS OF PARTICLES/ MOLECULES OF MATTER

SOLID

In *solids,* the molecules are closely packed. There is a strong force of attraction between the molecules and the space between them is very small (almost negligible). The molecules are, therefore, not free to move. They merely vibrate about their mean positions. ***This makes solids hard and difficult to compress, giving them a fixed shape and size.***

LIQUID

In the case of *liquids*, the molecules are not very closely packed. They do not attract each other as strongly as the molecules of solids. Thus, the intermolecular spaces are larger and the molecules are able to move about more freely. ***This makes a liquid flow and take the shape of the container into which it is poured. Thus, liquids have a fixed volume but no definite shape of their own.***



(a)	(b)	(c)
Molecules lie closely packed together, with a great force of attraction between them	Molecules lie fairly less apart from each other, with little force of attraction between them	Molecules lie very far from each other with very little force of attraction between them

Fig. 3.2 The position of molecules in the (a) solid, (b) liquid and (c) gaseous states.

GAS

In the case of *gases,* the molecules hardly attract each other. They lie far apart from each other and the intermolecular spaces are, therefore, very large. The intermolecular force of attraction is so weak that the molecules have great freedom of movement.

As a result, gases have neither a fixed shape nor a fixed volume. They completely fill up the space available to them. They can be easily compressed as well, thus decreasing the gaps between their molecules.

Thus, it is clear that difference in properties of states of matter is due to,

- intermolecular force or cohesive force
- random motion of particles.

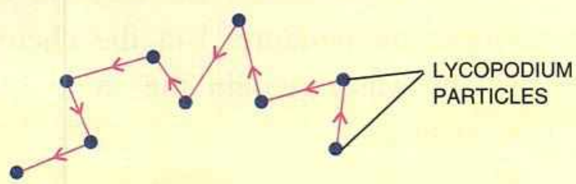
(i) **Cohesive force :** The force of attraction between like particles or molecules is called cohesive force. Solids have strong cohesive force. Mercury, although a liquid, also shows strong cohesive force. Liquids have weaker cohesive force and gases have the weakest.

(ii) **Random motion of particles**

(a) **Brownian movement :** The zig-zag motion of particles suspended in a medium is called **Brownian movement**.

Activity 10

Take a beaker half filled with water and suspend some lycopodium (rubber) powder in it. Look into the water through a microscope. You will notice that particles of lycopodium are moving rapidly in a zig-zag (irregular) manner throughout the water. If the beaker is heated, the movement further increases.



Particles showing zig-zag motion in water.

(b) **Diffusion :** Since particles of matter are in motion, the particles of one kind can mix with the particles of another kind through a natural movement.

"The phenomenon of intermixing of particles of one kind with another kind is called diffusion."

- Gases diffuse very fast because the particles of gases have enough space between them which allows them to move freely and to mix up easily.
- Liquids diffuse slowly than gases. But all liquids do not intermix with one another. Liquids which mix with each other are called **miscible liquids**. *Example :* Water and alcohol. Liquids which do not mix with each other are called **immiscible liquids**. *Example :* Water and oil.
- Solids are very rigid, hence either they do not diffuse under normal conditions or diffuse very little.

When temperature increases, diffusion also increases.

Do You Know ?

- We can detect the leakage of LPG because its smell spreads all around (diffusing property). The smell spreads because gases diffuse very fast.
- If we put a drop of red ink in a glass of water, its particles diffuse with particles of water slowly but continuously and the water turns red.
- Incense sticks lighted in one corner of the room release fragrance in the whole room or even out of the room, if the door is opened. It is due to diffusion.

EXERCISE – II

1. Name the smallest particle from which matter is made up of.
2. What are molecules ?
3. Give one difference between atoms and molecules.
4. Define :
   (a) Intermolecular force of attraction.
   (b) Intermolecular space.
5. Name the three states of matter and define them.
6. What are fluids ? Give two examples.
7. Classify the following into solids, liquids and gases.
   Oxygen, milk, common salt, wax, stone, L.P.G., carbon dioxide, sugar, mercury, coal, blood, butter, copper, coconut oil, kerosene.
8. Give reasons :
   (a) Liquids and gases flow but solids do not.
   (b) A gas fills up the space available to it.
   (c) The odour of scent spreads in a room.

(d) We can walk through air.

(e) Liquids have a definite volume but no definite shape.

(f) When a teaspoon of sugar is added to half a glass of water and stirred, the water level in the glass remains unchanged.

(g) When an empty gas jar is inverted over a gas jar containing a coloured gas, the gas also spreads into the empty jar.

(h) A red ink drop added to a small amount of water in a glass turns the water red in some time.

9. Define :
   (a) cohesive force
   (b) diffusion
   (c) Brownian movement

10. Why is an egg kicked out of a bottle when air is blown inside the bottle ?

EFFECT OF HEAT ON MATTER

When a substance is heated, it can cause:

- Interconversion of states of matter,
- Thermal expansion of the substance and
- Chemical change.

1. INTERCONVERSION OF STATES OF MATTER

In everyday life, we come across substances that change from one state to another. *For example*, water is a liquid under ordinary conditions, but when a glass of water is kept in a deep freezer, it turns into ice. This happens because it has been cooled down. When we heat water, it starts boiling and turns into steam.

$$\underset{\text{(solid)}}{\text{Ice}} \underset{\text{Cooled}}{\overset{\text{Heated}}{\rightleftharpoons}} \underset{\text{(liquid)}}{\text{Water}} \underset{\text{Cooled}}{\overset{\text{Heated}}{\rightleftharpoons}} \underset{\text{(gas)}}{\text{Steam}}$$

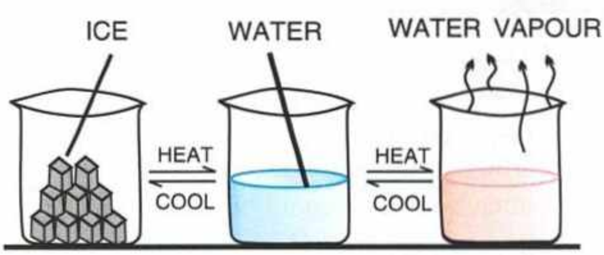


Fig. 3.3 Interconversion of states of water

Similarly, steam on cooling down, turns into liquid water, and so does ice when kept at room temperature. But the chemical properties of water remain the same in all the three states.

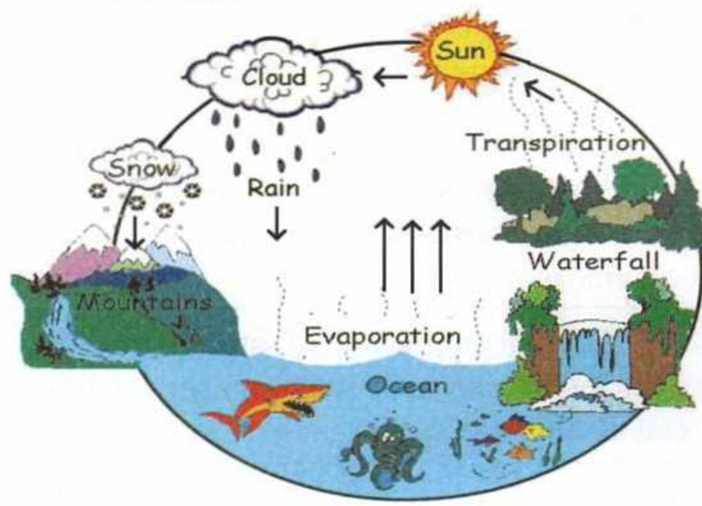


Fig. 3.4 Water cycle : The natural, never ending cycle of different states of water

The above example shows that matter can change from one state to another under certain conditions of temperature and pressure. This is called **interconversion of states of matter**.

Therefore, we can define interconversion of states of matter as *the process by which matter changes from one state to another and back to the original state, without any change in its chemical composition.*

The change in the state of matter is caused by **change in temperature** and by **applying pressure**.

Activity 11

Take some butter in a pan. Heat it and then stir with a spoon. The butter melts.

Butter remains in the solid state at room temperature (upto about 32°C) but when the temperature increases it changes from its solid state into a liquid. Put the melted butter in the refrigerator. What do you observe ? Does the chemical composition of butter changes ?

Activity 12

Take some orange juice in a bowl which is a liquid under normal condition. Put it into a freezer. After some time when you take it out you will find that it has turned into a solid. This is because the temperature is lower in the freezer than the room-temperature.

At room temperature *In the freezer*

If you lease it at room temperature for some time, it will again turn into a liquid and will taste the same.

The above two activities show that when temperature changes, matter changes its state.

Pressure is also one of the important factors for the change in the state of matter.

- LPG cylinders contain cooking gas in liquid state at high pressure. (However under normal conditions, LPG is a gas).
- Air contains mostly nitrogen and oxygen gases. Air changes to liquid state when temperature is decreased and pressure is increased. Oxygen cylinders used in the hospitals for patients contain oxygen in liquid form.

Even the hardest rocks under the earth's crust melt at a very high temperature and pressure to form magma.

Most of the substances known to us change their state when conditions are changed. Solid changes into liquid which further changes into gas when temperature is increased and when temperature is decreased, gas changes into liquid which further changes into solid.

$$\text{Solid} \underset{\text{Cool}}{\overset{\text{Heat}}{\rightleftharpoons}} \text{Liquid} \underset{\text{Cool}}{\overset{\text{Heat}}{\rightleftharpoons}} \text{Gas}$$

Note : There are some substances that directly change from the solid state to the gaseous state, and vice-versa, without passing through the liquid state. These substances are called **sublimable** substances and the conversion of a solid substance into its vapour without undergoing liquid state on heating is called **sublimation**. *For example*, camphor, iodine, dry ice (solid carbon dioxide) and naphthalene are sublimable substances. Naphthalene balls are thus used in bathrooms, wardrobes, *etc.*, to keep the pests away. Toilet freshners are also sublimable substances.

$$\text{Solid state} \underset{\text{Cooled}}{\overset{\text{Heated}}{\rightleftharpoons}} \text{Gaseous state}$$

Naphthalene balls kept along with woollen clothes, with passage of time, become smaller because they sublime and change into vapour state.

Do all the substances change their state ?

Activity 13

- Take a piece of paper. Put it over a flame.
- Heat a spoon of sugar in a pan.
- Heat 3/4th cup of butter in a pan.

What do you observe ?

Paper and sugar get burnt and do not change their state while butter melts.

SOME TERMS RELATED TO INTER-CONVERSION OF STATES OF MATTER

Melting or Fusion : The process by which a substance changes from solid state to liquid state is called **melting** or **fusion**.

This change occurs on heating a solid because the particles of solid gain energy and start vibrating more vigorously. A point is reached where particles gain enough energy to overcome the force of attraction and they start moving. Hence, with reducing intermolecular force of attraction, a solid changes into a liquid.

Melting Point : The fixed temperature at which a solid changes into a liquid at a given pressure is called its **melting point**. The temperature remains constant as long as the conversion is going on.

Different substances have different melting points in their pure state. *Example :* Melting point of ice is 0°C.

Vaporisation or Evaporation : The process by which a substance changes from a liquid state to vapour state is called **vaporisation** or **evaporation**. Evaporation takes place even at room temperature but it becomes faster on heating, that is on increasing the temperature.

The change of state of a liquid into vapour state on heating is called **boiling**.

Boiling is the extreme form of vaporisation.

As a liquid is heated, its particles start gaining energy and move more vigorously which increases the gaps between the particles and decrease the force of attraction. Ultimately, a liquid changes into gaseous state.

Boiling point : The fixed temperature at which a liquid starts changing into gaseous state is called its **boiling point**. The temperature remains constant till the whole of the liquid changes into gaseous state.

For example, the temperature of water will remain 100°C till all the boiling water converts into steam at normal atmospheric pressure.

Do You Know ?

Wet ink becomes dry because water in it turns into vapour and evaporates into air. Similarly a cut fruit left exposed to air dries up in a short time. We spread wet clothes under the sun to dry them fast.

Condensation or Liquefaction : The process by which a substance in gaseous state changes into its liquid state is called **condensation or liquefaction**.

This process occurs when a gas is cooled because on cooling, the energy of particles decreases and their movement becomes slow. The gaps between the particles decrease and the force of attraction between them increases, as a result they change from gas to liquid.

Condensation Point : It is the temperature at which a gas starts changing into its liquid state. *Example :* Condensation point of steam is 100°C.

Freezing or Solidification : The process by which a substance in liquid state changes into a solid state is called **freezing or solidification**.

This occurs when a liquid is cooled because on cooling, the particles lose energy and their movement becomes slow. They then come closer, decreasing the intermolecular space and increasing the intermolecular force of attraction, ultimately changing the liquid into a solid.

Freezing Point : The temperature at which a liquid starts changing into its solid state is called its **freezing point**.

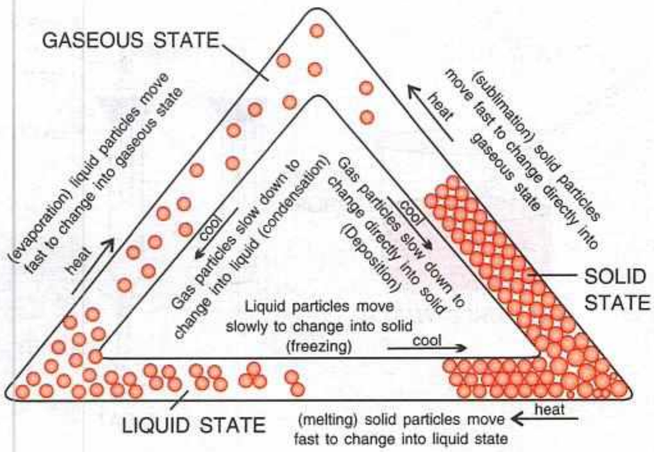


Fig. 3.5 Arrangement of particles in three states of matter and their interconversion

Note : Conversion of a solid to liquid on heating is called melting (or fusion).

Melting : Solid + Heat → Liquid

On cooling, liquid freezes into solid

Freezing : Liquid – Heat → Solid

The fixed temperature at which a solid melts to liquid is called its **melting point**.

The fixed temperature at which a liquid boils into its vapour state is called its **boiling point**.

Melting and boiling points depend upon the nature of the substance.

- Conversion of a liquid into vapour on heating is called **vaporisation**.

  Liquid + Heat → Vapour

- On cooling, vapour can be converted into liquid and is called **condensation**.

  Vapour – Heat → Liquid

Thus, we can see that the change of state is a **reversible change** affected by temperature and pressure.

2. EXPANSION OF MATTER

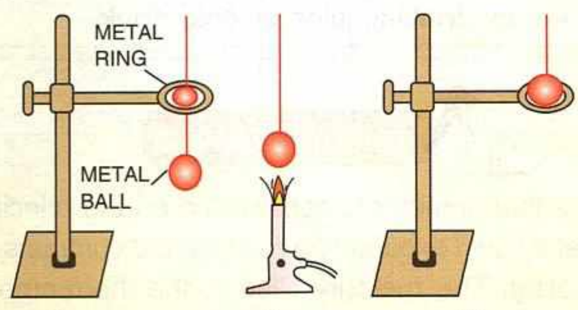
All the three states of matter *i.e.*, solid, liquid and gas expand on heating. This can be shown by the following activities.

Activity 14

Ball and ring experiment to show that a solid expands on heating and contracts on cooling.

Take a metallic ring and ball. Try to pass the metal ball through the ring. The ball is able to pass through the ring. Now heat the metal ball for 5-6 minutes. The hot ball is not able to pass through the ring.

This shows that a solid expands on heating. Now cool the ball, it again passes through the ring. This shows that a solid contracts on cooling.

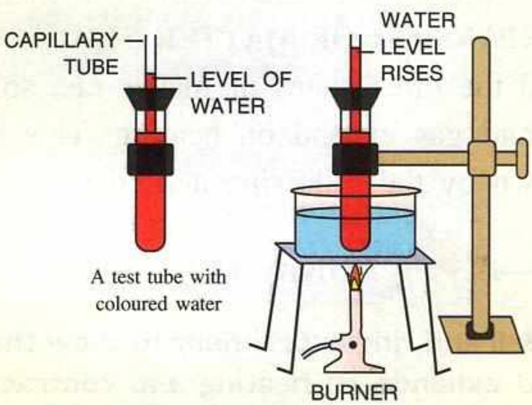


I — The metal ball passes through the ring
II — Metal ball is heated
III — The metal ball is unable to pass through the ring after being heated

Activity 15

To show that a liquid expands on heating and contracts on cooling.

Take a test tube filled with coloured water. Close the mouth of the test tube with a cork. Fit a capillary glass tube through a hole in the cork such that it is dipped in water. Some water enters the capillary tube. Note the level of water in the capillary tube. Now heat the test tube by putting in a water bath. You will observe that the level of coloured water increases in the capillary tube.



This shows that liquids expand on heating.

On cooling the test tube, the water level in the capillary tube decreases, showing that liquids contract on cooling.

Note : A capillary tube is a thin glass tube with small internal diameter.

The capillary action can also be shown with a straw by drinking juice or cold drink.

Do You Know ?

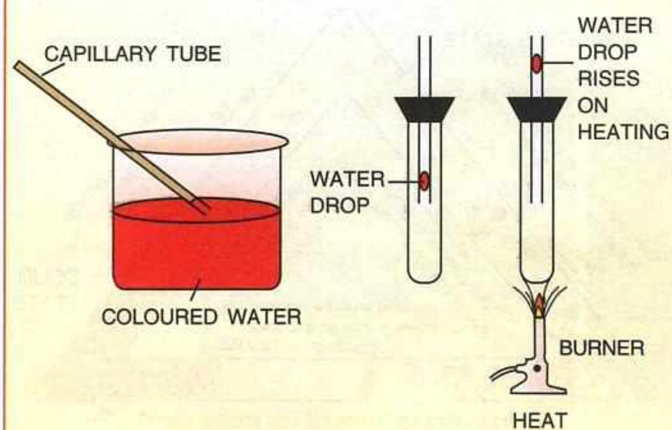
The thermometer is constructed on the principle that a liquid expands on heating and contracts on cooling. The mercury filled in the thermometer expands with increasing temperature and contracts on cooling *i.e.* decreasing temperature.

Activity 16

To show thermal expansion of a gas.

Take some coloured water in a beaker. Take a capillary tube and dip its one end in the coloured water to take a drop of it in the capillary tube. Fit this capillary through a hole in the cork. Now fit the cork in a test tube carefully.

Now heat the test tube. After some time you will observe that, drop of water moves up. This is because air in the test tube expands on heating which pushes the water drop up. Now cool the test tube, the water drop again comes down. This shows that air contracts on cooling.



3. CHEMICAL CHANGE ON HEATING

A chemical change is a permanent change in which new substances are formed from the substances taken. The properties of the new substances are entirely different from those of the original substances.

Heating causes chemical change in a substance. This can be shown by the following activity.

Activity 17

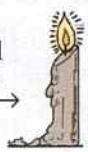
Take a piece of paper and burn it. It turns into ash. This is a new substance whose properties are different from that of the paper. Ash cannot be changed into paper again.

This proves that burning of a substance causes chemical change.

An example showing both physical and chemical changes is burning of a **candle**.

When a candle is lit, first, candle wax melts, then turns into vapour.

The vapours react with air to produce two new substances, carbon dioxide and water.

Lighting of a candle —physical change→  Candle wax —burning of wax / chemical change→ Carbon dioxide + Water vapour

Therefore, a candle on burning becomes smaller and smaller and the part of wax which has undergone chemical change cannot be recovered.

POINTS TO REMEMBER :

1. Gradual mixing of two or more substances by molecular motion is called ***diffusion***.
2. The freezing point of matter in the liquid state and the melting point of that matter in its solid state have the same numerical value for that substance. The freezing point of water is 0°C and the melting point of ice is 0°C.
3. The boiling point of matter in the liquid state and the condensation point of that matter as a gas have the same numerical value. The boiling point of water is 100°C and the condensation point of steam is also 100°C.
4. The substances which remain in the gaseous state under normal conditions of temperature and pressure are called **gases**.

   Example : Oxygen, hydrogen, nitrogen, carbon dioxide, etc. are in gaseous state at room temperature.

   The substances in gaseous state are called **vapour**.

   Example : Water changes into gaseous state on heating. Hence, its gaseous state is called water vapour.
5. A substance in pure state has a fixed boiling or melting point. Hence, boiling and melting points are used to test the purity of a substance. Their values change if the substance is not pure.

RECAPITULATION

- Matter occupies space, has mass and also offers resistance.
- Matter exists in three states – solid, liquid and gas.
- Solids have a definite volume and a definite shape.
- Liquids have a definite volume but no definite shape.
- Gases neither have a definite volume nor a definite shape.
- Liquids and gases are fluids because they can flow.
- Matter is made up of atoms and molecules.
- The distinction between atoms and molecules is that atoms are the smallest particles that may or may not have an independent existence, whereas molecules are the smallest particles capable of an independent existence.
- Molecules can have atoms of same type as well as of different types.
- Atoms and molecules are in random motion.
- The space between the molecules is called intermolecular space.
- The force of attraction between the molecules is called intermolecular force of attraction.
- Matter can change from one state to another if the factors like temperature and pressure are changed.
- Some solids on heating directly change into a gaseous state without passing through the liquid state. This process of conversion is known as sublimation.
- Matter can expand and undergo chemical change on heating.

EXERCISE – III

1. State the three effects of heat on matter.
2. (a) Define : interconversion of states of matter.
   (b) What are the two conditions for the interconversion of states of matter ?
3. Define the following terms :
   (a) Fusion (b) Vaporisation
   (c) Condensation (d) Sublimation
   (e) Diffusion (f) Melting point
   (g) Boiling point (h) Liquefaction
4. Differentiate between :
   (a) Solidification and condensation
   (b) Melting and boiling
   (c) Gas and vapour
   (d) Miscible and immiscible liquids
5. How is interconversion of states of matter different from a chemical reaction ?
6. How does a liquid change into its gaseous state ? Explain.
7. Water cycle is an example of interconversion of states of water. Explain.
8. What happens to a metal ball when it is heated ? What does this show ?
9. Why does a candle become smaller on burning with time ?

OBJECTIVE TYPE QUESTIONS

1. Fill in the blanks :
   (a) Water is matter because it has .... and occupies ....
   (b) Any matter which has a definite .... but no definite shape is called a ....
   (c) .... and .... can flow.
   (d) The molecules are at a greater distance in .... as compared to liquids.
   (e) Water boils at .... °C.
   (f) The physical state of a substance, which has neither fixed volume nor fixed shape is a ....

2. Write whether the following statements are ***true*** or ***false***.
   (a) Only water can exist in three different states. ....
   (b) If the container in which a gas is collected has an opening, the gas will flow out and spread itself indefinitely. ....
   (c) Solids have the largest inter-molecular space. ....
   (d) There is no difference between evaporation and boiling. ....
   (e) All solids, on heating, first change to liquid and then to the gaseous state. ....
   (f) The intermolecular force of attraction is the weakest in gases. ....
   (g) A gas has no free surface. ....

4. For each of the following statements, say whether it describes a solid, a liquid or a gas.
   (a) Particles move about very quickly but do not leave the surface.
   (b) Particles are quite close together.
   (c) Particles are far apart and move in all directions.

5. Match the following :

	Column A		Column B
(a)	Solids	(i)	Can flow in all directions.
(b)	Sublimation	(ii)	The temperature at which a liquid changes into its gaseous state.
(c)	Boiling point	(iii)	Can have any number of free surfaces.
(d)	Gases	(iv)	Gaps between particles.
(e)	Intermolecular space	(v)	Change of state directly from solid to gas.

6. Name the phenomenon which causes the following changes :
   (a) Formation of water vapour from water.
   (b) Disappearance of camphor when exposed to air.
   (c) Conversion of ice into water.
   (d) Conversion of water into steam.

7. Give two examples for each of the following:-
   (a) Substances which sublime.
   (b) Substances which do not change their state.
   (c) Substances which are rigid and not compressible.

MULTIPLE CHOICE QUESTIONS

1. Which one is a kind of matter ?
   (a) light (b) petroleum
   (c) sound (d) heat

2. The state of matter which has no definite shape or volume is called
   (a) solid (b) liquid
   (c) gas (d) water

3. There are large intermolecular gaps in
   (a) water (b) iron ball
   (c) common salt (d) air
4. All kinds of matter
   (a) occupy space and have a definite mass
   (b) have mass and a definite shape
   (c) can change their states
   (d) have a definite volume
5. A kind of matter which can sublime is
   (a) water (b) plastic
   (c) milk (d) iodine
6. A substance which can change its state
   (a) wood (b) oxygen
   (c) paper (d) cloth
7. The process by which a solid changes into a liquid is called
   (a) freezing (b) melting
   (c) condensation (d) evaporation

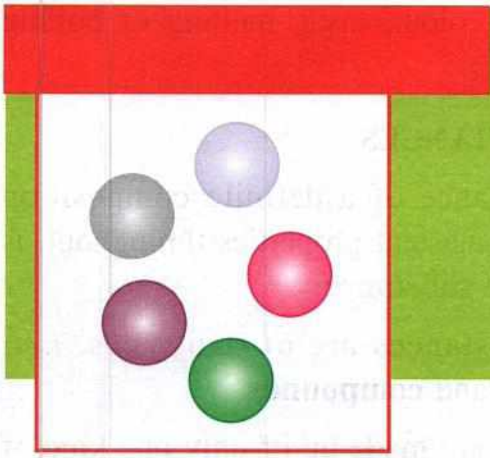
Project

1. Write the names of twelve solids, twelve liquids and four gases under the respective headings given below.

Solids	Liquids	Gases
....	....	....
....	....	....
....	....	....
....	....	....
....	....	....
....	....	....
....	....	....

2. Think and try to find a way to demonstrate water cycle in class.
3. To identify materials of common use :
   Procedure — Just move around in your house — in the drawing room, sitting room, bedroom, kitchen, bathroom, etc.
   Identify the things and fill in the blanks in the table given below :

S.No.	Place	Name of the thing	Material used for making the thing
1.	Study room	....	....
2.	Drawing room	....	....
3.	Kitchen	....	....
4.	Bathroom	....	....
5.	Any other place	....	....



Elements, Compounds, Symbols and Formulae

4

Theme : All materials/objects found around us are either in solid, liquid or gaseous form and occupy space and have mass. In science, the term matter is used for all these materials. Chemically matter can be classified as element, compound and mixture.

In this chapter you will learn :

- Element (a substance made up of identical atoms)
  - Use of symbols as short hand notations of writing names of elements.
  - Origin of symbols of elements.
  - Names and symbols of first 20 elements.
  - Molecules of elements contain atoms of the same element (O_2, N_2, H_2)
- Compound (two or more than two elements combine in fixed definite proportions to form a compound. Original properties of the constituent elements are lost and a substance with new properties is formed.)
  - Molecules of compounds contain atoms of different elements. (H_2O, CO_2, NO_2, CaO, $ZnCl_2$)

LEARNING OBJECTIVES

The children will be able to :

- ☞ define elements as made up of identical atoms.
- ☞ classify elements as metals and non-metals on the basis of their properties.
- ☞ define compounds as made up of different types of atoms.
- ☞ use symbols of elements and molecular formulae of the compounds to represent their names as short hand notations.

INTRODUCTION

In the previous chapter you have learnt that all substances are made up of matter. On the basis of its state, matter can be a solid, liquid or gas although they may contain the same kind of matter.

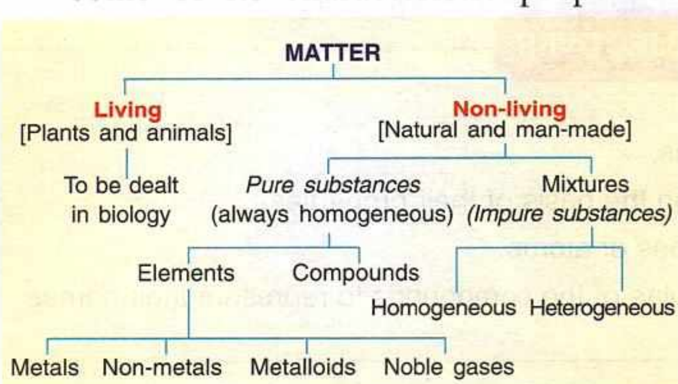
For example : Water, water vapour and ice are the three states of the same kind of matter.

Classification of matter can also be done on the basis of some **similarities and dissimilarities in their chemical composition.**

For example :

- Salt and sugar both are solids but they differ from each other because they are made up of different kinds of atoms.
- Water and oil are both liquids but their matter differs from each other.

  The substances made up of different kinds of matter may be **pure or impure, homogeneous** (uniformly mixed) **or heterogeneous** (with non uniform composition).
- A substance in which some other substances are also present in smaller amounts is called an impure substance.
- The purity of a substance can be checked by measuring or examining some of its characteristic properties such as colour, taste, melting or boiling point, etc.



PURE SUBSTANCES

A substance of a definite composition which has consistent properties throughout, is called a **pure substance**.

- Pure substances are of two types, *i.e.,* **elements** and **compounds**.
- Elements are made up of only one kind of atoms and compounds are made up of only one kind of molecules.
- They have uniform composition throughout, *i.e.,* they are homogeneous.
- They have a definite set of physical and chemical properties.
- They have fixed melting and boiling points.
- Pure substances have characteristic colour, odour and taste.
- Pure substances cannot be broken into simpler substances by any physical means.

For example : Water is a pure substance, it has a fixed boiling point of 100°C and it freezes at 0°C. If some common salt is mixed in it, the resulting solution boils at a higher temperature and freezes at a lower temperature, that means it has some impurity.

ELEMENTS

There are millions of substances in this world. But they are all made up of a limited number of basic substances. ***These basic substances are called elements***. Oxygen, hydrogen, nitrogen, carbon, copper, silver, gold, iron, tin and zinc are a few examples of elements.

To be done by the subject teacher

Show the samples of iron powder, zinc granules and sulphur to the students to make them familiar with elements.

Scientists have so far discovered 118 elements. Of these, 92 are found on earth, which occur in nature like in rocks, soil, air and water. The remaining 26 have been created artificially.

An element is defined as a pure substance made up of only one kind of atoms that *cannot be converted into anything simpler than itself by any physical or chemical process.*

Thus, each element has its own unique properties. For example, a gold bar is made up of only gold atoms.

Elements are the basic substances from which all other substances are made.

On the basis of their properties, elements are classified 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, iron, copper, aluminium, tin, zinc, magnesium, lead, calcium, *etc.*

Properties of Metals :

1. Metals are usually shiny (lustrous) and hard (*Exception* : Sodium is a soft metal).
2. They are solids (*Exception* : Mercury is a liquid metal).
3. They are ductile, *i.e.*, they can be drawn or stretched into thin wires.
4. They are malleable, *i.e.*, they can be beaten into thin sheets (*Exception* : Zinc is brittle; on beating it breaks into pieces).
5. They are good conductors of heat and electricity. (*Exception :* Tungsten which is a poor conductor).
6. They have high melting and boiling points.
7. They produce a specific sound when struck, *i.e.* they are sonorous substances.

Non-metals

1. These are elements with dull surfaces, *i.e.*, they do not shine. *Exception :* Iodine and carbon (in the form of diamond and graphite) shine.
2. They are less in number as compared to metals.
3. Non-metals are either *soft solids*, [*Examples* : sulphur, phosphorus, iodine] or *gases* [*Examples* : oxygen, nitrogen, hydrogen, chlorine] (*Exception*: Bromine is the only liquid non-metal).
   Note : Carbon exists as soft solid like charcoal, soot, coal and graphite and as hard solid like diamond.
4. Non-metals cannot be drawn into wires or beaten into thin sheets, *i.e.* they are neither ductile nor malleable.
5. They are mostly brittle in nature.
6. Non-metals are bad conductors of heat and electricity. (Carbon as graphite is the only exception since it is a good conductor of electricity).
7. They have low melting and boiling points, except diamond and graphite.
8. They do not produce sound when struck, *i.e.* they are non-sonorous.

Do You Know ?

Diamond (carbon), though a non-metal, is the hardest naturally occurring solid substance.

Table 4.1 Differences between metals and non-metals

S.No.	Property	Metals	Non-metals
1.	Boiling point	High	Low
2.	Melting point	High	Low
3.	Conductivity	Good conductor	Bad conductor
4.	Density	High	Low
5.	Metallic lustre	Shiny	Dull surface
6.	Malleability	Malleable	Non-malleable
7.	Ductility	Ductile	Non-ductile
8.	State	Solid	Solid, liquid,

Metalloids

These are the elements which are neither metals nor non-metals. They show some properties of metals and some properties of non-metals. Metalloids are solids. These are : boron, silicon, arsenic, antimony, germanium, tellurium and polonium.

Noble or Inert Gases

These are gaseous elements that do not react chemically with other elements. As a result, they are known as *inert gases* or *noble gases.* They are found in air only in traces. They are six in number : helium, neon, argon, krypton, xenon and radon.

SYMBOLS OF ELEMENTS

The symbols of chemical elements are abbreviations that are used to denote chemical elements. It was Berzelius who first used English alphabets to represent the elements.

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

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

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

Example : Carbon, calcium and cobalt are three such elements whose first letter is same *i.e.* C.

Thus carbon is denoted by the symbol 'C', calcium is denoted by two letters 'Ca' and cobalt is denoted by the symbol 'Co'.

If the first two letters of the elements are same, then for one of them the symbol is taken from its Latin name.

Example : Cobalt and copper.

Cobalt is denoted by 'Co' while copper is denoted by 'Cu' taken from its Latin name Cuprum. Element iron is denoted by 'Fe' taken from its Latin name Ferrum.

Symbol is a short form that also represents an atom of a specific element [atom is the smallest unit of an element].

Table 4.2 : Names and symbols of first 20 elements

Name	*Symbol*	*Name*	*Symbol*
Hydrogen	H	Sodium	Na
Helium	He	Magnesium	Mg
Lithium	Li	Aluminium	Al
Beryllium	Be	Silicon	Si
Boron	B	Phosphorus	P
Carbon	C	Sulphur	S
Nitrogen	N	Chlorine	Cl
Oxygen	O	Argon	Ar
Fluorine	F	Potassium	K
Neon	Ne	Calcium	Ca

Elements mentioned in Table 4.2 are the first twenty elements occuping the first 20 positions in the **Periodic Table** which is a systematic arrangement of elements in a tabular form for their convenient study.

Group :	↓	IA	IIA	IIIA	IVA	VA	VIA	VIIA	Zero
Period →	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.

The horizontal rows are called **periods** represented by 1, 2, 3, 4 ...... while vertical columns are called **groups** represented by IA, IIA ..... zero.

The subject teacher should use the Periodic Table Chart to show the first 20 elements.

BIRTH OF THE ELEMENTS

The simplest element is hydrogen, which was the first to be formed shortly after the Big-Bang. It was followed by Helium. All the elements now known to us were created in the heart of stars which were scattered through space when the stars exploded.

Exploding Star

COMMON ELEMENTS

1. **In the universe –** Hydrogen and helium are the two most common elements.
2. **In the earth's crust –** Oxygen is in greatest amount followed by silicon, aluminium and iron.
3. **In the atmosphere –** Nitrogen is the most abundant element.
4. **In the human body –** Carbon, hydrogen and oxygen are the most common elements because they make up the different compounds in all the body cells.

COMPOUNDS

To understand the meaning of a compound, the following facts are to be considered.

(i) The 26 English alphabets make huge number of words with different combinations you read in a dictionary.

(ii) The ten digits from 0-9 make infinite sets of numbers.

(iii) Only a few basic units (building blocks) make a large number of objects and materials with various combinations.

That means most of the things known to us consist of combinations of different elements.

Compounds are pure substances formed by the chemical combination of two or more elements in a definite proportion by mass.

Example : Water, marble, glucose, sugar, salt, alcohol, carbon dioxide, calcium oxide, nitrogen dioxide, zinc chloride, etc.

A compound can be broken down into simpler substances. A substance like table salt is a compound, not an element, because it can be broken down into two elements, *i.e.*, sodium and chlorine by a chemical process. [Its chemical name is sodium chloride].

Table 4.3 : Examples of compounds

Compound	Elements present
Water	Hydrogen, oxygen
Sugar	Carbon, hydrogen, oxygen
Common salt (or sodium chloride)	Sodium, chlorine
Alcohol	Carbon, hydrogen, oxygen
Ammonia	Nitrogen, hydrogen
Marble/chalk	Calcium, carbon, oxygen
Sand/Silica	Silicon, oxygen
Sodium carbonate	Sodium, carbon, oxygen
Glucose	Carbon, hydrogen, oxygen
Carbon dioxide	Carbon, oxygen
Nitrogen dioxide	Nitrogen, oxygen
Calcium oxide	Calcium, oxygen
Zinc chloride	Zinc, chlorine

Molecule is the smallest unit of a compound. A molecule of a compound consists of atoms of two or more elements in a definite proportion *i.e.* fixed ratio.

Note : All the molecules of a compound are same in all respects, but they differ from the molecules of other compounds. Therefore, each compound has its own specific physical and chemical properties. A molecule of water is completely different from a molecule of glucose.

The properties of compounds are also found to be completely different from those of the elements of which they are made up of.

Remember :

The important characteristics of a compound are :

1. It consists of two or more elements.
2. The constituting elements of a compound are combined in a definite proportion in every sample of the compound.
3. It is pure and homogeneous.
4. The physical and chemical properties of a compound differ from those of its constituent elements.
5. The components of a compound cannot be separated by simple physical means, *e.g.* filtration, evaporation, decantation, boiling, melting, freezing, *etc.*
6. Energy is either absorbed or evolved when a compound is formed.

To explain the above characteristics let us take an example of a very simple compound, water, which was earlier thought to be an element but later on it was found that, it is a compound.

- Water is formed when the two elements hydrogen and oxygen combine chemically in a fixed ratio of 1:8 by mass. From whatever source the water is taken and tested, the ratio of hydrogen and oxygen is found to be the same. It will always have a fixed formula H_2O *i.e.* two atoms of hydrogen and one atom of oxygen.
- The properties of water are entirely different from those of its constituent elements. Hydrogen and oxygen are gases but water is a liquid under normal conditions. Hydrogen burns itself, oxygen supports burning but water helps in putting off fire.
- Water molecule cannot be broken into its constituent elements hydrogen and

oxygen by simple physical methods. Its components can only be separated by a chemical process known as **electrolysis***.

- Heat and light are produced when hydrogen and oxygen burn together and chemically combine to form water.

Another example is **common salt** which is a compound "sodium chloride" made up of sodium and chlorine. Sodium is a metal that is stored in kerosene oil as it reacts very fast with air and water. Chlorine is a reactive greenish yellow gas which is poisonous. When these two elements combine chemically they form common salt, a non poisonous white solid substance that we use in our food to add taste and to obtain nutrition.

The two elements present in salt can be separated only by electrolysis, a chemical process.

Note : Two or more elements, when mixed in any proportion and not combining chemically, form a **mixture**. *E.g. :* A mixture of iron and sulphur. These elements can be separated by physical methods.

** Electrolysis is a chemical process in which electric current is passed through a compound in liquid state to separate its constituent elements.*

Table 4.4 : Proportion of elements by mass in some compounds

Compounds	*Elements*	*Proportion of elements by mass*
H_2O	H : O	1 : 8
CO_2	C : O	3 : 8
NO_2	N : O	7 : 16
CaO	Ca : O	5 : 2
NaCl	Na : Cl	23 : 35·5
$ZnCl_2$	Zn : Cl	65 : 71

In a compound, elements always combine in a fixed proportion. Any change in the proportion of elements will make a different compound, *e.g.* if two hydrogen atoms and one oxygen atom combine, they form a molecule of water (H_2O). However, if two hydrogen atoms and two oxygen atoms combine, they form a different compound hydrogen peroxide (H_2O_2), which is completely different, as compared to water.

In the same way NO_2, N_2O and NO are different compounds, though all three are made up of nitrogen and oxygen but in different proportions.

EXERCISE – I

1. Classify the following substances into elements and compounds.
   Mercury, sulphur, sugar, water, sand, gold, carbon, oxygen, alcohol, iron, marble, baking soda.
2. Give the symbols of : carbon, calcium, copper, chlorine, cobalt, argon.
3. Define a pure substance. Name the types of pure substances you know.
4. Define :
   (a) Elements (b) Compounds.
5. Give two examples for each of the following :
   (a) Metals (b) Non-metals
   (c) Metalloids (d) Noble gases
6. Name the elements which form water. State three characteristics of water to justify that it is a compound.
7. Give three differences between metals and non-metals.
8. State four important characteristics of compounds.
9. How is sodium chloride different from its constituent elements, sodium and chlorine in its properties ? Justify.
10. Give two examples for each of the following :
    (a) Non-metals which are solids
    (b) Metals which are soft
    (c) Non-metals which are lustrous
    (d) Elements which are liquids
    (e) Inert gases
11. Name the elements present in the following compounds.
    (a) Sugar (b) Ammonia
    (c) Marble (d) Washing soda
12. What is the proportion of elements by mass present in the following compounds ?
    (a) H_2O (b) CO_2
    (c) CaO (d) NO_2

ATOMS AND MOLECULES

You have studied in the previous chapter that matter is made up of particles called molecules which have independent existence. These molecules are made up of even smaller particles called **atoms** which may or may not have independent existence. Hence,

> "An atom can be defined as the smallest indivisible unit of an element which exhibits all the properties of that element and may or may not have independent existence".

However, these atoms can take part in chemical reactions.

> Atoms were discovered by the famous scientist John Dalton.

> "A molecule can be defined as the smallest unit of an element or a compound which exhibits all the properties of that element or compound and has independent existence. They are divisible into atoms".

Molecules do take part in chemical reactions.

Molecules of elements are of the following types :

1. A molecule is ***monoatomic*** when it contains only one atom.

Examples : Helium (He), Potassium (K), Sodium (Na), Calcium (Ca).

2. A molecule is ***diatomic*** when it contains two atoms.

Examples : Elementary gases (gases made up of only one element)

Hydrogen (H_2), Oxygen (O_2), Nitrogen (N_2), Chlorine (Cl_2).

3. A molecule is ***triatomic*** when it contains three atoms. *Example :* Ozone (O_3).

4. A molecule is ***polyatomic*** when it contains more than three atoms.

Example : • Phosphorus (P_4) which contains four atoms in its molecule.

• Sulphur (S_8) which contains eight atoms in its molecule.

Molecules of compounds : When atoms of two or more elements combine, they form a molecule of a compound.

Examples :

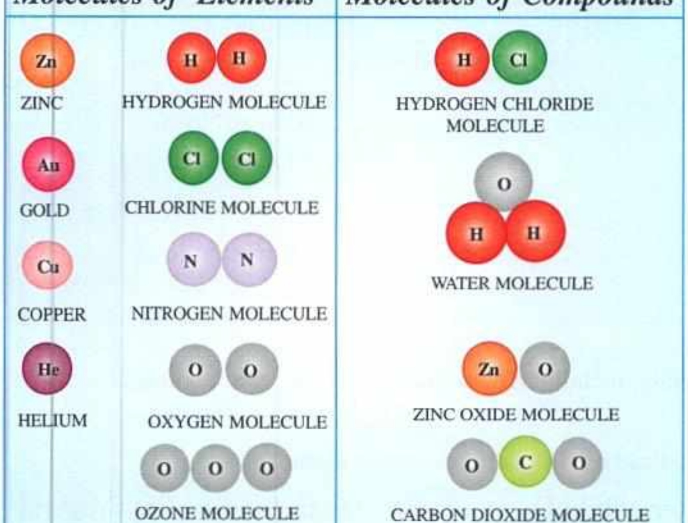
(i) A water molecule is formed by two atoms of hydrogen and one atom of oxygen.

(ii) A molecule of carbon-dioxide is formed by one atom of carbon and two atoms of oxygen.

The combination of atoms to form molecules of different elements and compounds can be represented diagrammatically. (Table 4.5).

Table 4.5 : Diagrammatic representation of molecules

Molecules of Elements	*Molecules of Compounds*



[Atoms of zinc, gold, copper and helium also represent their molecules]

FORMULA

The molecule of an element or a compound can be represented by a formula which is accepted universally all over the world.

A formula* (plural : *formulae) is a short way of representing the molecule of an element or a compound.

It is meant to save time, space and energy.

Formulae of elements : In case of an element, each molecule is made up of a definite number of atoms. The number of atoms in a molecule of an element is called its **atomicity**. While writing the formulae, atomicity is mentioned as subscript along with the short form of the element. Normally subscript 1 (one) is not written. *Examples :*

1. We write the formulae of monoatomic elements by simply writing their symbols. *e.g.* Helium (He), Potassium (K), Sodium (Na), Calcium (Ca), etc.
2. If an element is diatomic, we write the subscript 2 along with the symbols. *e.g.* Hydrogen (H_2), Oxygen (O_2), Nitrogen (N_2), Chlorine (Cl_2), etc.
3. We follow the above method in writing the formulae of triatomic and polyatomic elements. *e.g.* Ozone is written as O_3, Phosphorus is written as P_4 and Sulphur is written as S_8.

Formulae of compounds : Compounds are formed by the combination of the atoms of more than one element. Atoms combine with each other in whole numbers, which can be 1, 2, 3 or more. This whole number is the combining capacity of the elements.

For example, water is a compound of hydrogen and oxygen. Two atoms of hydrogen combine with an atom of oxygen to form a molecule of water. This is represented by the formula, H_2O. Therefore, the whole number ratio in which hydrogen and oxygen

Table 4.6 : Formulae of molecules of some common elements

Elements	*Formulae of molecules*	*Atoms in one molecule*	*Atomicity*
Metals			
Iron	Fe	1	Monoatomic
Zinc	Zn	1	Monoatomic
Copper	Cu	1	Monoatomic
Magnesium	Mg	1	Monoatomic
Lead	Pb	1	Monoatomic
Calcium	Ca	1	Monoatomic
Sodium	Na	1	Monoatomic
Cobalt	Co	1	Monoatomic
Chromium	Cr	1	Monoatomic
Gold	Au	1	Monoatomic
Manganese	Mn	1	Monoatomic
Silver	Ag	1	Monoatomic
Mercury	Hg	1	Monoatomic
Non-metals			
Carbon	C	1	Monoatomic
Hydrogen	H_2	2	Diatomic
Nitrogen	N_2	2	Diatomic
Oxygen	O_2	2	Diatomic
Fluorine	F_2	2	Diatomic
Chlorine	Cl_2	2	Diatomic
Bromine	Br_2	2	Diatomic
Iodine	I_2	2	Diatomic
Ozone	O_3	3	Triatomic
Phosphorus	P_4	4	Polyatomic
Sulphur	S_8	8	Polyatomic
Metalloids			
Antimony	Sb	1	Monoatomic
Arsenic	As	1	Monoatomic
Inert gases			
Helium	He	1	Monoatomic
Neon	Ne	1	Monoatomic

Note : • From the above table it is clear that molecules of metals, metalloids and inert gases are monoatomic, *i.e.* their atoms exist freely.

• Hydrogen, nitrogen, oxygen, fluorine and chlorine are gaseous, non-metallic diatomic elements.

In 2H and H_2 — 2H represents two atoms of hydrogen while H_2 represents one molecule of hydrogen.

In $2O_2$ and 2O — $2O_2$ represents two molecules of oxygen while 2O represents two atoms of oxygen.

atoms combine is 2 : 1. That means, the combining power of hydrogen is 1 and that of oxygen is 2.

Now, let us look at the formulae of some common compounds like sodium chloride, calcium chloride and magnesium oxide. First, write down the symbols of the elements side by side that form the compound. Under each symbol, write down the combining power of the element. Then interchange the combining power to obtain the chemical formula of a compound. *Example :*

Na Cl	Ca Cl	Mg O
1 ╳ 1	2 ╳ 1	2 ╳ 2
NaCl	$CaCl_2$	MgO

***Note :** Do not write down the subscript numbers if they are the same.* For example, *the formula of magnesium oxide is MgO, not Mg_2O_2.*

Student activity

Following are the combining powers of the constituting elements of the compounds shown in the table. Now write down the formulae for these compounds :

Combining power : Na : 1, Cl : 2, Fe : 2, Zn : 2

Al : 3, O : 2, S : 2, Cl : 1

1. Iron oxide
2. Iron sulphide
3. Sodium oxide
4. Calcium oxide
5. Calcium sulphide
6. Zinc chloride
7. Zinc sulphide
8. Aluminium oxide
9. Aluminium chloride

Table 4.7 : Molecular formulae of some gaseous compounds

Compounds	*Formula*	*Compounds*	*Formula*
1. Carbon dioxide	CO_2	6. Hydrogen sulphide	H_2S
2. Carbon monoxide	CO	7. Nitrogen dioxide	NO_2
3. Sulphur dioxide	SO_2	8. Nitric oxide	NO
4. Sulphur trioxide	SO_3	9. Nitrous oxide (Dinitrogen oxide)	N_2O
5. Ammonia	NH_3		

Table 4.8 : Formulae of some metallic oxides and metallic sulphides

Metallic oxide	*Formula*	*Metallic sulphides*	*Formula*
1. Magnesium oxide	MgO	7. Magnesium sulphide	MgS
2. Calcium oxide	CaO	8. Calcium sulphide	CaS
3. Iron (II) oxide	FeO	9. Iron (II) sulphide	FeS
4. Copper oxide	CuO	10. Copper sulphide	CuS
5. Zinc oxide	ZnO	11. Zinc sulphide	ZnS
6. Lead oxide	PbO	12. Lead sulphide	PbS

IMPORTANCE OF FORMULAE

A formula gives us the following information about a compound.

(i) Types of elements present in the compound.

(ii) Number of each kind of atoms in one molecule of the compound.

(iii) Ratio of different types of atoms present in the molecules.

(iv) Mass of one molecule of the compound.

Examples :

(i) A molecule of carbon dioxide gas is represented by CO_2.

It indicates that a carbon dioxide molecule is formed by the combination of two elements *i.e.* carbon and oxygen. The number of carbon atom is one and that of oxygen atom is two. The mass of one molecule of carbon dioxide can be calculated by adding the mass of one atom of carbon and two atoms of oxygen.

(ii) If we write $2CO_2$, it represents two molecules of carbon dioxide. It contains two atoms of carbon and four atoms of oxygen [we multiply the number of atoms of each type in one molecule by the numeral written on the left hand side].

(iii) A molecule of sulphuric acid is represented by 'H_2SO_4'. It indicates that one molecule of this acid is formed when two atoms of hydrogen, one atom of sulphur and four atoms of oxygen combine together.

Table 4.9 : Some common compounds — their state, formulae and elements present in them

Compounds	*State*	*Formulae*	*Elements present*
1. Water	Liquid	H_2O	Hydrogen and oxygen
2. Common salt [Sodium chloride]	Solid	NaCl	Sodium and chlorine
3. Sand [Silicon dioxide]	Solid	SiO_2	Silicon and oxygen
4. Hydrochloric acid	Liquid	HCl	Hydrogen and chlorine
5. Sodium hydroxide	Solid	NaOH	Sodium, oxygen and hydrogen
6. Marble and chalk [Calcium carbonate]	Solid	$CaCO_3$	Calcium, carbon and oxygen
7. Sulphuric acid	Liquid	H_2SO_4	Hydrogen, sulphur and oxygen
8. Nitric acid	Liquid	HNO_3	Hydrogen, nitrogen and oxygen
9. Calcium hydroxide	Solid	$Ca(OH)_2$	Calcium, oxygen and hydrogen
10. Glucose	Solid	$C_6H_{12}O_6$	Carbon, hydrogen and oxygen
11. Cane sugar [Sucrose]	Solid	$C_{12}H_{22}O_{11}$	Carbon, hydrogen and oxygen
12. Vinegar [Acetic acid]	Liquid	CH_3COOH	Carbon, hydrogen and oxygen
13. Baking soda [Sodium bicarbonate]	Solid	$NaHCO_3$	Sodium, hydrogen, carbon and oxygen

EXERCISE – II

1. Define :
   (a) Atom (b) Molecule
   (c) Atomicity (d) Formula
2. Why are symbols and formulae of substances important ?
3. Mention three gaseous elements and write their molecular formulae.
4. State the information obtained from the formula of a compound.
5. State the difference between the following :
   (a) 2H and H_2 (b) H_2O and $3H_2O$?
6. State the number of atoms of each element, present in
   (a) $C_6H_{12}O_6$ (b) H_2SO_4
   (c) HNO_3 (d) $CaCO_3$
   Also name these compounds.
7. Write the molecular formulae of compounds calcium oxide, hydrogen sulphide, carbon monoxide and lead sulphide.
8. Give two examples each of compounds existing in the following states :
   (a) Solid (b) Liquid (c) Gaseous

USES OF DIFFERENT ELEMENTS AND COMPOUNDS ON THE BASIS OF THEIR PROPERTIES

Now you know that there are different types of elements and compounds since they consist of different types of atoms and molecules, *i.e.* different kinds of matter differ from one another in their properties. The difference in their properties forms the basis of their uses in our daily life.

For example : A frying pan is made up of steel but its handle is made up of wood or plastic. This is because steel is a good conductor of heat and it allows heat to pass to the food kept in the pan for cooking while wood and plastic being bad-conductors or insulators do not get too hot to burn our hand.

Fig. 4.1 A frying pan

Some of the substances of use are mentioned below :

- *Gold, platinum and silver* are lustrous. They shine and look very attractive. They can also remain in free state. They do not tarnish in air. Therefore these metals are used to make ornaments and jewellery.
- *Copper and aluminium* are good conductors of heat and electricity. They can be drawn into wires and beaten into sheets. Therefore, they are used to make utensils, electric wires, *etc.*
- Copper can be mixed with metals like zinc and tin to produce mixtures like **brass** and **bronze** which are stronger and durable. They are used to make statues, utensils, door knobs, handles, machine parts, taps, electrical fittings, *etc.*
- *Iron* is one of the most useful of all metals. It is strong and easily available. Therefore, it is used to make heavy tools and machines.
- *Diamond* is the hardest naturally occuring substance. It shines brilliantly. Pure diamond is used as a gem while impure diamond is used to cut glass.

- *Graphite* can mark the paper black. It is used to make the lead of pencils. It is also used to make lubricants.
- *Coal, wood and natural gas* burn to produce lots of heat energy. Hence, they are used as fuels.
- *Water* is considered to be a **universal solvent**. It carries dissolved substances around in blood in animals and as sap in plants. It is used to prepare solutions of medicinal and industrial importance. It has various other uses in our daily life.
- *Plastic :* It is a non-conductor, used as an insulator. There are different types of plastic materials used for making bags, shoes, balls, bats, tyres, pipes, unbreakable utensils, non-stick cookware, *etc.*
- *Sand* is a compound used to prepare glass.
- *Argon and neon :* A noble gas such as argon or neon is filled in electric bulbs due to its inert nature. It does not react with the tungsten filament of the bulb and prevents it from destruction.

Diamond, graphite and coal are all different forms of element carbon.

Activity 1

Identify the metal which is used to make :

(i) electric wires

(ii) ornaments

(iii) filament of bulb

(iv) silvery foil over sweets

(v) foils to wrap food

(vi) pipes to supply water.

RECAPITULATION

- An element is a substance which cannot be broken further into simpler substances. It is made up of extremely small indivisible particles called atoms. An element has a definite set of properties.
- Atoms of a given element are identical both in mass and in properties. Atoms of different elements have different masses and properties.
- Atoms cannot be created, destroyed or transformed into atoms of other elements.
- An atom is the smallest unit of an element and it may or may not have independent existence. Atoms combine to form molecules.
- A compound is a substance formed by the chemical combination of two or more elements in a fixed proportion by mass. It is made up of only one kind of molecules. A compound also has a definite set of properties.
- A molecule is the smallest unit of a compound (or an element) which always has an independent existence.
- Same kind of atoms combine to form molecules of elements.
- Different kinds of atoms combine to form molecules of compounds.
- Elements and compounds are represented by symbols and formulae respectively. They represent the atoms and molecules of elements and also the molecules of compounds.
- The difference in the properties of different types of elements and compounds forms the basis of their uses in our daily life.

EXERCISE – III

1. Name :
   (a) Three different forms of carbon.
   (b) A form of carbon used as a gem.
   (c) Two substances used to make electric wires.
   (d) Two substances used to make jewellery.
   (e) A substance used as an insulator.
2. Give one use of each of the following substances :
   (a) Iron (b) Brass (c) Coal
3. Give reason :
   (a) A frying pan is made up of steel but its handle is made up of wood.
   (b) Graphite is used to make lead of the pencils.
   (c) Argon is filled in electric bulbs.
4. Answer the following questions :
   (a) Why are copper and aluminium used to make electric wires ?
   (b) What do you understand by the statement : 'metals are ductile and malleable' ?

OBJECTIVE TYPE QUESTIONS

1. Fill in the blanks :
   (a) .... refers to the number of atoms in the molecule of an element.
   (b) The most abundant element in the earth's crust is ....
   (c) A metal which is a liquid at room temperature is ....
   (d) The most abundant element in the atmosphere is ....
   (e) A metal which is a poor conductor of electricity is ....
   (f) A diatomic gaseous element is ....
   (g) A liquid non-metal is ....
2. Match the columns :

	Column A		Column B
(a)	Metals	(i)	Non-reactive
(b)	Molecules	(ii)	Brittle
(c)	Non-metals	(iii)	Lustrous
(d)	Noble gases	(iv)	Smallest unit of compound

3. Indicate whether the following statements are *true* or *false*.
   (a) A compound is made up of just one kind of atom. ....
   (b) Metals reflect light and are good conductors of electricity. ....
   (c) Metals can be polished. ....
   (d) Elements are made up of compounds. ....
   (e) All elements are artificially prepared. ....
   (f) Molecules can exist independently. ....
   (g) Molecules combine to form atoms. ....
   (h) Noble gases are highly reactive. ....
   (i) Ozone is a triatomic molecule. ....

MULTIPLE CHOICE QUESTIONS

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

1. All pure substances have
   (a) the same physical state
   (b) the same colour
   (c) the same composition
   (d) a definite set of properties

2. Sugar is a compound which consists of the elements
   (a) carbon and hydrogen
   (b) hydrogen and oxygen
   (c) carbon, hydrogen and oxygen
   (d) hydrogen, carbon and sulphur
3. Atoms of different kinds combine to form molecules of
   (a) an element (b) a compound
   (c) a mixture (d) all of the above
4. Sulphur and carbon are
   (a) metals (b) non-metals
   (c) metalloids (d) noble gases
5. Gold is used to make jewellery because
   (a) it is dull
   (b) lustrous and attractive
   (c) highly reactive
   (d) very cheap
6. The most abundant elements in the universe are
   (a) neon and argon
   (b) hydrogen and helium
   (c) aluminium and copper
   (d) oxygen and nitrogen
7. The compound used as common salt is
   (a) sodium chloride
   (b) calcium chloride
   (c) sodium oxide
   (d) hydrogen chloride
8. Brass and bronze are
   (a) elements (b) mixtures
   (c) compounds (d) all of the above
9. Sand is a compound of
   (a) silicon and nitrogen
   (b) silicon and oxygen
   (c) oxygen and sulphur
   (d) none of the above
10. From the list given below select the correct substance which is most suitable to the statements given :
    [oxygen, diamond, zinc, graphite, gold]
    (a) A metal which is brittle.
    (b) A non-metal which is a good conductor of electricity.
    (c) The hardest naturally occurring substance.
    (d) The most ductile metal.
    (e) A gaseous non-metal.

Project

- Using the combining powers of : sodium, calcium, aluminium and zinc, write the formulae of their : (a) chlorides, (b) oxides and (c) sulphides.

Pure Substances & Mixtures; Separation of Mixtures

5

Theme : In nature, matter occurs mostly in the form of mixtures. Since substances are required in their pure form, the separation of the components of a mixture is done by different techniques which depend upon the properties of the components of the mixture.

In this chapter you will learn :

- Mixture (components of more than one substance combine in any proportion, original properties of the components are retained)
- Difference between mixtures and compounds (on the basis of proportion of combination of components and their properties).
- Separation techniques of mixtures into their components:
  - Sieving
  - Sedimentation
  - Decantation
  - Filtration
  - Evaporation
  - Magnetic Separation

LEARNING OBJECTIVES

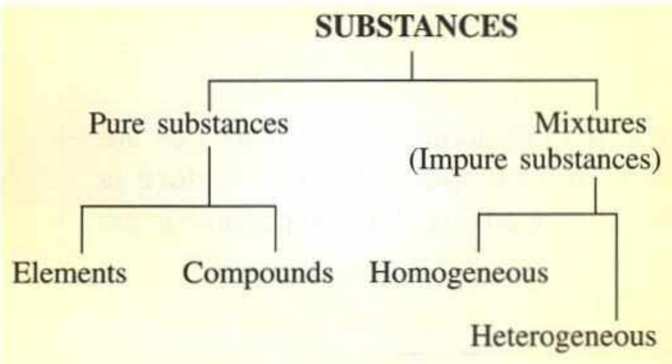
The children will be able to :

- discuss elements and compounds as pure substances.
- define mixture and discuss the differences between compounds and mixtures.
- separate different components of samples of some mixtures.
- discuss the reasons for opting a particular technique for the separation of components of the mixture.

INTRODUCTION

You know that all kinds of substances are made up of elements, a kind of pure substance. Another type of pure substance is a **compound** made up of elements by chemical combinations in a specific proportion.

But there are many substances that we come across in our daily life which are not pure. They are mixtures. They are made up of only elements or only compounds or both elements and compounds mixed in any proportion and without any chemical combination. Hence, all the substances are divided into two groups : pure substances and mixtures.



PURE SUBSTANCES

Pure substances are either elements or compounds. They contain the same kind of atoms and molecules and have a definite set of physical and chemical properties.

Examples : Gold is an **element** which contains the same kind of atoms. Sugar is a **compound** which contains the same kind of molecules and has the same properties throughout.

MIXTURES (Impure Substances)

A substance in which some other substances are also present in smaller or larger amounts is called a **mixture** or **impure substance**.

> *Two or more pure substances (elements or compounds) mixed together in any proportion such that they do not undergo any chemical change and retain their individual properties is called a mixture.*

A mixture may consist of elements or compounds or both. Mixtures can be in solid, liquid or gaseous state, depending upon the physical states of its components. The substances which form mixtures are called *components or constituents of the mixture.*

Example : *Air is a mixture*. Its constituents are oxygen, nitrogen, carbon dioxide, water vapour, dust particles, microbes, smoke, *etc*. These constituents have different kinds of molecules. Therefore, a ***mixture is an impure substance*** having no fixed composition.

Activity 1

Milk, bronze, air, ink and petrol are some examples of mixtures. Write in your notebook, some other mixtures that you can recall from your daily life.

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 uncooked rice and pulses or a handful of soil added into 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 seen separately is called a ***heterogeneous mixture****.*

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

Examples of heterogeneous mixtures

Components	Examples
Solid + Solid	Sand and iron filings, sand and sugar, sand and salt, sulphur and iron filings, soil (sand + clay + minerals), heap of wheat (wheat + stones + husk), Namkeen mixtures.
Solid + Liquid	Chalk in water, sand in water, charcoal in water, pond water (salts + clay + water).
Liquid + Liquid	Oil in water, petrol in water.
Liquid + Gas	Mist (water in air).
Solid + Gas	Smoke, dust.

Most of the mixtures occurring in nature are heterogeneous.

Homogeneous Mixtures

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

Example : 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.

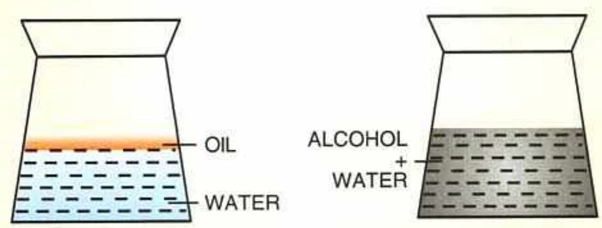
Examples of homogeneous mixtures

Components	Examples
Solid + Solid	Alloys such as brass, bronze, etc.
Solid + Liquid	Salt + water, sugar + water, sulphur + carbon disulphide, iodine + alcohol, nitre + water, etc.
Liquid + Liquid	Water + alcohol, water + vinegar, acetone + water, oil + carbon-tetra chloride
Liquid + Gas	Carbon dioxide + water, ammonia + water, air dissolved in water, etc.

Activity 2

Take some mustard oil and water in a small glass bottle. They form two layers; oil being lighter forms the upper layer. Shake the mixture vigorously and allow it to stand for some time. You will observe that water and oil do not mix with each other and the two layers can be seen easily.

Such mixtures are called heterogeneous mixtures.



A heterogeneous mixture of two immiscible liquids

A homogeneous mixture

Take another bottle, put water and alcohol in it. You will observe that they mix with each other uniformly. No separate layer can be seen. Such mixtures are called homogeneous mixtures.

We come across many substances which are commonly thought to be pure, when actually they are homogeneous mixtures. *Example* : tap water, milk, air, honey, fruit juice, sharbat, ice-cream, ink, medicines, bronze, brass, steel, duralumin, *etc.*

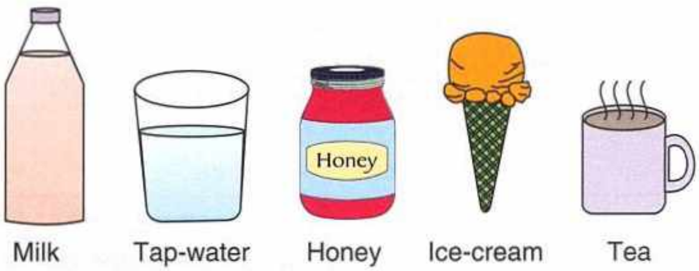


Fig. 5.1 Mixtures that look like pure substances.

Alloy : A homogeneous (solid) mixture of two or more metals or a metal and a non-metal is called an alloy. Example :

1. **Brass :** Copper + Zinc
2. **Bronze :** Copper + Tin + Zinc
3. **Steel :** Iron + Carbon
4. **Duralumin :** Aluminium + Copper with little magnesium and manganese.

Do You Know ?

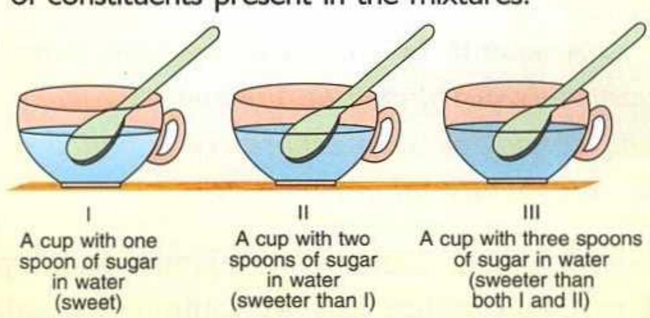
A space craft is made up of a substance called **Duralumin**. It is a solid mixture of metals — aluminium, copper, manganese and magnesium. Space craft should be made up of a light and strong substance. Aluminium metal is light but it is not strong enough. To increase its strength, small amounts of manganese and magnesium are mixed.

Characteristics of Mixtures :

- **In mixtures, components are loosely held together and they retain their individual properties.** *Example* : In a mixture of common salt and pepper, both the components retain their individual properties, *i.e.* salt particles retain their salty taste and pepper particles retain their hot and bitter taste. Therefore, we can say that the atoms and molecules of the components forming a mixture do not react among themselves and no new substances are formed.
- **A mixture has no definite set of properties.** *For example*, a mixture of sugar and water will have different physical and chemical properties if they are mixed in varying proportions. Their densities, boiling points, *etc.*, depend upon the amounts of the two components present in it. These properties can be varied by adding water or sugar, but their individual properties are not lost by doing so.

Activity 3

Take three cups. Fill three-fourth of each cup with water. To one cup, add a spoonful of sugar and stir it to make a solution by completely dissolving the sugar. To the second cup, add two spoonfuls of sugar and stir it. To the third cup, add three spoonfuls of sugar and stir it properly. Now taste all the three sugar solutions you have prepared. You will find that all samples are sweet to taste but the degree of their sweetness is different. The solution containing more sugar is more sweet. In each case, we are getting a homogeneous mixture of sugar and water but they differ in properties depending upon the ratio of constituents present in the mixtures.



Note : Such a mixture formed by sugar and water is called a ***solution***. Sugar is the ***solute*** because it dissolves in water. Water is the ***solvent*** because sugar dissolves in it.

Solvent – The substance in which a solute is dissolved to make a solution is called a solvent.

Solute – The substance which is added and dissolved in a solvent is called a solute.

Solution – The homogeneous mixture of water (or any other solvent) and a substance soluble in it (solute) is called a solution.

i.e. solution = solute + solvent

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.

Hence the main characteristics of mixtures are as follows :

1. A mixture *consists of two or more substances* mixed together without any chemical force acting on or between them.
2. *Mixtures do not have any fixed composition i.e.* they can have their components in varying proportions.
3. *Mixtures do not have any specific set of properties.* They show the properties of the individual components from which they are formed.
4. *The melting point or the boiling point of a mixture is not fixed. It depends on the proportion of its components present in it.*
5. *Mixtures can be heterogeneous or homogeneous.*
6. The constituents of mixtures are loosely held, so they can easily be *separated by simple physical methods.*
7. Formation of mixtures *does not involve any energy exchange* and no new substances are formed.

Formation of Mixtures

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.

Activity 4

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

(To be demonstrated by the teacher to make the difference between a compound and a mixture more clear).

Mix some iron filings and sulphur (in any proportion) 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 test tube. The black mass formed is put on another watch glass. We shall call it sample **B**.

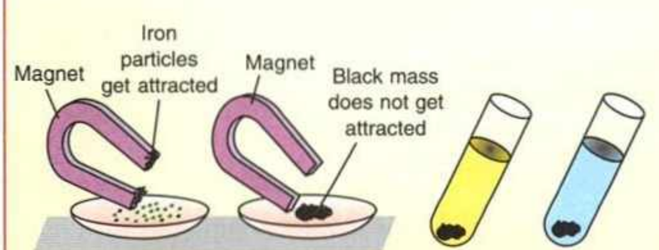
(a) Bring a magnet over sample A and sample B. What do you observe ?

In sample A, the iron filings are attracted by the magnet but not in sample B.

(b) Put small proportions 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 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, iron chemically combines with sulphur on heating,



A (A mixture of iron and sulphur) B (Iron sulphide) C Sulphur dissolves leaving iron at the bottom D Black mass does not dissolve 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.

Another example : When carbon (solid) and oxygen (gas) are heated, they combine in a fixed proportion by mass to produce the gas carbon dioxide [CO_2], which has completely different properties than the elements from which it is formed.

Carbon is a black solid and oxygen is a gas which supports combustion while carbon dioxide, a gas, is a non-supporter of combustion.

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. Properties of components are changed during the formation of a compound.	4. Mixtures retain the properties of its components.
5. Components of compounds can be separated only by chemical methods.	5. Components of mixtures can be separated by **simple physical methods**.
6. A molecule of a compound is represented by a definite chemical formula.	6. Mixtures cannot be represented by any formula.

Why is water a compound and air a mixture :

We all know about air and water, the two important substances to sustain life.

Earlier they were thought to be elements but later on it was proved that while water is a **compound**, air is a **mixture**. There are enough evidences to prove the above fact.

Water	*Air*
1. Water is a compound.	1. Air is a mixture.
2. Water is made up of hydrogen and oxygen in a fixed proportion by mass.	2. Air contains oxygen, nitrogen, carbon dioxide and water vapour, but they are not in a fixed proportion. Their amount varies from place to place.
3. The properties of water are completely different from those of its elements.	3. Air retains their properties of its component gases.
4. Water is represented by a molecular formula H_2O.	4. Air cannot be represented by any formula.

EXERCISE – I

1. Select homogeneous and heterogeneous mixtures from the following :
Salt solution, petrol and water, sand and charcoal, alcohol and water, air dissolved in water, air, sea water, fruit juices, mist, brass.
2. Define the following with an example for each :
   (a) Pure substance (b) Impure substance
   (c) Alloy (d) Solution
   (e) Heterogeneous mixture
   (f) Homogeneous mixture
3. List *four* characteristics of a mixture.
4. Give reasons :
   (a) Why do sugar and water retain their individual properties in a sugar solution ?
   (b) Why do petrol and water form a heterogeneous mixture ?
   (c) Why does sulphur dissolve when carbon disulphide is added to a mixture of iron and sulphur but not when it is added to iron sulphide ?
5. Give two examples for each of the following types of mixtures.
   (a) solid-solid (b) solid-liquid
   (c) liquid-gas (d) gas-gas
6. Name the components present in the following mixtures :
   (a) Brass (b) Duralumin
   (c) Tap water (d) Bronze
7. State :
   (a) Three differences between water and air.
   (b) Four differences between compounds and mixtures.

NEED FOR THE SEPARATION OF CONSTITUENTS OF MIXTURES

We need many substances for purposeful uses in our homes and industries. Most of these substances are available in the form of mixtures.

- 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.
- Sea water is a mixture of water and common salt. ***Common salt*** is an important substance used in our food, to add taste and nutrients. Therefore, there is a need to obtain salt from sea water by separating them.
- When the components of crude petroleum oil are separated, we get many important substances like LPG, CNG, petrol, diesel and kerosene oil. They are all used as fuels.
- Water used for drinking purposes is not completely pure. It contains air and salts. It is required in its purest form to prepare medicines, in laboratories and in car batteries. For these purposes, all the impurities of water need to be removed.

Therefore, *separation of constituents of mixtures is necessary to :*

(i) remove undesirable and harmful substances,
(ii) get useful substances and
(iii) get completely pure substances for preparing other useful substances.

SEPARATION TECHNIQUES OF MIXTURES

The process by which constituents forming 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* and *the characteristic properties of the constituents forming it like size, shape, colour, density, melting point, boiling point, solubility, magnetic nature, etc.*

Example : Tea leaves are separated from tea by ***filtering*** it through a strainer.

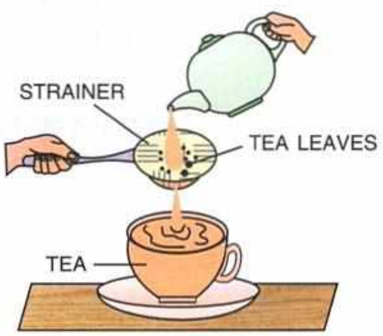


Fig. 5.2 Filtration

Thus, for different types of mixtures, different methods are applied to separate their components. Following are some simple methods of separation :

(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 and picked out by hand. Small stones are picked out from rice, pulses and spices by this method.

Winnowing : This method is used to separate light solids from heavier ones.

Example : Take a mixture of rice and husk. When it is allowed to fall from a height, rice grains, being heavier, fall vertically down 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.

The process of separation of grain from husk and hay with the help of wind is called winnowing (Fig. 5.3).

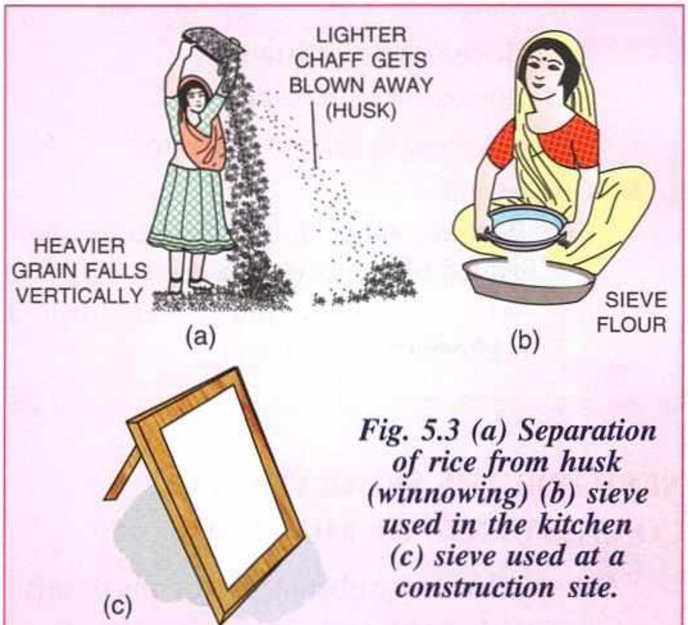


Fig. 5.3 (a) Separation of rice from husk (winnowing) (b) sieve used in the kitchen (c) sieve used at a construction site.

Sieving : This method is used when the mixture contains components of different sizes. A sieve is made by fitting a mesh into a frame. The size of the holes in the mesh varies for different mixtures. When a mixture of solids is sieved, those which are larger in size than the holes in the sieve remain on it, while the smaller ones pass through. Fine sieves are used in the kitchen to remove undesirable solid impurities from flour, rice powder, etc. Larger sieves are used to separate sand and stones for construction purposes. Jewellers separate pearls of different sizes by sieving. It is also used for separation of cashewnuts of different sizes, separation of sand from gravel, etc.

Magnetic separation : This method is used when one of the components of the mixture is iron. Iron gets attracted towards a magnet and hence can be separated. Mixtures of iron and sulphur, iron and sand, *etc*., can be separated by moving a magnet over them. Iron gets attached to the magnet and is separated.

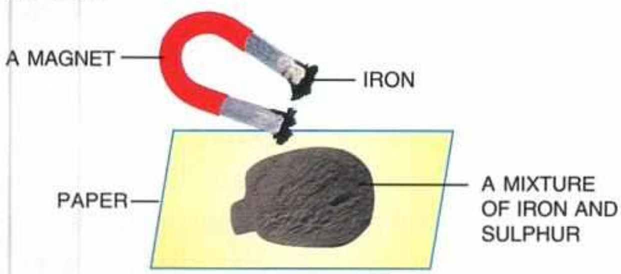


Fig. 5.4 Separation by a magnet

Sublimation : *The process in which a solid changes directly into its vapour on heating is called* ***sublimation***. This method is used for solid mixtures in which one of the components *sublimes* on heating. The solid which sublimes escapes as vapour, while the other one is left behind. On cooling, the vapour again turns into a solid. Camphor, naphthalene, iodine and ammonium chloride undergo sublimation.

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

Experiment : To separate common salt and ammonium chloride.

The mixture of common salt and ammonium chloride is placed in a dish and covered with an inverted funnel as shown in Fig. 5.5. On heating, ammonium chloride will change into vapour, which will condense into a solid along the neck of the funnel (from where it may be scraped off), whereas common salt will be left behind in the dish.

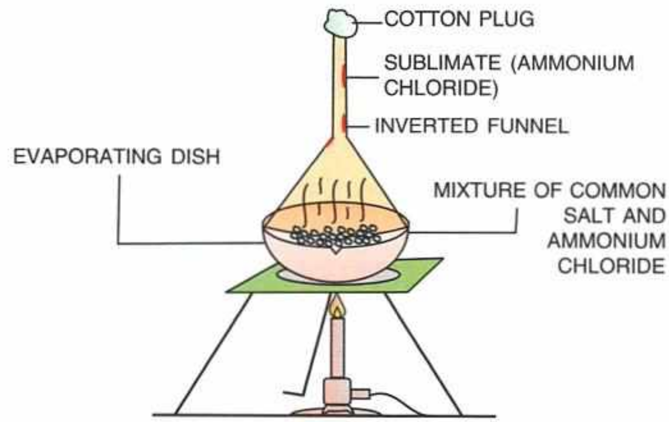


Fig. 5.5 Sublimation : Separating a mixture of common salt and ammonium chloride

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. In this way, they can be separated.

(B) Separation of solid-liquid mixtures

Such 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* ***supernatant liquid****.*

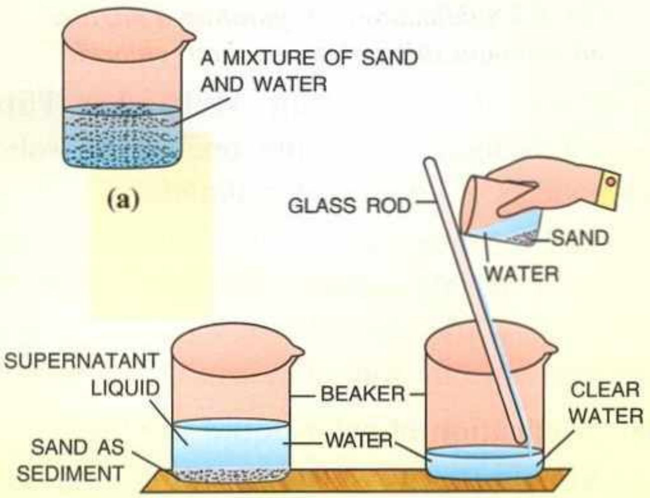
The process of pouring out the clear liquid, without disturbing the ***sediment****, is called the* ***decantation****.*

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.

Activity 5

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



(b) Sedimentation **(c) Decantation**

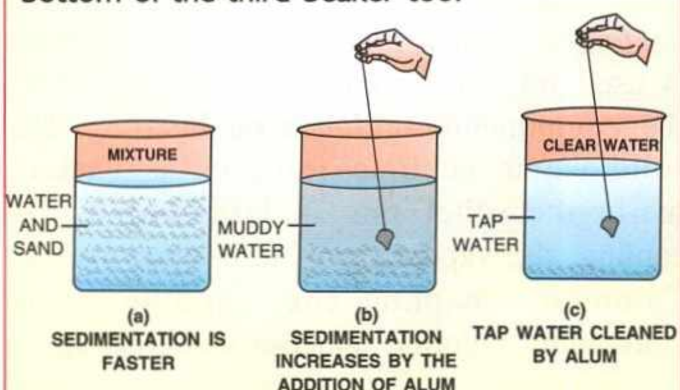
Loading : *The process of helping fine solid particles in a solid-liquid mixture to settle faster, by adding a special chemical, is called loading or coagulation.*

There are some heterogeneous solid-liquid mixtures containing very fine solid particles that do not settle down easily.

Example : Water from a river, pond or lake contains very fine clay particles. To make them settle at a faster rate, a chemical substance called **alum** in powdered form is added to such mixtures. It dissolves in water and forms *clusters with clay and dust particles making them heavier* and increasing the rate of sedimentation.

Activity 6

Take three beakers and fill three fourth of them with tap water. Add some sand to the water in the first beaker and some clay to the second beaker. Stir the mixtures and allow them to stand for sometime. Sand, being heavier, settles down easily in the first beaker. But the water in the second beaker remains muddy. Now take a piece of alum and tie it with a string. Move it around in the muddy water in the second beaker. Then move it around in the third beaker containing clear tap water. You will observe that clay particles in the second beaker settle down more easily. You will see some fine solid sediment at the bottom of the third beaker too.



Loading or coagulation

This shows that :

(i) alum helps in faster settling of fine solid particles, and

(ii) tap water too contains fine dust particles, though it appears to be clear.

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 the complete separation of the components of a heterogeneous solid-liquid mixture in which solids are insoluble in liquids.

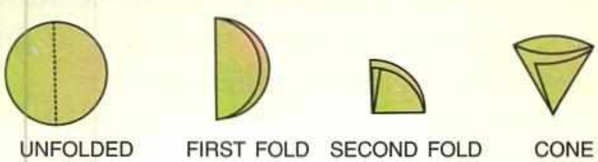
The substances that can be used as filters are a layer of sand, charcoal, cotton, glass wool, unglazed porcelain, filter paper, muslin cloth, *etc*. Even the strainer that we use to separate liquid tea from tea leaves is a filter.

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

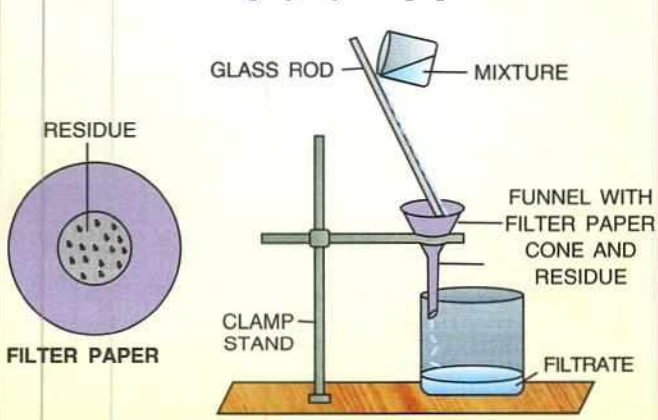
Activity 7

Take some water in a beaker. Crush a chalk into powder and mix it well with water by stirring.

Take a circular filter paper and fold it to make semicircular halves. Refold it to make a



Folding of a filter paper



Filtration using a funnel and filter paper (chalk powder remains on the filter paper as a residue and clear water collects as the filtrate).

cone. Open the cone with three layers on one side and one layer on the other side.

Fix the cone into a funnel in such a way that it is about one-fourth of an inch below the edge of the funnel. Hold the funnel over a beaker with the help of a stand.

Now pour the mixture of chalk powder and water slowly into the funnel using a glass rod such that the liquid stands below the edge of the cone. You will observe that clear water drips into the beaker under the funnel. Remove the filter paper and open it when all the mixture is poured in. The chalk powder left on the filter paper is *the residue* while the clear water in the beaker is the filtrate.

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

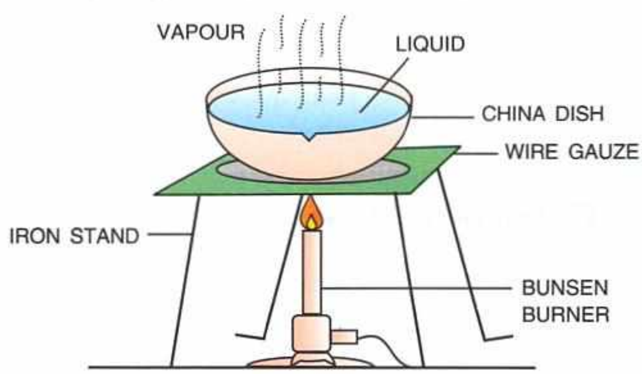


Fig. 5.6 Evaporation

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 of obtaining crystals from a solution containing more solute than it can hold at room temperature.

To obtain crystals, such solutions can either be strongly heated and then cooled down or they can be left to evaporate at room temperature. The solute in both the cases will crystallise out from the solution.

Pure sugar is obtained from its solution in water by the process of crystallisation. At first the sugar solution is heated to evaporate water. When very less of water is left, the solution is cooled. On cooling, sugar dissolved in it starts separating out in the form of **crystals**.

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

Distillation : *Distillation is the method of getting a pure liquid from a solution by evaporating and then condensing the vapours* (Fig. 5.7).

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

Tap water, which is a mixture containing dissolved salts, is purified by *distillation*. The pure water so obtained is called *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.

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

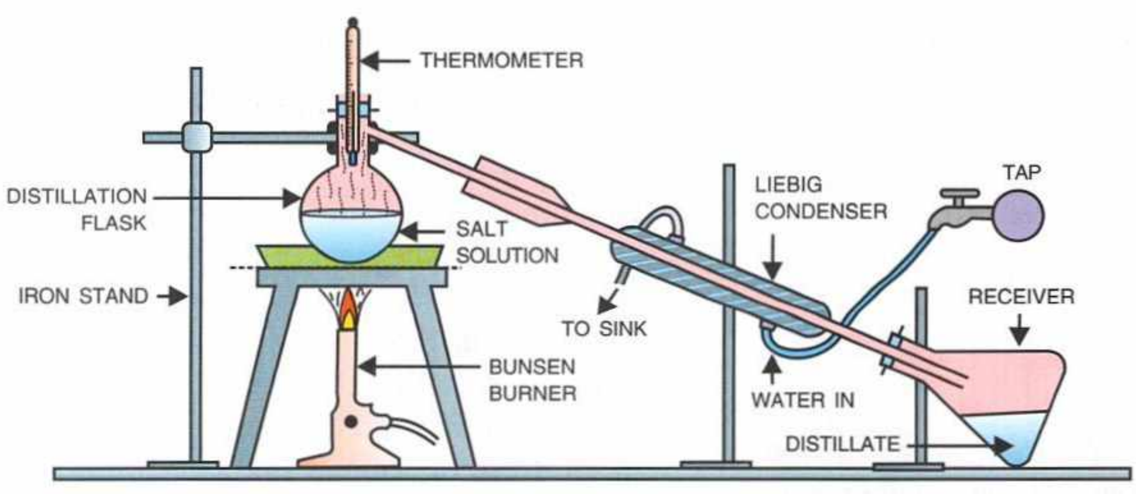


Fig. 5.7 Distillation

Table 5.1 : Showing methods of separation of components of mixtures and the principle used

Types of mixtures	Method of separation	Principle of separation	Examples
1. **Solid + Solid [Heterogeneous]**	(a) *Hand picking*	When the substance to be separated is large enough to be picked up by hand and forms a small portion of the mixture.	Small stones from rice and pulses.
	(b) *Winnowing*	When the mixture contains light and heavy particles.	Rice and husk. Sand and dry leaves.
	(c) *Sieving*	When the components of mixture are of different sizes.	Rice powder and small stone particles.
	(d) *Magnetic separation*	When one of the components is magnetic in nature.	Iron and sulphur.
	(e) *Sublimation*	When one of the components can sublime.	Sand and ammonium chloride.
	(f) *Solvent extraction method*	When one of the solids is soluble in liquid.	Sand and salt.
2. **Solid + liquid [heterogeneous]**	(a) *Sedimentation and decantation*	When the solid component is much heavier than the liquid component.	Sand and water rice and water.
	(b) *Loading*	When the mixture contains very fine particles in the liquid which do not settle down easily.	River and pond water containing very fine clay particles.
	(c) *Filtration*	When solid particles are insoluble in the liquid and complete separation is needed.	Chalk powder and water. Sawdust and water.
3. **Solid + liquid [homogenous]**	(a) *Evaporation*	When a solid is soluble in a liquid to form a solution.	Salt from sea water.
	(b) *Crystallisation*	When the solution contains more solid.	Sugar from its solution in water.
	(c) *Distillation*	When a pure liquid is to be obtained from a solution.	Pure water from tap water.

RECAPITULATION

- A pure substance is made up of only one kind of atoms or molecules.
- A mixture is an impure substance made up of different kinds of elements and compounds held loosely.
- The constituents of a mixture retain their properties because they do not combine chemically to form a new substance.
- The constituents of a mixture can be separated quite easily by physical methods.
- Mixtures are of *two* types : heterogeneous and homogeneous.
- Mixtures need to be separated 1. to remove undesirable components, 2. to get desirable substances and 3. to get pure substances.
- The methods of separation depend upon the nature and the characteristic properties of the components of the mixture.

EXERCISE – II

1. Define :
   - (a) Filtration
   - (b) Sublimation
   - (c) Evaporation
   - (d) Crystallisation
2. Why do we need pure substances ?
3. Give one example for each of the following types of mixtures.
   - (a) Solid-solid heterogeneous mixture
   - (b) Solid-liquid heterogeneous mixture
   - (c) Solid-liquid homogeneous mixture
4. Name the process by which the components of following mixtures can be separated.
   - (a) Powdered glass and sugar
   - (b) Chalk powder and iron filings
   - (c) Chaff and grain
   - (d) Salt and water
   - (e) Wheat and sugar
   - (f) Sand and camphor
   - (g) Sugar and water
5. Name :
   - (a) two substances which can sublime
   - (b) two substances soluble in water
   - (c) two substances insoluble in water
   - (d) four substances that can be used as filters.
6. Give reasons :
   - (a) Sand and sawdust cannot be separated by hand picking.
   - (b) Magnet is used to separate a mixture of iron and sulphur.
   - (c) Alum is used in purification of river water.

OBJECTIVE TYPE QUESTIONS

1. Fill in the blanks :
   - (a) The substances that make a mixture are called its .... or ....
   - (b) .... is a process to separate solids dissolved in liquids.
   - (c) Mist is a .... mixture of droplets of water and air.
   - (d) Clay is separated from water by the method of ....
   - (e) When cereals are washed before cooking, water is separated from the cereals by ....
   - (f) .... is a process to obtain a very pure form of a solid dissolved in a liquid.
   - (g) Ammonium chloride can be separated from common salt by the method of ....
   - (h) The solid particles which remain on the filter paper are called .... and the liquid which passes through it is called ....
   - (i) The process of transferring the clear liquid above the solid particles which settle at the bottom of the container is known as ....
   - (j) .... is a method used for the separation of an insoluble solid from a solid-liquid mixture.

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

(a) A pure substance consists of only one kind of atom or molecule. ....

(b) Common salt is separated from its solution in water by decantation. ....

(c) Winnowing is a process to remove small stones from grains. ....

(d) Gold jewellery is a homogeneous mixture of metals. ....

(e) Air can be separated from water by filtration. ....

(f) Salt and air dissolved in water add taste to water. ....

(g) Steel is an alloy of iron and aluminium. ....

MULTIPLE CHOICE QUESTIONS

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

1. The process of adding a chemical substance to help the suspended solid particles to deposit as sediment faster is called

   (a) loading (b) sedimentation
   (c) decantation (d) filtration

2. Salt is separated from sea water by

   (a) evaporation (b) sublimation
   (c) crystallisation (d) filtration

3. A mixture of mustard oil and water forms

   (a) a compound (b) a homogeneous mixture
   (c) an alloy (d) a heterogeneous mixture

4. A heterogeneous mixture is one

   (a) made up of only one kind of atom
   (b) made up of only one kind of molecule
   (c) made up of different kinds of atoms and molecules.
   (d) that looks uniform.

5. Example of a homogeneous mixture is

   (a) distilled water (b) tap water
   (c) sand and water (d) sawdust and water

6. A set of mixture is

   (a) gold, common salt, water, alloy
   (b) alloy, ink, honey, icecream
   (c) alloy, mercury, air, sea water
   (d) milk, duralumin, brass, silver.

7. A gas dissolved in a liquid can be separated by :

   (a) filtration (b) boiling
   (c) using magnet (d) by crystallisation

8. Copper is not a part of the alloy :

   (a) brass (b) bronze
   (c) steel (d) duralumin

9. Which is not a mixture ?

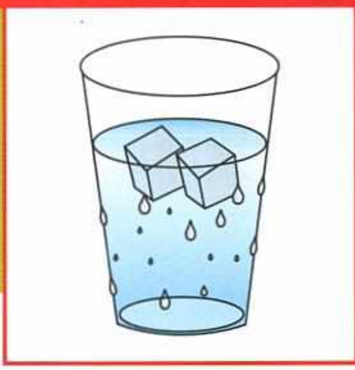
   (a) sugar solution (b) tap water
   (c) milk (d) distilled water

10. Give one word for the following :

   (a) The solid which is left on the filter paper after filtration. ....
   (b) The solid particles which separate out from the solution on slow evaporation. ....
   (c) The solid particles that settle at the bottom of the beaker in a heterogeneous mixture of a solid and a liquid. ....
   (d) The clear liquid which is poured out after sedimentation. ....
   (e) The technique used to separate the light particles from heavy particles using the flow of wind. ....

Project

- Visit a nearby dairy and prepare a report about the processes used to separate cream from milk.
- Try to pick out different methods of separation you watch daily in your surroundings and kitchen at home.



Air and Atmosphere

6

Theme : Atmosphere around us consists of air which is a mixture of different gases such as nitrogen, oxygen, carbon dioxide, helium, argon, moisture. Air is essential for sustenance of life on earth. Air should remain clean and attempts should be made to make it free of pollutants.

In this chapter you will learn :

- *Air is present everywhere around us.*
- *Air — a mixture of gases namely, nitrogen, oxygen, carbon dioxide, water vapour; dust and smoke as pollutants.*
- *Percentage composition of air.*
- *Uses of the components present (importance of nitrogen to plants to be mentioned).*
- *Definition of atmosphere as layer of air around the earth.*

LEARNING OBJECTIVES

The children will be able to :

- describe different components of air and their composition.
- state the importance of air for sustaining of life and for other physical and chemical processes.
- describe the uses of oxygen and nitrogen.
- discuss the causes of increase of carbon dioxide in the atmosphere.

INTRODUCTION

"Air is a kind of matter". All of us are well aware of the fact that no living being can survive without air even for a few minutes. It is one of the most important components of life on the earth. Air is present everywhere around us.

The earth is surrounded by a thick layer of air called the *atmosphere* that extends upto a height of about 320 kilometres above the surface of the earth. There is air all over the land and the oceans. Air is also present in water in a dissolved state. This dissolved air in water is used by marine life. We cannot see air, because it is colourless, odourless, tasteless, transparent gaseous matter but we can feel its presence when it blows as wind [Fast moving air is called wind].

Fig. 6.1 Earth surrounded by a layer of air called the atmosphere

Let us do some activities to understand and feel the presence of air and its significance in sustenance of life on earth.

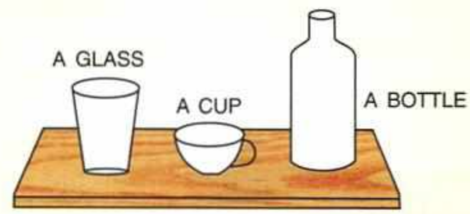
Activity 1

Try to hold your nose tightly and keep your mouth closed for a while. Observe what happens. State your responses for the following questions.

1. Why is it that you cannot hold your nose tightly for a long time ?
2. What would happen to you if you do not breathe in air ?

Activity 2

Put a glass, a cup and a bottle on a table and observe them.



Are they empty ?

No they are filled with air.

They appear to be empty because air is colourless and transparent.

Activity 3

Switch on the fan in your room. Immediately you feel air, which is blowing. Because when the fan is switched on, the air starts moving at a faster speed. Thus, presence of air is felt.

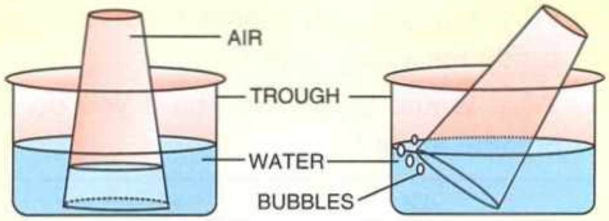
Air, like any other form of matter, has mass and occupies space.

Activity 4

Take an empty glass tumbler and lower it vertically downward in an inverted position in a trough of water.

Does the glass get completely filled with water ? No.

You will observe that the level of water inside the tumbler is lower as compared to the water in the trough.



Air is present everywhere

This is because air trapped within the glass, did not allow the water in the tumbler to rise.

Now, gently tilt the glass tumbler to one side. Bubbles rush out and the water flows into the tumbler.

What do these bubbles contain ? They contain air. This proves that air is present everywhere.

Do You Know ?

Atmosphere protects us from harmful rays of the sun.

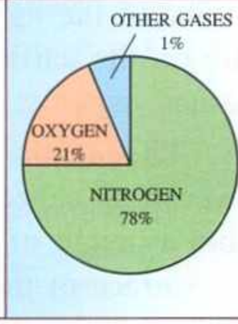
We could be burnt or frozen if there was no atmosphere around the earth. In the absence of the atmosphere, the earth would get very hot during the day and very cold at night that we would not be able to survive. There would be no life on earth under such a condition.

COMPOSITION OF AIR

Air is a mixture of gases : In ancient times, air was considered to be an *element*. A number of scientists tried to find out the exact composition and nature of air. In 1774, Lavoisier, a French chemist, showed that air is a mixture and the main gases in it are nitrogen and oxygen. Besides these two gases, air also contains small quantities of carbon dioxide, water vapour, dust particles and traces of inert gases like helium, neon, argon, etc. Air also contains smoke as a pollutant.

The composition of air by volume is shown in the table below :

Table 6.1 : Percentage composition of air by volume

Gases	Percentage	Figure
Nitrogen	78%	
Oxygen	21%	
Carbon dioxide	0·03 - 0·04%	
Inert gases	0·9%	
Water vapour	Varies	
Dust particles	Varies	
Other impurities	Varies	

Properties of air

1. Air occupies space.
2. Air has mass.
3. Air can be easily compressed.
4. Air exerts pressure equally in all directions.
5. Air is a mixture of gases.

Confirmatory evidences that air is a mixture

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

1. The composition of air varies from place to place and from time to time. This can be proved from the fact that during the rainy season, the weather becomes very humid as compared to the summer season. It is because air contains more water vapour during rainy season. The percentage of water vapour in air depends on both place and time. Besides dust and smoke, air also contains gases like sulphur dioxide, hydrogen sulphide, etc. as impurities. The amount of dust and these gases vary in air. *Since the composition of a compound irrespective of place and time is fixed, air is not a compound.*
2. No energy change occurs when the components of air are mixed together whereas *energy changes occur in the formation of a compound.*

3. The components of air retain their individual properties. But in a compound, *the individual properties of the components are not evident*.
4. Air cannot be represented by a formula as its constituents are not in a fixed proportion. *A compound is always represented by a definite formula.*
5. The components of air can be separated by simple physical methods. *Components of compounds cannot be separated by physical methods.*

Do You Know ?

Hilly places have more fresh air i.e. more oxygen content because of more plants and trees, whereas urban places have less fresh air due to deforestation and pollution. That is why patients are often advised by the doctors to go to hilly lower areas for their fast recovery.

STUDY OF COMPONENTS OF AIR

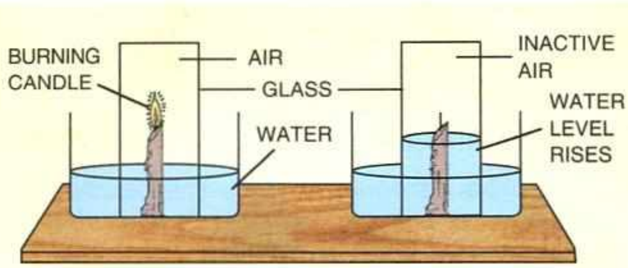
Now you know that air mainly contains nitrogen and oxygen and small quantities of carbon dioxide and water vapour. Dust particles and traces of inert gases like helium, neon, argon, etc. are also present in air.

Since the constituents of air retain their properties, their presence in air can be easily proved by certain experiments.

Activity 5

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 the candle with an empty jar and mark the



Air contains oxygen and nitrogen

level of water inside the jar. Now lift the jar and light the candle and cover it with the jar again.

Observe carefully. Does the candle continue to burn or goes off ? Does the level of water inside the jar remains same ?

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 the candle to burn. When it is used up, candle stops burning. The 4/5th part of air still present in the jar is inactive air that does not support burning, and it is nitrogen.

The above activity proves that air contains oxygen. It also proves that air contains nitrogen. It is observed that candle in the jar burns till it gets oxygen from air.

It is now clear that air is made up of an 'active' part and an 'inactive' part. The 'active' part of air, which is used up when substances burn, is about one-fifth of the total volume of the air. It is a gas called **oxygen**. The 'inactive' part, which does not support burning, consists mainly of a gas called **nitrogen**, constituting 4/5th of air by volume.

Do You Know ?

Nitrogen does not support burning but controls burning. If nitrogen were not present in the atmosphere all the substances would be on fire because of the highly reactive nature of oxygen.

Activity 6

To show that air contains carbon dioxide.

(To be demonstrated by the teacher)

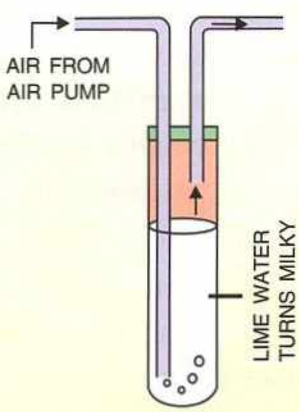
Take a test tube fitted with a two-bore rubber cork. Fit a long bent tube through one hole and fit a short bent tube through the other hole. Take out the cork and pour some freshly prepared lime water into the test tube. Fit the cork again. Make sure that the long bent tube is immersed in lime water while the short one remains suspended in air

Blow air by an air pump through the long tube. You will observe that the air blown through lime water turns it milky.

Why does lime water turn milky ?

Carbon dioxide that is present in the air reacts with lime water and turns it milky.

This shows that *air contains carbon dioxide.*



Air contains carbon dioxide

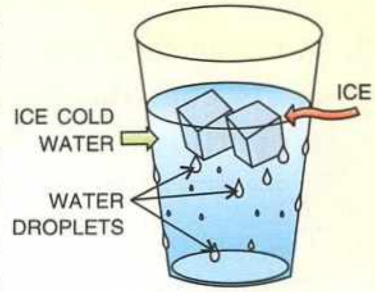
Note **(1)** Lime water is an aqueous solution of calcium hydroxide. Carbon dioxide reacts with lime water to form white insoluble calcium carbonate which gives milky white appearance to the solution.

(2) Turning of lime water milky is a confirmatory test for the presence of carbon dioxide.

Activity 7

To show that air contains water vapour.

Take a glass tumbler. Fill it half with ice cubes or ice cold water. Let it stand undisturbed for some time. 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.



Air contains water vapour

Where have they come from ?

Due to the cold surface of the glass tumbler, the water vapour present in air got condensed as water droplets.

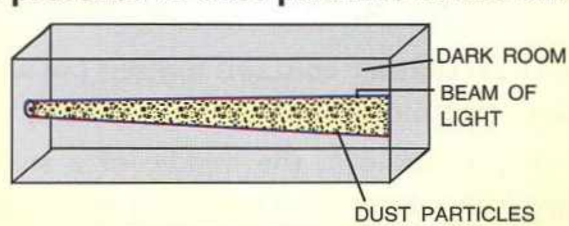
This proves that *air contains water vapour.*

Activity 8

To show that air contains dust particles.

Close the doors and windows of a room and put curtains to make the room dark. Allow only a beam of light to come into the room through a small hole or a slit in the door.

You will observe randomly moving dust particles in the beam of light. **This confirms the presence of dust particles in the air.**



Air contains dust particles

EXERCISE – I

1. What is atmosphere ?
2. Why can't we see air ?
3. What is wind ?
4. What would have happened if there would have been no atmosphere around the earth ?
5. Why is air called a mixture ? Give five facts in support of your answer.
6. What are the main components of air ? Write down the composition of three main gases present in air by volume.
7. What do you observe when
   (a) Ice cold water is filled in a glass tumbler.
   (b) A burning candle is covered with an inverted jar.
   (c) Carbon dioxide gas is passed through lime water.
   (d) A beam of light is allowed to enter in a closed dark room through a small hole.
8. Write the chemical name of
   (a) Lime water
   (b) The white insoluble solid formed on reaction of carbon dioxide with lime water.

USES OF THE COMPONENTS OF AIR

1. Oxygen

- Of all the substances necessary for life, namely air, water and food, air is the most important component. All living beings can live without food or water for some days but without air, they will die within a few minutes. This is because **oxygen** present in air is required for respiration by all living organisms.

Of all the components present in air, oxygen is the most vital component which is responsible for two of the most important processes,

- **Respiration** and
- **Combustion**

Air needed for respiration

Animals and plants living on land get air (oxygen) from the atmosphere while aquatic plants and animals use the air (oxygen) dissolved in water for respiration.

"Respiration is a chemical process that takes place in all living beings. In this process, oxygen present in the inhaled air reacts with the digested food material in the body. This results in the release of energy, carbon dioxide and water".

Sugar + Oxygen → Carbon dioxide + Water + Energy
(Glucose)

Therefore, we can conclude that without oxygen, our body cannot utilize the food we eat, to obtain energy.

*The air which we breathe in is known as **inhaled air** and the air which we breathe out is called **exhaled air** (or expired air). Exhaled air is more moist (due to more water vapour) than inhaled air. The exhaled air contains less amount of oxygen but more amount of carbon dioxide than inhaled air because in respiration, oxygen is used and carbon dioxide is produced by all organisms.*

Note : The complete process in which air is inhaled and then exhaled is called **breathing**.

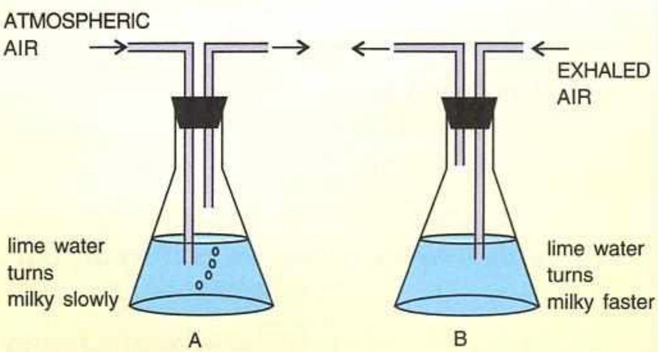
Activity 9

To show that exhaled air contains more carbon dioxide than inhaled air.

Take two same type of arrangements as done in Activity-6. Mark them as A and B.

In test tube A, blow air by an air pump through the long tube. In test tube B, blow air from your mouth.

It is observed that lime water in test tube B turns milky faster than that in test tube A. This is because test tube A gets atmospheric air while test tube B gets **exhaled air** which has **more amount of carbon dioxide gas**.



At higher altitudes, the air is less dense or thin and breathing becomes difficult. Similarly, air becomes less dense below the surface of the earth. That is why mountaineers, astronauts,

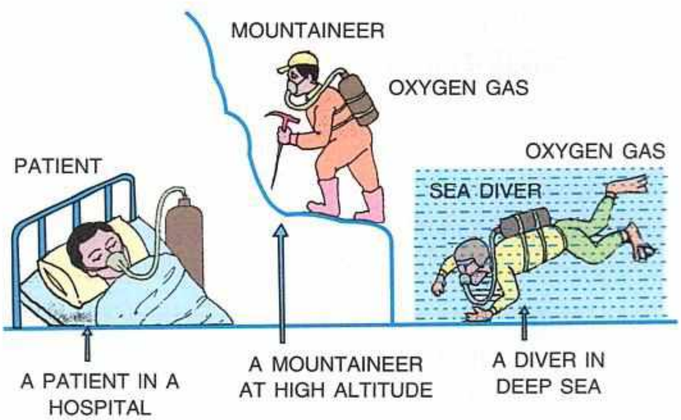


Fig. 6.2 Air is necessary for breathing

miners and divers carry oxygen cylinders with them. Artificial respiration is given to patients suffering from breathing problems.

Activity 10

Take some water in a glass vessel or beaker. Heat it slowly on a tripod stand. Well before the water begins to boil, look carefully at the inner surface of the vessel. Do you see tiny bubbles.

These bubbles come from the air dissolved in water.

The marine life uses air dissolved in water.

Activity 11

To show that soil contains trapped air.

Take a small quantity of water in a glass jar or beaker. Add a handful of soil into it and look carefully. You will observe air bubbles being formed in water. This shows that the soil contains some air in spaces between the soil particles.

This proves that soil contains air trapped in between its particles.

The organisms living in burrows like earthworm and the plant roots respire using this trapped air in soil.

RESPIRATION IN PLANTS

There is a misconception that only animals and human beings breathe in oxygen and breathe out carbon dioxide but plants breathe in carbon dioxide and breathe out oxygen. In fact plants do this during photosynthesis to prepare food. However, plants respire just as human beings and other animals. They too breathe in oxygen and breathe out carbon dioxide during respiration.

Activity 12

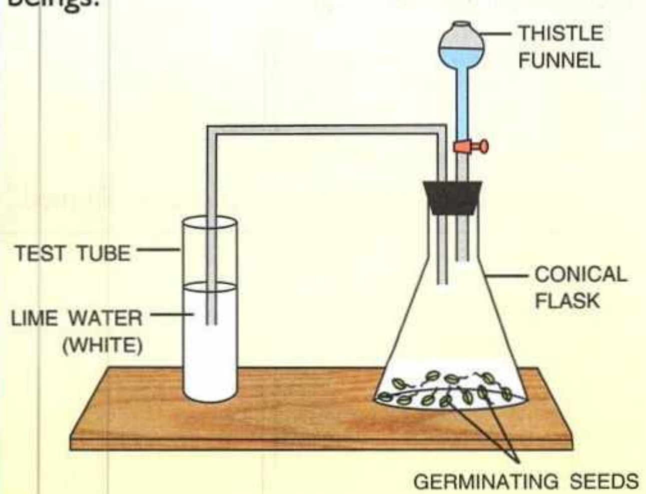
To show that plants also respire.

Take a conical flask and place some germinating gram seeds in it. Take a bent glass tube and insert its shorter end through the bore (hole) in a cork and fix it on the conical flask. Dip the longer end of the glass tube in a test tube containing lime water. Insert a thistle funnel through the second bore of the cork fitted on the flask. Make the conical flask air tight by applying vaseline on its rim. Now add some water to the flask through the funnel.

After sometime you will observe that lime water in the test tube turns milky indicating the presence of carbon dioxide in the flask. From where has this carbon dioxide come into the flask ?

It is very obvious that the gas is produced by the germinating seeds during respiration. This shows that **plants respire too** by taking oxygen from air and giving out carbon dioxde.

Note : Water is added to the flask to increase the rate of respiration in plants as they respire slowly in comparison to animals and human beings.



Do you know ?

During heavy rains when holes/pores in the soil get filled with water, the organisms like earthworm come out of soil to breathe in air necessary for respiration.

COMBUSTION OR BURNING

You might have seen a burning candle, a burning paper, a burning splinter. When they burn, they produce heat and light. But how do they burn ?

They burn using the oxygen present in air.

Hence :

"*Burning or combustion* is a process in which a substance reacts chemically with oxygen and gets oxidised, with the release of energy in the form of heat and light". *It is a fast process.*

During the process of burning, along with energy, carbon dioxide and water vapour are also produced.

Without oxygen, burning cannot take place. It is an essential component for burning which is obtained from air.

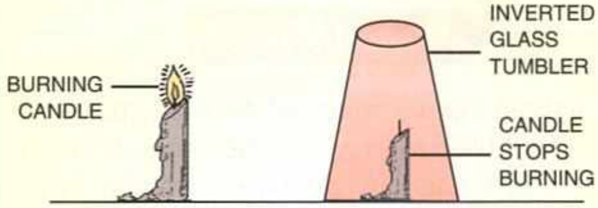
Hence, air is necessary for burning.

Activity 13

To show that air is necessary for burning

Take a candle and fix it on a table. Now light the candle with the help of a match stick. The candle burns and gives a flame.

Now cover the burning candle with an inverted glass tumbler. You will notice that after a few minutes, the flame gets extinguished.



Air is necessary for burning

This is because the oxygen in the air trapped in the inverted glass is used up and the candle does not get any more oxygen for burning. This proves that air (oxygen) is necessary for burning.

Fuels : Substances which are burnt to produce large amount of energy in the form of heat and light are known as **fuels**.

$$\text{Fuel} + \text{Oxygen} \xrightarrow{\text{burning}} \text{Energy (heat + light)} + \text{Carbon dioxide} + \text{Water vapour}$$

Some of the fuels are burnt to produce fire while others are used to get heat and light.

Some common fuels used in daily life are wood, coal, cooking gas (LPG), petrol, kerosene, CNG, etc.

These fuels provide energy for various purposes such as for cooking food, for automobiles (vehicles), for producing electricity, for industries, etc.

Some commonly used fuels are discussed below :

Wood and charcoal : Wood is used as a fuel since ancient times. **Charcoal** is obtained when wood is heated in the absence of air.

Coal : It is a fossil fuel, obtained from coal mines. It contains mainly carbon. It is burnt to obtain energy.

Petrol, kerosene and diesel are some of the important fuels obtained from crude petroleum oil. They are all fossil fuels.

CNG (Compressed Natural Gas) **:** It is produced along with crude oil. It mainly contains methane gas. It has become a popular fuel for vehicles like three wheeler scooters, cars and buses. It is a cheap and low polluting fuel. It is used as a substitute for petrol.

Table 6.2 : Comparison between respiration and burning

Respiration	***Burning (combustion)***
Similarities :	
1. Oxygen is required.	1. Oxygen is required.
2. Carbon dioxide and water vapour are formed.	2. Carbon dioxide and water vapour are formed.
Differences :	
1. Small amount of energy is released in the form of heat only.	1. A large amount of energy is released in the form of heat and light.
2. A slow process.	2. A fast process.
3. A natural and continuous process.	3. An artificial and discontinuous process.
4. Takes place at body temperature.	4. It takes place at a higher temperature which needs initiation.

LPG (Liquefied Petroleum Gas) : It is obtained from crude petroleum oil. It mainly contains gaseous compounds known as isobutane and butane. Popularly, it is known as **cooking gas**. It is the best fuel for domestic purposes and in laboratories. It is available in cylinders. It is also supplied through pipes in big cities.

Small amount of a foul smelling substance is mixed with this gas to detect leakage, if any.

LPG and CNG are modern day fuels which do not leave any residue on burning.

2. **Nitrogen** constitutes 78% of air by volume. It is of vital importance to the plants, animals and human beings as it is needed to prepare vital nutrient **'protein'** which every living being needs for its growth.

   The **plants** convert nitrogen into proteins, while animals and human beings get it directly or indirectly from them. Nitrogen cannot be absorbed directly by plants. It is first 'fixed' in the soil as nitrites and nitrates and then absorbed by the plants in soluble form. This phenomenon is called **nitrogen fixation**. Nitrogen is also present in enzymes and hormones of living beings.

   Nitrogen fixation is the process by which free nitrogen of air is converted into nitrogen compounds like nitrites and nitrates which are useful plant nutrients to produce proteins.

   When plants and animals die, they decay and nitrogen is returned to the soil. In this way, amount of nitrogen is balanced in air and can be used again and again.

   — Nitrogen dilutes the effect of oxygen present in air because it does not support burning.

   — It is used to make fertilizers and various nitrogenous proudcts.

Do You Know ?

In nature, symbiotic bacteria living in root nodules of leguminous plants like peas, grams, beans, etc. absorb nitrogen directly from air and convert it into nitrates to be absorbed and used by plants. That is why these plants are rich sources of proteins.

3. **Carbon dioxide** is very important for green plants to prepare their food by photosynthesis. Oxygen is released during this process which is used for respiration by both plants and animals.

- Carbon dioxide maintains the temperature of the earth and keeps it warm at night.
- Carbon dioxide being a non-supporter of burning is used as a fire-extinguisher.
- Dry ice (solid carbon dioxide) is used as a refrigerant.
- Carbon dioxide is used to prepare fizzy drinks like soda-water.

4. **Water vapour** present in the air provides moisture for both plants and animals. It also helps in predicting climatic conditions of a particular area as its amount varies from place to place and time to time.

Besides these, air as a whole is useful in many ways. Some of these are as follows:

- Air acts as the medium for propagation of sound.
- Air speeds up drying up of wet agricultural products like grains, pulses, fruits, etc.
- Air also dries up wet clothes. Moving air evaporates water faster and the clothes become dry easily.
- Air plays an important role in water cycle.

- Birds and insects can fly due to the presence of air.
- Air helps in pollination of flowers and dispersal of seeds.
- Air is filled in tyres of vehicles like cars, scooters, trucks, buses, bicycles, etc. for their smooth movement.
- Air helps in the movement of yachts, parachutes, aircrafts, etc.
- Windmills move due to the movement of air. They are used in flour mills and to draw water from tube wells. They are also used to generate electricity.

Fig. 6.3 Windmill in a coastal area to produce electricity

BALANCE OF GASES IN NATURE

Now you know that there are two important processes, respiration and burning in which the oxygen of air is utilized and carbon dioxide is produced. These two processes increase the amount of carbon dioxide in the atmosphere.

Then why does not the amount of oxygen in the air get depleted ?

Why does not the amount of carbon dioxide increase to a very large extent ?

There must be some process in nature which utilizes large quantities of carbon dioxide and restore the quantity of oxygen in air. Otherwise, the composition of air will change appreciably and there will be an imbalance in nature and no life.

The main process in nature that helps in balancing the quanties of oxygen and carbon dioxide in air is **photosynthesis** that occurs in green plants.

Photo means light and *synthesis* means putting together.

"It is a process through which green plants prepare their food in presence of sunlight with the help of carbon dioxide and water". The food is prepared in the form of **glucose** (a carbohydrate) with the release of **oxygen** gas.

$$\text{Carbon dioxide + Water} \xrightarrow[\text{chlorophyll}]{\text{light}} \underset{\text{(food)}}{\text{Glucose}} \text{ + Oxygen}$$

Plants take carbon dioxide from air and water from soil for photosynthesis.

This process takes place only in green plants because they contain a green pigment called chlorophyll which is able to trap solar energy from the sun. Hence, it takes place only during daytime while respiration takes place both during day and night.

Note : Although glucose is prepared during photosynthesis, it is stored as starch in plants.

During respiration in plants and animals, food material is broken down with the help of oxygen in the air to produce carbon dioxide, water and energy. Photosynthesis in green plants uses carbon dioxide from the air. Respiration

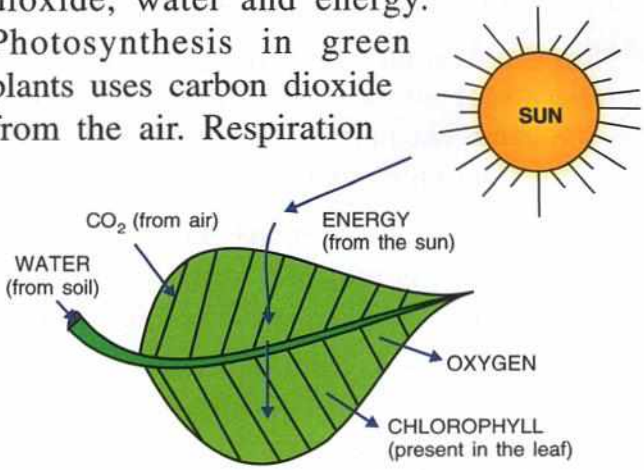
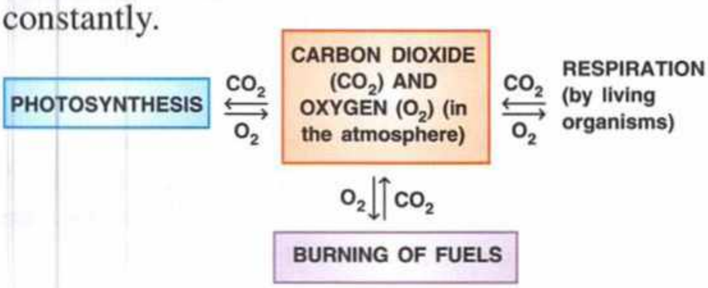


Fig. 6.4 The process of photosynthesis

in living beings returns carbon dioxide into the air. Thus, these two opposing processes together keep the composition of the air constant.

Oxygen produced during photosynthesis mixes in the air and makes it more fresh, *i.e.* maintains the required amount of oxygen in air. Plants also maintain the required amount of carbon dioxide in air by using it constantly.



Balance of oxygen (O_2) and carbon dioxide (CO_2) in the atmosphere

Photosynthesis is the major source of oxygen in the biosphere. The process of photosynthesis, respiration and burning of fuels maintain the oxygen-carbon dioxide balance in nature.

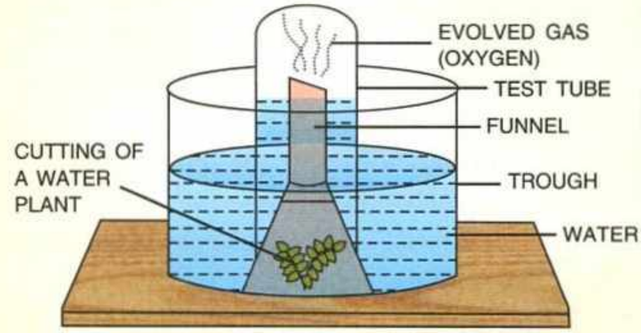
Activity 14

To be demonstrated by the teacher.

To show that green plants produce oxygen during photosynthesis.

Fill about three-fourth of a glass trough with pond water. Place a few cuttings of a water plant like *Hydrilla* in it and cover them with an inverted glass funnel. Fill a large test tube with water, cover its mouth with your thumb and place it over the stem of the funnel. Place the whole set up in the sunlight. After sometime bubbles of a gas, emerging from the leaves, are found moving into the test tube. Let the test tube be filled with the gas. Remove the test tube and bring a glowing splinter near its mouth. The splinter starts burning with a bright flame.

This proves that, the gas in the test-tube is oxygen, and it is produced during photosynthesis.



Production of oxygen during photosynthesis

Note : Plant is also consuming oxygen for respiration but photosynthesis is faster than respiration in the sunlight. That is why there is surplus oxygen which is collected in the test tube.

Rusting

This is a chemical process which takes place in presence of moist air.

When some iron objects like iron scraps or bright iron nails are kept in moist air for a few days, their surface gets coated with a reddish brown powdery mass which is commonly called **rust**. This mass is chemically known as **hydrated iron oxide**.

The slow conversion of iron into its hydrated oxide in the presence of moisture and air is called *rusting*.

Conditions necessary for rusting

In all cases of rusting, it is necessary for the iron materials to get exposed to air and moisture.

Rusting of iron is a wasteful process. It can be prevented by painting, greasing, coating or alloying with a non-corrosive metal.

EXERCISE – II

1. Name two important processes supported by oxygen present in air.
2. Give two uses of the following components present in air :
   (*a*) oxygen (*b*) nitrogen
   (*c*) carbon dioxide (*d*) water vapour
3. Define the following :
   (*a*) Respiration, (*b*) Photosynthesis
   (*c*) Combustion.
4. What are fuels ? Give two examples of modern fuels.
5. Give reasons :
   (*a*) Aquatic animals and plants are able to survive in water.
   (*b*) A burning candle stops burning if covered with a glass tumbler.
   (*c*) Mountaineers and divers carry oxygen cylinders with them.
   (*d*) When water is heated, we see bubbles rising up.
6. Name the processes which maintain the balance between oxygen and carbon dioxide in the air. How is it done ?
7. State two similarities and two differences between respiration and burning.
8. Define rusting. What are the two necessary conditions for rusting of iron ? Give the chemical name of rust.
9. How is air useful to :
   (*a*) water boats (*b*) agriculture
   (*c*) windmills (*d*) scooters and cars ?
10. State the full form of LPG and CNG. How are the two different in their composition ?
11. (*a*) Why is nitrogen important to all living beings?
    (*b*) What is nitrogen fixation ?

AIR POLLUTION

Air is important for our survival. But the air we breathe, should be free from impurities. Nowadays, many harmful substances get mixed in the air and cause air pollution. This polluted air causes harm not only to humans but also to plants and animals. The harmful and undesirable substances mixed in air are called pollutants.

The common ***pollutants*** which make the air impure are smoke, dust and soot. These pollutants are emitted by automobiles and industries. Gases like sulphur dioxide, carbon monoxide and carbon dioxide (in excess) also pollute the air. Some other gases like ammonia and methane also enter the air due to the decaying of dead plants and animals.

HARMFUL EFFECTS OF AIR POLLUTION

1. **Effects on health :** Common air pollutants like dust and smoke cause respiratory, skin and eye problems. Sometimes, air pollution may lead to cancer.

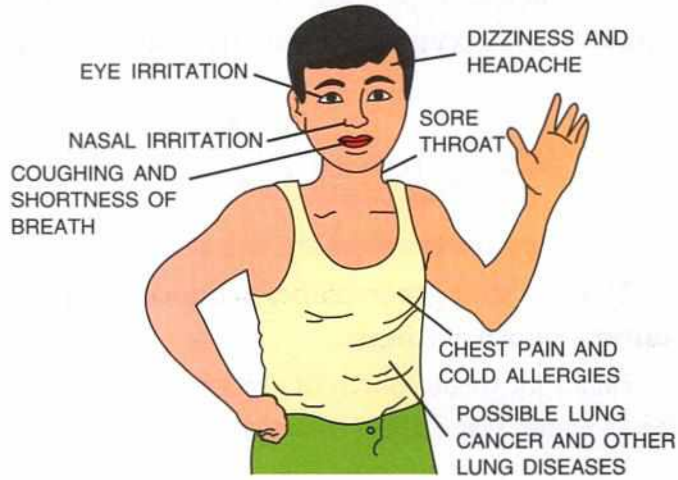


Fig. 6.5 Diseases in human beings caused due to air pollution

2. **Effects on vegetation :** Air pollution affects vegetables and fruits, which is a great economic loss.
3. **Acid rain :** Gases like sulphur dioxide and nitrogen dioxide (pollutants) get mixed in

rain water to form acid rain. This rain damages crops, marble buildings, metals, *etc*. If it gets mixed with river water, it causes death of aquatic plants and animals.

4. **Effects on the atmosphere :** Pollutants like smoke, dust, *etc*. make the atmospheric air dense. This reduces the visibility which leads to road and rail accidents.

An increase in the percentage of carbon dioxide, methane, nitrous oxide, *etc*. traps more heat from the sunlight causing **global warming**. These gases are called **greenhouse gases**.

Global Warming : Carbon dioxide has the capacity to absorb heat from the sunlight. Excess of carbon dioxide near the earth's surface traps the heat and prevents it from escaping into space. This ultimately results in increasing the temperature of the earth, a phenomenon known as *global warming* or greenhouse effect.

It has been predicted that due to global warming, there will be a 1°C rise in the temperature of the earth every fifteen years. This will gradually cause an imbalance in the ecological system.

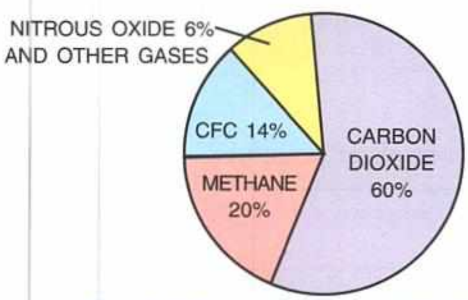


Fig. 6.6 Percentage contributions of different gases to global warming

5. **Ozone-layer depletion :** Ozone is present in the upper layer of atomsophere called stratosphere. It protects the earth from harmful ultraviolet rays of the sun. Some air pollutants like chlorofluorocarbons (CFCs) react with ozone present in the atmosphere. These pollutants reduce the density of ozone in the stratosphere due to which the ultraviolet rays from the sun reach directly on the earth affecting human health, causing skin diseases and cancer.

CAUSES OF AIR POLLUTION

1. Increase in human population.
2. Indiscriminate cutting of forests.
3. Burning of fossil fuels.
4. Emission of harmful gases from vehicles.
5. An increase in the number of industries near the residential areas.
6. Agricultural activities such as the use of chemicals like fertilisers, insecticides, pesticides, *etc.*
7. Chemical weapons like atomic bombs used in wars.
8. Natural causes like volcanic eruptions.

The following steps need to be taken for controlling air pollution :

1. Growing more trees and plants in big cities and towns. Trees clean the atmosphere by using carbon dioxide and releasing oxygen. Trees also help in bringing more rains that make the atmosphere free of pollutants.
2. Factories and power houses should be provided with tall chimneys so that smoke and gases go high up into the air.
3. Unleaded petrol should be used in vehicles. Vehicles should be regularly checked for pollution control. Nowadays, CNG (Compressed Natural Gas) is being used as a fuel in all the public transport vehicles to reduce pollution.

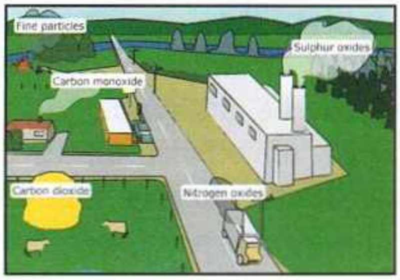


Fig. 6.7 Air Pollution

4. Using smokeless sources of energy, like solar energy and electrical energy in place of the conventional fossil fuels. Smokeless *chulhas* use biogas and solar energy.
5. Industries should be located far away from residential areas.

RECAPITULATION

- Air is the most important component of life.
- Air is a mixture of nitrogen, oxygen, carbon dioxide, helium, argon, water vapour and dust particles.
- Air is divided into two parts, the 'active' air (oxygen) which takes part in burning, and the 'inactive' air (mainly nitrogen, carbon dioxide, water vapour and noble gases) which does not take part in burning.
- Active air is only one-fifth by volume of the total air present in the atmosphere, which is necessary for burning and respiration.
- Nitrogen contained in the air is essential for making proteins necessary for the growth of living beings. It is also used for making fertilisers.
- Carbon dioxide is needed by plants for photosynthesis.
- Air dissolved in water is used by aquatic plants and animals.
- Rusting and burning are similar chemical processes in terms of consuming oxygen.
- Rusting takes place in the presence of both air and moisture.
- Rusting should be prevented, as it is a wasteful process. It can be prevented by painting, greasing, coating or alloying with a non-corrosive metal.
- Air gets polluted by smoke, dust, burning coke and harmful gases.
- Polluted air is harmful for our health. Therefore, it is necessary to control air pollution.

EXERCISE – III

1. What is air pollution ?
2. Mention five causes of air pollution.
3. Name two air pollutants which
   (*a*) affect our health, (*b*) cause acid rain,
   (*c*) cause global warming.
4. What is meant by ozone depletion ?
5. State four steps to be taken to control air pollution.
6. Name three greenhouse gases.

OBJECTIVE TYPE QUESTIONS

1. Fill in the blanks :
   (a) The layer of air around the earth is called the ....
   (b) Although we cannot see air, we can .... it.
   (c) Air is a .... of gases.
   (d) Plants and animals maintain the balance of .... and .... in air.
   (e) Polluted air is .... for health.
   (f) The supporter of combustion in air is ....
   (g) Green plants need .... to prepare food.
   (h) Oxygen is used in .... of the food to get ....
   (i) Aquatic plants and animals use .... in water.
   (j) The reddish brown powder on the surface of iron nails exposed to air and moisture is called ....

2. Write '*true*' or '*false*' for the following :
   (a) Air is a compound. ....
   (b) Carbon dioxide is given out during photosynthesis. ....
   (c) Respiration needs nitrogen. ....
   (d) The composition of air was discovered by Lavoisier. ....
   (e) The major component of air is oxygen. ....

MULTIPLE CHOICE QUESTIONS

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

1. Air consists of
   (a) only oxygen (b) only nitrogen
   (c) only carbon dioxide (d) all of these.
2. Air pollution is due to the
   (a) cutting of green plants
   (b) gases like carbon monoxide, sulphur dioxide, etc.
   (c) smoke given out by factories
   (d) all of the above.
3. The gases which cause acid rain are
   (a) sulphur dioxide and oxygen
   (b) nitrogen and oxygen
   (c) carbon dioxide and water vapour
   (d) nitrogen dioxide and sulphur dioxide.
4. Rust is
   (a) hydrated iron oxide
   (b) hydrated copper sulphate
   (c) anhydrous iron oxide
   (d) none of the above
5. Photosynthesis is a process in which plants
   (a) take in oxygen and give out carbon dioxide
   (b) take in carbon dioxide and give out oxygen
   (c) take in nitrogen and give out oxygen.
   (d) none of the above
6. Fuels which do not leave any residue on burning are
   (a) coal and wood (b) coal and LPG
   (c) wood and CNG (d) LPG and CNG.
7. Respiration
   (a) is a slow process
   (b) is a natural and continuous process
   (c) takes place at body temperature
   (d) all of the above
8. Which of the following is common in combustion and respiration
   (a) oxygen (b) release of heat and light
   (c) natural process (d) nitrogen.
9. Which of the following is not a greenhouse gas?
   (a) carbon dioxide (b) sulphur dioxide
   (c) methane (d) nitrous oxide

Water

7

Theme : Water is essential for sustenance of life. It is considered as a universal solvent due to its capacity to dissolve a large number of compounds in it. It is becoming scarce day by day. It is therefore important to use it judiciously, conserve it and keep our water resources clean.

In this chapter you will learn :

- *Importance of water in everyday life (household purpose, industry, watering plants, etc.)*
- *Water resources (well, river, hand pump, lake, pond, etc.)*
- *Capacity to dissolve many substances in it.*
- *Definition of solute, solvent and solution.*
- *Importance of water for sustenance of life on earth.*
- *Reasons for water pollution; its prevention; conservation of water.*

LEARNING OBJECTIVES

The children will be able to :

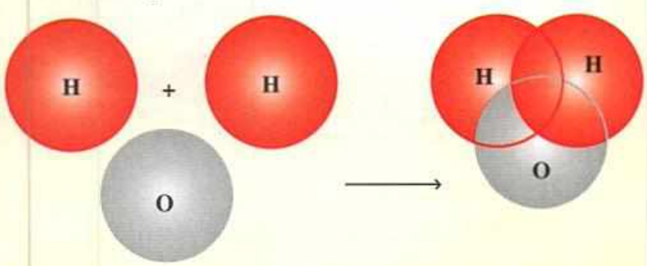
- define solute, solvent and solution.
- infer that solution is a homogeneous mixture of solute and solvent.
- discuss different examples of solutions.
- state reasons for pollution of water resources and suggest ways to conserve water.

INTRODUCTION

We have read in the earlier chapter that air is the most essential substance for life. Now, we will study the second most important substance for the existence of life, *i.e.*, **water**. Water cannot be replenished and without water one cannot survive. "Water is the liquid of life."

WATER – A COMPOUND

Water is a clear transparent liquid. Earlier considered an element, *Henry Cavendish in 1781 proved that water is a compound* made up of two elements, hydrogen and oxygen. One molecule of water is composed of two atoms of hydrogen and one atom of oxygen. Hydrogen and oxygen are present in a fixed proportion in a water molecule, therefore it is a compound. A molecule of water is represented by the formula H_2O.



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

OCCURRENCE OF WATER

Water is one of the most common and important substances around us. Water exists on the earth's surface, above it and below it.

- **Water on the earth's surface :** Water is widely distributed on earth. Nearly $4/5^{th}$ of earth's surface is covered with water. About 97% of the total water available on earth is in oceans. Around 2% of it is frozen in the form of glaciers and polar ice caps. The remaining 1% of water is available in the form of rivers, lakes, ponds, underground water, *etc.* which can be utilized for agriculture and consumption by living beings.
- **Water in the atmosphere :** In the atmosphere water is present in the form of vapour, mist, clouds, *etc*.
- **Water in living organisms :** All living organisms contain high amounts of water in their bodies. Human blood has 90% water, whereas the human body as a whole has 70% water. Foodgrains, fruits, vegetables, *etc*. contain water in different amounts.

The consumption of water for daily activities depends upon the weather conditions. During summers more water is needed than in winters.

Do You Know ?

We need minimum one and a half litres of water everyday to stay alive. Much of this water comes from the food that we eat.

Make a list of things you consumed from morning till night in one day.

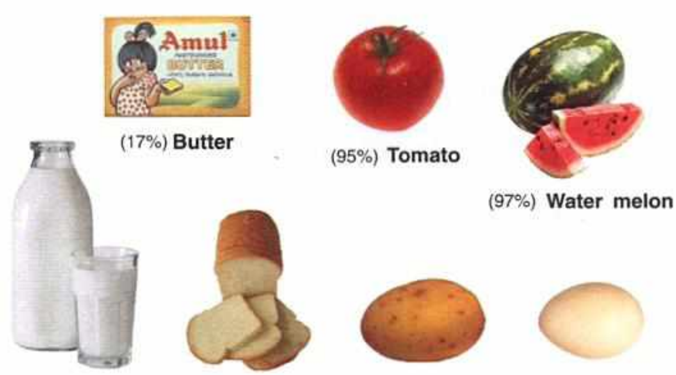


Fig. 7.1 Water content in some foods

Table 7.1 : Water content in some organisms

Living organism	*Percentage of water*
Fish	67%
Elephant	80%
Humans	70%
Plant	60%

Do You Know ?

Thin people may contain 75% water where as fat people may contain only 55% of water.

Even dry grains like wheat, rice, pulses contain 3% to 4% of water. All foods containing water less than 14% are called non-perishable foods. Foods containing more than 14% water like vegetables and fruits, are called perishable foods.

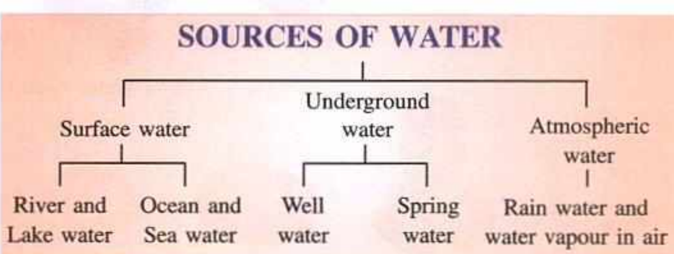
SOURCES OF WATER

The main sources of natural water are :

- Surface water
- Underground water and
- Atmospheric water (water above the surface of the earth).

On the basis of sources, water can further be classified into

1. Rain water
2. River and lake water
3. Spring and well water
4. Ocean and sea water.



Now let us study about the natural sources of water.

SURFACE WATER

Ocean and Sea Water

Most of the water is in seas and oceans. Figure 7.2 shows the proportion of the earth's surface that is covered by different oceans.

Sea is the largest source of natural water, but it contains a large amount of dissolved impurities, mainly common salt.

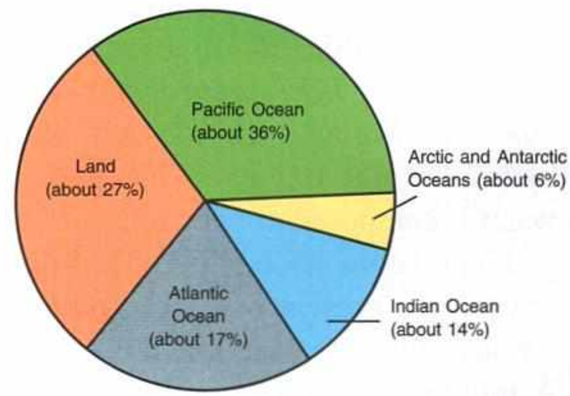


Fig. 7.2 The amount of earth's surface covered by the oceans

Activity 1

Take equal volumes of rain water, tap water and sea water as samples and evaporate them separately in three China dishes. What do you observe ?

No residue is left behind when rain water is evaporated. However, evaporation of tap water leaves some deposit and sea water leaves a large deposit of salts in the dish.

The concentration of common salt in sea water is very high, therefore sea water is saline. Sea water is the chief source of common salt. It also contains all the impurities of river water. Thus, sea water cannot be used directly for drinking or irrigation.

Activity 2

To show that plants cannot tolerate saline water.

Take two healthy potted plants and keep them at a suitable place in sunlight.

Water one of the plants with saline water and the other one with tap water for a few days regularly.

It is observed that the plant watered with saline water did not grow well.

Thus, plants do not tolerate saline water.

Do You Know ?

The process of removal of the dissolved salts from sea/ocean water is called desalination.

River and Lake Water :

Water in rivers and lakes comes from rains and the melting of snow from mountains. It flows down the hills and plains before falling into the sea. On its way, it carries with it many substances, especially mineral salts. It also contains a lot of suspended impurities like clay, sand particles, organic matter, harmful bacteria, etc.

Fig. 7.3 River water

River water is the most suitable source for domestic and industrial uses.

However river water is absolutely unfit for drinking directly due to the presence of the impurities stated above.

UNDER GROUND WATER [Water below the surface of the earth]

When rain falls, a part of rain water seeps through the soil (through porous rocks of the soil) and gets collected on the non-porous rocks. This collected water is called underground water and the level of ground water is known as the **water table**. Due to high pressure, sometimes water escapes on to the surface of the earth in the form of springs. Ground water can also be obtained by digging wells or tube wells or lifting pumps (hand pumps).

Well water and spring water are considerably pure as they contain dissolved impurities but no suspended impurities or germs (harmful bacteria) because they have been filtered through different layers of the soil. The dissolved impurities depend on the nature of the soil surrounding the spring or well. Therefore, the taste of underground water differs at different places. Usually a deep well contains more pure water than a shallow well. Sometimes this underground water is rich in minerals which have medicinal values. This water is usually pure and safe to drink.

Water in the Atmosphere *i.e.* Water above the Surface of the Earth

Rain water :

The occurrence of rain is a clear evidence for the presence of water in the air.

Rain water is almost **pure water** formed by evaporation of water followed by its vapour condensation. The only impurities present in rain water are dust and dissolved gases such as oxygen, nitrogen and carbon dioxide. Since these gases are not poisonous, rain water is safe to drink. After some showers these impurities are washed away. In that case, rain water is considered as the purest form of water available on earth.

THE THREE STATES OF WATER

Water can exist in all the three states of matter :

(i) Solid — ice (ii) Liquid — water

(iii) Gas — water vapour or steam.

In nature, water

- **In the solid state**, is found as glaciers, snow, frost, hail, etc. Snow is mostly present on the peaks of mountains and in Arctic and Antarctica regions.
- **In the liquid state** is present in oceans, seas, rivers, lakes, ponds, springs and rain water.
- **In the gaseous state** is present as water vapour in air.

INTERCONVERSION OF STATES OF WATER

Water under normal conditions is in liquid state. If it is heated up to 100°C, it boils and turns into its gaseous state called *steam*. On cooling, water changes to its solid form (ice) at 0°C.

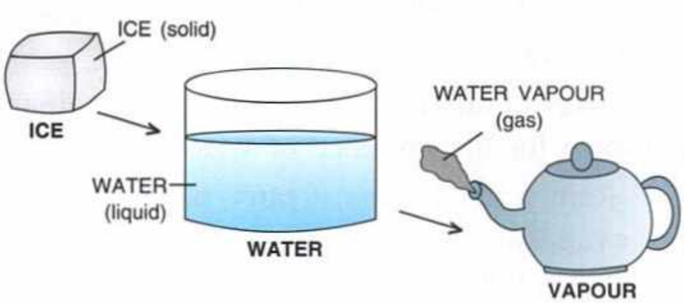


Fig. 7.4 Water in three different states

Ice, water and steam seem to be different substances, because they have different physical properties. However, chemically, they are identical. Therefore, ice, water and steam are said to be the same chemical substance in different physical states. Water can change into vapour state even without heating.

$$\text{Ice} \underset{\text{Cool}}{\overset{\text{Heat}}{\rightleftharpoons}} \text{Water} \underset{\text{Cool}}{\overset{\text{Heat}}{\rightleftharpoons}} \text{Water vapour or steam}$$

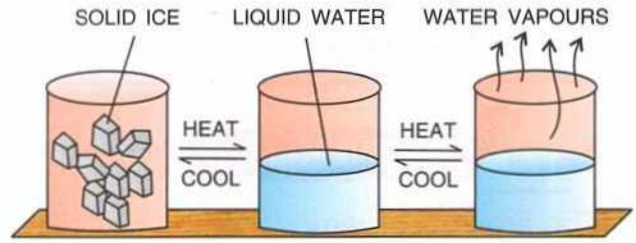


Fig. 7.5 Interconversion of states of water

The interconversion of the three states of water also occurs in nature which is known as the *water cycle*.

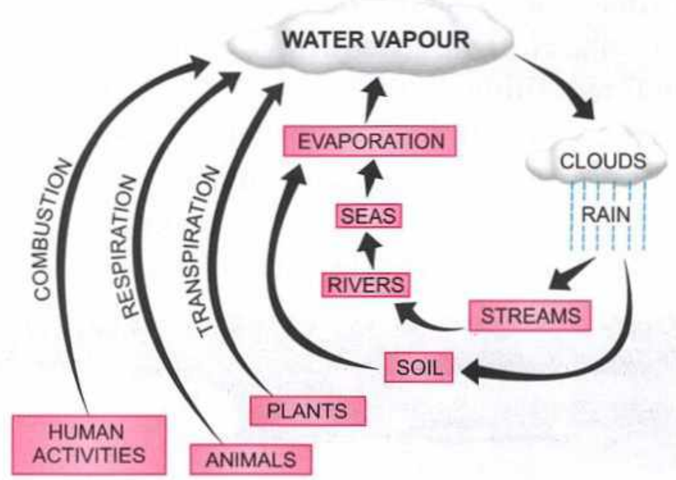


Fig. 7.6 Water Cycle

The change of water from one form to another in nature, which results in its continuous circulation from earth's surface to the atmosphere and from the atmosphere back to the earth's surface is called water cycle.

The heat of the Sun evaporates water from the sea, rivers and lakes, and also from the soil and plants on the land. Water is turned into water vapour, which gets mixed with air. Moist air rises high up into the atmosphere where the temperature is low and it cools down. Cool air cannot hold as much water vapour as warm air, thus the water vapour condenses into tiny droplets of water. In the sky, the tiny water droplets form clouds and when these tiny water droplets in the clouds combine to form larger droplets, they fall on the earth as rain.

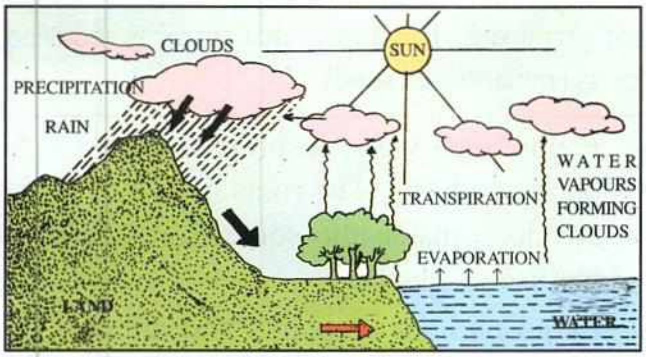


Fig. 7.7 Water Cycle in nature

When air cools to a greater extent, the water droplets freeze into snow. In cool places, they fall as snow.

Water cycle in nature plays an important role in :

- restoring the lost water from the earth's surface and maintaining the balance in underground water. The rain water is very important because agricultural production depends mainly on rains in many parts of the world.
- controlling the climatic conditions all over the world.

Fog : When the water vapour changes into tiny droplets of water near the ground, it is known as **fog**.

Mist : When the tiny droplets of water remain suspended in air, it is called **mist**.

Dew : When the water vapour condenses on the cold objects, it forms tiny droplets of water called **dew**. It is often seen on grass, leaves and flowers in winter mornings.

Frost : When the dew freezes, it is called **frost**.

EXERCISE – I

1. Name :
   (*a*) Three major sources of natural water
   (*b*) Four sources of surface water
   (*c*) Two underground sources of water.
2. Answer the following questions in short :
   (*a*) In which form is water present in the atmosphere ?
   (*b*) Which source of water contains the highest concentration of salt in it ?
   (*c*) Why is rain water considered the purest form of natural water ?
   (*d*) What possible impurities does rain water contain ?
   (*e*) What is water table ?

(f) Why is spring water pure enough for drinking but unsuitable for laboratory use?

(g) Why the taste of spring water differs at different places ?

3. List *three* major impurities present in river water.

4. Find the percentage of water in the following:

(a) Rice and wheat grains

(b) Eggs (c) Tomatoes

(d) Bread (e) Water melon

5. What are the three states of water ?

6. Why are ice, water and steam considered to have the same chemical composition ?

7. How is a cloud formed ?

8. What is water cycle ? What is its importance ?

9. How are the following formed ?

(a) fog (b) mist

(c) dew (d) frost.

IMPORTANCE OF WATER

We cannot imagine life without water. It is the most abundant substance present in all living organisms. We need lots of water in our daily life for different purposes.

1. We drink water to fulfill our biological needs. Also it regulates our body temperature by the process of sweating and evaporation.
2. Water being a liquid has the property to flow easily and also it acts as a solvent. These properties make it useful in the process of digestion, blood circulation, excretion, *etc.* in the body of living organisms.
3. Water is essential for agriculture because crops cannot grow without water. Seeds need water to germinate and grow into plants.

Activity 3

Take some bean seeds and soak them in water for 5-6 hours. Remove the seeds from water and wrap them in a wet cloth for 2 days. What do you observe? You will observe that the wet bean seeds begin to germinate.

In another experiment take the same quantity of bean seeds but do not soak them in water. Wrap these seeds in a cloth for few days. You will observe that unsoaked bean seeds do not germinate. This shows that water is required for germination of seeds.

4. Plants need water to prepare food *i.e.* for photosynthesis. The roots of plants, which are deep inside the soil absorb water for the use of plants.
5. Large number of plants and animals live in water. They take up nutrients and oxygen dissolved in water for their survival.
6. Water also controls the earth's climate.
7. Water is used by human beings for various domestic purposes such as bathing, cooking, washing clothes and utensils, *etc*.
8. Water is used in thermal, hydroelectric and nuclear power plants to generate electricity.

Do You Know ?

Per person consumption of water in a village in our country is about 12 litres per day whereas the consumption per person in a city is between 50 - 2000 litres per day.

A person needs about 2·5 litres of water per day for drinking.

Some other uses of water

9. Water is a good medium for the transportation of people and goods through boats and ships.
10. The flowing water is also used for doing some mechanical work, such as running a flour mill, in navigation, generation of electrical energy, etc.
11. In cold countries, water is used to keep houses warm.
12. Water in the radiator of a car helps in keeping its engine cool.
13. Water provides a medium for recreational sports, such as swimming, boating, *etc*.
14. Water is used in medical and chemical industries for different processes.

Fig. 7.8 Dam water generates electricity

Importance of anomalous expansion of water

Under normal conditions, when a substance in liquid state is heated, it expands, hence its volume increases and density decreases and when the liquid is cooled it contracts, therefore its volume decreases and density increases.

But water has an unusual property. When it is cooled from a higher temperature, it contracts till 4°C, increasing its density and decreasing its volume just like any other liquid does. But on cooling further below 4°C, water starts expanding, as a result its volume increases and density decreases till the temperature reaches 0°C at which water freezes into ice to float in liquid water. This is called the **anomalous expansion of water**.

Hence, water has maximum density at 4°C. Ice is lighter than water, therefore it floats in water.

Activity 4

Take a glass tumbler and fill two third parts of it with water. Add 2-3 ice cubes to it.

What do you observe ?

The ice cubes float in water. This proves that ice is lighter than liquid water.

This anomalous property of water enables aquatic plants and animals to survive in colder regions of the world because even when the water of ponds, lakes and rivers freezes, it freezes on the top but remains liquid below the ice layer.

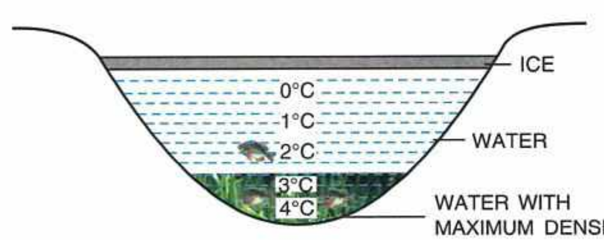


Fig. 7.9 Formation of ice at the top of a pond in colder regions [anomalous property of water].

NEED FOR POTABLE WATER [DRINKING WATER]

Natural water is the best for human consumption as well as for animals and plants but it is not available, in the pure form, in abundance.

> Water fit for drinking purposes is called potable water.

Water needs to be purified before its consumption. This is done by killing the germs and removing other impurities.

Drinking water should have the following characteristics :

1. It should be colourless and odourless.
2. It should be transparent.
3. It should be free from harmful micro-organisms or germs which cause infections and diseases.
4. It should be free from suspended impurities and other harmful substances.
5. It should contain some minerals and salts, necessary for our body and some dissolved gases to add taste. (*Water containing carbon dioxide has taste*).

WATER-BORNE DISEASES

Water obtained from any source which looks clear is not always potable. It may contain certain germs which are very small organisms. These germs cause diseases like cholera, gastroenteritis, dysentry, typhoid, jaundice, *etc*. These diseases are called water-borne diseases.

Cholera and **gastroenteritis** cause acute **diarrhoea** along with vomiting and loose motions due to infection in the digestive canal. There is very little or no urination because of the shortage of water in the body. If the patient is not treated in time, these diseases may cause dehydration which becomes fatal.

Typhoid is another water-borne disease which is caused by bacteria that affect the intestine. One of its symptoms is that the patient has high fever for a number of days and if not treated properly, it may cause death.

Jaundice affects the liver of a person and becomes fatal if the patient is not given proper treatment.

> **Sterilisation :** The process of removal of germs from water to avoid water borne diseases is known as sterilisation. It can be done by the following :
>
> - **Boiling —** Germs cannot exist at the temperature of boiling water. Therefore, prolonged boiling of water destroys them.
> - **Exposure to air and sunlight —** ozone present in air and sunlight causes the killing of germs present in water.
> - **Chemical treatment —** Chemicals like chlorine and ozone can kill the germs. Swimming pools are usually chlorinated to remove the danger of infection. Bleaching powder as a source of chlorine is added to water tanks to kill the germs. Use of ozone to sterilise water is called ozonisation.

PURIFICATION OF WATER FOR DRINKING

For cities and towns, the source of water is a river or a lake running nearby. This water contains both suspended and dissolved impurities. Therefore, before supplying it for drinking purposes, it is necessary to purify this water.

Purification of water in cities involves the following operations :

- Loading and Sedimentation
- Filtration
- Aeration
- Chlorination
- Ozonisation
- Storage

Loading and sedimentation : Running river water is permitted to flow into basins, tanks or reservoirs. Most of the suspended matter settles to the bottom. The slower the water moves through the reservoir, greater is the possibility for suspended matter to settle down at the bottom as **sediment**. They are made to settle down more quickly by loading with the addition of a chemical known as *potash alum*.

- The settling of suspended solid matter at the bottom of a liquid is called **sedimentation.**
- The process of adding a chemical to an impure liquid in order to increase the rate of sedimentation of suspended particles is called **loading**.

Do You Know ?

Sea water is not fit for drinking, cooking and washing because it contains high concentration of salts. It induces vomiting.

Filtration : The water after sedimentation still contains some lighter suspended impurities which are removed by filtration through beds of sand and gravel.

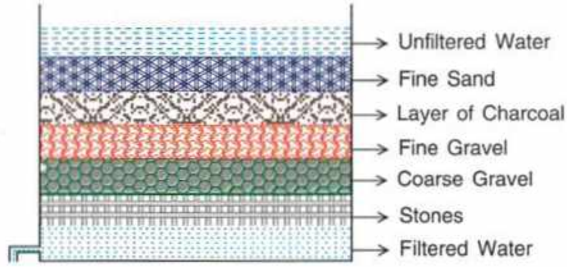


Fig. 7.10 : A cross-section of a sand filter

This leaves a perfectly clear water but it still contains germs.

Aeration : Air under pressure is then blown into the filtered water. This process is called **aeration**. It kills harmful micro-organisms present in the filtered water.

Chlorination : Water is then passed into a chlorination tank where it is treated with chlorine to kill all the germs present in it. Water is now potable or safe for drinking

Storage : The potable water is then stored in a storage tank from where it is supplied to homes through pipes.

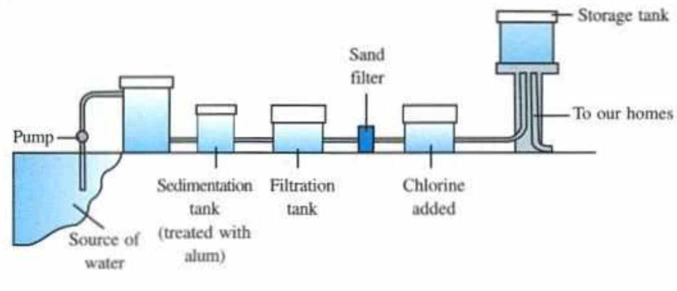


Fig. 7.11 : Purification of water by water works

TAP WATER CONTAINS DISSOLVED IMPURITIES

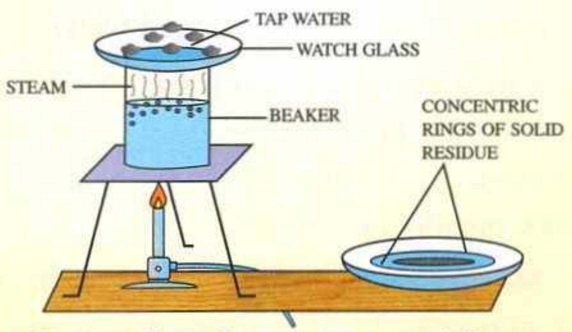
The potable water obtained through taps is free from suspended impurities and germs but it still contains dissolved impurities. This can be shown by the following activity :

Activity 5

Take some tap water in a watch glass and place it over a beaker containing water. Place the apparatus on the wire gauge over a tripod stand and heat it.

When water in the beaker boils, the heat released causes water in the watch glass to evaporate slowly. When all the water is evaporated, hold the watch glass against light. A number of concentric rings of solid matter are observed.

These rings are of the dissolved solid impurities present in tap water.



Evaporation of tap water containing dissolved solid impurities

Household methods to get safe drinking water

Different methods are used for making water potable at home.

By boiling :

- The easiest method is **to boil water before drinking**. Water boils at 100°C and most of the bacteria are killed at this temperature.

  This process is feasible only at a small scale and not on a large scale.

By water purifiers :

- Nowadays, many companies have come up with **water purifiers** and **R.O. systems**. The purifier is attached to a tap in the kitchen and the tap water is passed through the purifier.

  The purifier is fitted with ceramic candles and an ion-exchanger (carbon powder), which retain the impurities and bacteria present in water and we get pure water for drinking.

By chlorination :

- The stored water in the tanks fitted on the roofs of the houses is made safer by adding chlorine tablets. For every 25 litres of water, we need to add one chlorine tablet.
- The stored water can also be purified by adding potassium permanganate crystals or passing ozone.

By filtration : Any suspended impurities in the water from well, river or lake can be removed by filtering water through a fine muslin cloth.

WATER PURIFIED BY DISTILLATION TO REMOVE SOLUBLE IMPURITIES

Distillation : It is a process of getting a pure liquid from a solution by evaporating it and then condensing the vapours back into the liquid. Water is also purified by this method.

Activity 6

Add potash alum to a sample of water collected from a tap to see if this water is completely free from suspended particles. Repeat the same with distilled water. Compare your results. You will observe that some particles settle down in the case of tap water but nothing happens in the case of distilled water.

Distilled water is the purest form of water but it is not good for drinking because :

(i) it does not contain any salt or mineral required by our body.

(ii) it is tasteless.

Distilled water is used for preparing solutions for medicinal purposes and laboratories, in car batteries, *etc*.

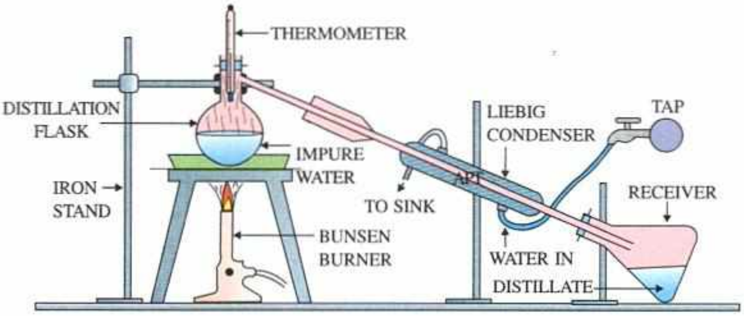


Fig. 7.12 Distillation

EXERCISE – II

1. Name :

(*a*) Two chemicals used to destroy germs present in water.

(*b*) Two diseases which spread through impure water.

(*c*) A chemical used for loading.

(*d*) Two substances which add taste to water.

(*e*) Two household methods to get safe drinking water.

2. Answer in brief :

(*a*) Why is river water unfit for drinking ?

(*b*) Why is tap water a mixture ?

(*c*) What is mineral water ?

(*d*) What is the purpose of adding bleaching powder to water supplied to the town ?

(*e*) How is chemically pure water obtained in the laboratory ?

(*f*) How is water in a swimming pool kept free from germs ?

3. Define :

(*a*) Sterilisation (*b*) Sedimentation

(*c*) Loading (*d*) Aeration

4. What is potable water ? List four characteristics of potable water.

5. Why is water important for plants and animals?

6. What are the three methods of removing germs from natural water? Explain.

7. Name the steps involved in the purification of drinking water supplied in cities and towns.

8. What is the taste of distilled water ? Why is it not potable ?

9. Give reasons :

(*a*) Ice floats on water.

(*b*) Marine life is able to survive in colder regions.

(*e*) Water droplets can be seen outside a chilled water bottle.

WATER — A UNIVERSAL SOLVENT

Water has the ability to dissolve most of the solid, liquid and gaseous substances in itself, therefore it is often termed as the **universal solvent**.

Activity 7

Take two beakers A and B of the same capacity. Fill half of each beaker with water.

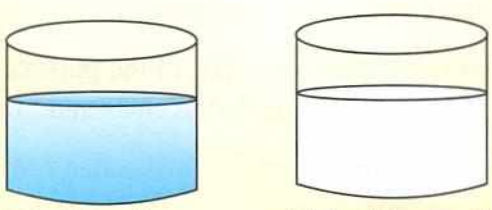
Now add the same quantity of solid copper sulphate and solid sodium carbonate to the beaker A and B respectively. Stir each of them properly.

What do you observe ?

The solids added to water are no more visible. In fact the solids dissolve in water to give a uniform mixture.

What are such mixtures called as ?

These mixtures are called as "solution". The solids are called as "solute" and the water to which the solids are added acts as a "solvent".



(A) A solution of copper sulphate in water

(B) A solution of sodium carbonate in water

Hence, a **solute** is a substance that dissolves in a medium which can be water or any other substance. Solute is in a smaller quantity in a solution.

A **solvent** is a medium in which a solute dissolves. It is in a large quantity in a solution. Water is the most common solvent. The other solvents are alcohol, carbon tetrachloride, etc.

A **solution** is a homogeneous uniform mixture formed by a solute and a solvent.

In daily life, you come across many solutions. Give two examples and identify the solute and solvent in those solutions.

- Two liquids can also mix to form a uniform mixture, *e.g.* water and alcohol. In such a solution, the liquid which is present in a larger quantity is termed as a solvent and the one in a smaller quantity is called a solute. If alcohol is less and water is more, alcohol acts as the solute and water acts as the solvent.
- If you expose water to air, it begins to dissolve the gases present in the air.

Water is the most frequently used solvent. The substances which dissolve in water are said to be **water soluble** substances whereas those substances which do not dissolve in water are said to be **water insoluble** substances.

Do You Know ?

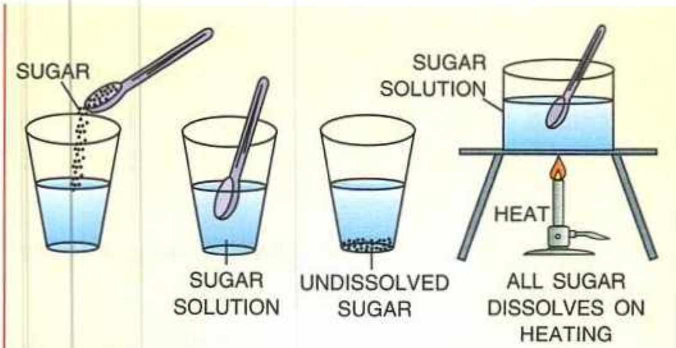
If you keep water in containers made of copper, iron, brass, etc. for some time, it will dissolve small traces of the materials of which the containers are made up of. This happens because water being a universal solvent has the property of dissolving even the substances in which it is kept.

Capacity of water to dissolve substances

To find out whether there is any limit to the amount of a substance that can be dissolved in a given quantity of water, let us do the following activities.

Activity 8

Take some water in a glass. Add a little sugar to it and stir it properly. You will observe that all the sugar is dissolved in water. Add some more sugar to it. It also dissolves. Go on adding



sugar to the water in the glass till no more sugar dissolves in it. Now heat this solution. You will observe that sugar which was not dissolved earlier gets dissolved now.

This shows that water has a great capacity to dissolve substances on changing the conditions.

Both ***stirring*** *and* ***heating*** *help in the quick dissolution of the substances in water.*

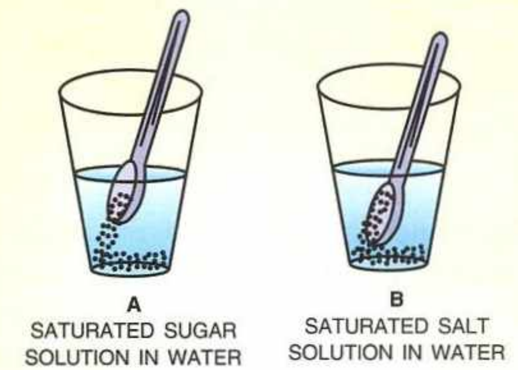
Saturated and Unsaturated Solution

A solution can be of *two* types, namely **saturated** and **unsaturated**. *A solution is said to be* ***saturated*** *when it cannot dissolve any more of the solute at a given temperature.* A solution that can dissolve more of the solute at a given temperature, is said to be an **unsaturated solution**.

However water dissolves different amounts of different substances under the same conditions.

Activity 9

Take two glasses. Fill half of each glass with water. Mark the glasses as **A** and **B**. In glass **A**, add a tea spoon of sugar and stir. Keep on adding sugar to it, one teaspoon at a time, till no more sugar dissolves in it. Count the total number of teaspoons of sugar added.



Now start adding one teaspoon of salt each time to the water kept in glass **B** till no more salt dissolves in it. Count the number of teaspoons of salt added.

You will observe that the amount of dissolved sugar is more than the amount of dissolved salt in the same volume of water at room temperature.

The amount of solute that dissolves in a given quantity of solvent at a given temperature to form a saturated solution is called the **solubility** of the solute. Solubility usually increases with increase in temperature.

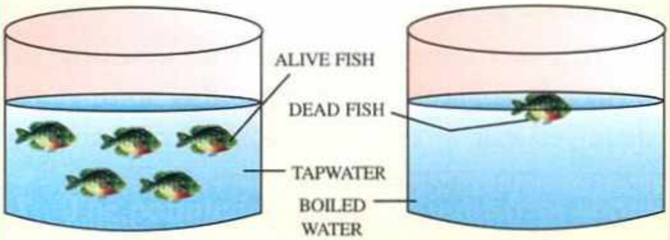
How would you recover the solute and the solvent from a solution ?

When a solution is heated, the solvent evaporates, leaving the solute as a residue. Thus, the solute of a solution can be recovered by evaporation till dryness. If the vapours coming out of the solution are condensed, the solvent can also be recovered. If you carry out evaporation and condensation at the same time, the process is called ***distillation***. The liquid obtained by condensation of vapours is called the ***distillate***. Common salt is obtained from sea water through the process of evaporation.

Activity 10

To show the importance of air dissolved in water.

Take some tap water in a trough. Put a few small fishes in it. Now take another trough and pour boiled (and cooled) water with a little oil. Put one small fish in the second trough. After some time, you will observe that the fishes kept in tap water remain alive, while the one kept in boiled water dies.



A trough containing tap water (Air is dissolved in water)

A trough containing boiled water (No dissloved air is present in boiled water)

This is because tap water contains dissolved air, which the fishes are able to breathe in. But boiled water has no air, so the fish kept in boiled water is unable to breathe and dies.

This shows that air dissolved in water helps aquatic animals and plants to survive.

Note : Some oil is added to boiled water so that air does not enter it. Oil being lighter forms the upper layer and does not allow air to enter the water.

PHYSICAL PROPERTIES OF WATER

1. Pure water is a transparent, colourless, odourless and tasteless liquid.
2. The freezing point of pure water is 0 °C and its boiling point is 100 °C.
3. The density of water is 1 g/cc at 4 °C.

EXERCISE – III

1. Why is water called a universal solvent ?
2. Define :
   (a) Solute (b) Solvent
   (c) Solution
   (d) Saturated solution
   (e) Unsaturated solution
3. State two factors by which solubility of a solute in a solvent can be increased.
4. Why do aquatic animals die in boiled water ?
5. Identify solute and solvent in the following solutions :
   (a) Salt and water (b) Iodine and alcohol
   (c) Air and water

NEED TO CONSERVE WATER

The amount of water needed for living organisms is not available in abundance. Therefore there is a need to conserve water.

- Wastage of water should be avoided, *e.g.* taps should never be left open.
- Do not allow water to drip from defective taps.
- More plantations should be done as plants help in bringing rain.
- We should use drip irrigation or spray-irrigation system for crops.
- Organizing mass awareness programmes through public and private agencies.
- By maintaining the water cycle.
- Water pollution should be prevented.

- More dams should be built because it helps in agriculture and also prevents droughts and floods.
- **Harvesting of rainwater** should be done. In this process rainwater is collected from the roofs of buildings and then carried with the help of pipes to underground tanks for storage.

Do You Know ?

22[nd] March is celebrated as the world water day every year to attract public attention towards the importance of conserving water.

The amount of water recommended by the United Nations for drinking, washing, cooking and maintaining proper hygiene is a minimum of 50 litres per person per day.

We must preserve water because water cannot be replenished and without water one cannot survive.

At an individual level, we should consciously save water and not waste it. **Reduce, reuse** and **recycle** should be our motto!

Think of your daily routine-how can you save water ?

1. Use a bucket for taking bath.
2. Make sure, water does not overflow from the overhead tanks of your house.
3. Close the tap when you are brushing your teeth.
4. Wash fruits and vegetables in a bowl of water, rather than under a running tap. Also water used for washing vegetables may be used to water plants in the garden.

WATER POLLUTION

Water is the most freely available resource on earth, yet most of it is not fit for drinking purposes.

Water present in seas, rivers, ponds and lakes comes from rains and the melted snow of mountains. As it flows down the plains, it carries many dissolved and suspended impurities. The impurities in this water further increase with the addition of the waste products from homes, agricultural land, industries, *etc*. These substances pollute water and are called **water pollutants**.

The process due to which undesirable changes occur in the properties of water that make it unfit for human consumption is called **water pollution**.

Do You Know ?

The deficiency of oxygen in the water may cause the death of aquatic animals. This loss of dissolved oxygen from water in water-bodies is called **eutrophication**.

Activity 11

Try to collect samples of water from a tap, pond, river, well and lake. Pour each into separate glass containers. Compare these for smell, colour and acidity. Complete the following table.

	Smell	Acidity	Colour
Tap water			
Pond water			
River water			
Well water			
Lake water			

Causes of water pollution

1. **Domestic sewage :** Water discharged from our homes contains dirt from excreta of the toilet, washing of clothes, utensils

and food and vegetable waste. It is called **sewage**. It is drained off into the lakes, rivers and seas. It contains microorganisms which spread jaundice, cholera, typhoid, *etc*.

2. **Agricultural waste :** Pesticides, insecticides and fungicides used in the fields are washed away by rain water into rivers. These chemicals harm aquatic life and spoil the human food.
3. **Industrial waste :** The waste chemicals from industry, called **effluents**, get dissolved in water bodies and are toxic to aquatic plant and animal life. They make water unfit for human consumption as well.

Therefore, it is necessary to prevent water pollution. The following steps should be taken:

1. The polluted water from industries should be passed through **effluent treatment plants** so that all the harmful chemicals present are removed from it.
2. Sources of underground water, like wells, should be covered properly to keep them clean.
3. Washing and cleaning of utensils and clothes should not be done near sources of water.
4. Bathing and cleaning of animals in or near sources of water like rivers, lakes and ponds should not be done.
5. The use of pesticides, insecticides, fungicides, herbicides and other chemicals should be reduced.
6. Water containing sewage should be passed through **sewage treatment plant** first and then this water could be used for irrigation.
7. Trees and plants must be planted along the banks of rivers.
8. The use of synthetic detergents should be minimised. If possible use biodegradable detergents.

To create awareness amongst children about water pollution and the need of conservation of water, it is advised to show them audio-videos related to these topics.

WHAT HAPPENS IF IT RAINS HEAVILY?

Collecting of huge amount of water due to heavy rain or over flowing of rivers is called a flood. Heavy rainfall may cause many problems —

- A rise in the level of water in dams, rivers, lakes, *etc*.
- Heavy rainfall also causes soil erosion.
- Floods cause extensive damage to crops, property, animal and human life.
- Crop-fields, villages and many low-lying areas get submerged under flood water.
- Rains/floods also affect smaller animals living in the soil.

WHAT HAPPENS IF IT DOES NOT RAIN FOR A LONG PERIOD?

Drought is the condition of usually dry weather within a geographical region which does not receive rain for a long duration continuously or receives very low rainfall.

- Crops may die, fodder may become scarce.
- Living organisms of the soil die.
- Animals may die, plants and trees will not survive.
- Soil becomes dry, water level in rivers, lakes, dams, etc. may fall. The ground water level falls.
- Drought displaces people from a large number of villages and towns.

RECAPITULATION

- Water is essential for all living beings.
- Two main sources of water are surface water and underground water.
- Surface water contains both dissolved and suspended impurities while underground water contains only dissolved impurities.
- Water is a compound containing hydrogen and oxygen. It is represented by the formula H_2O.
- Water can exist in all the three states of matter : ice (solid), water (liquid) and water vapour and steam (gas).
- Pure water is colourless, tasteless, odourless and transparent at ordinary temperature.
- Water cycle is a natural process involving the interconversion of the three states of water.
- Water is a universal solvent.
- When a solute dissolves in water, a solution is formed. A solution can be saturated or unsaturated.
- Natural water needs purification for consumption by human beings, animals and plants.
- Water carrying germs cause diseases like cholera, typhoid, diarrhoea, gastroenteritis, etc.
- It is necessary to control water pollution and conserve water.

EXERCISE – IV

1. State four ways by which water can be conserved.
2. Explain harvesting of water.
3. What are the three main causes of water pollution ?
4. State the main steps to be taken to prevent water pollution.
5. What are the causes of floods and drought ?
6. State some of the ways in which you as an individual can conserve water.

OBJECTIVE TYPE QUESTIONS

1. Fill in the blanks :
   (*a*) Water is a .... solvent.
   (*b*) .... is the purest form of natural water.
   (*c*) Sand and dust are .... impurities in water.
   (*d*) Sea water has a high concentration of ....
   (*e*) Water covers nearly .... of the surface of the earth.
   (*f*) Evaporation of rain water leaves .... residue.
   (*g*) .... is the chemical added to water to remove the tiny suspended particles.
   (*h*) A .... is a uniform mixture of a solute and a solvent.
   (*i*) Ice, water and steam have different physical states but are chemically ....
   (*j*) Boiling kills most of the .... in water.
   (*k*) The elements present in the molecules of water are .... and ....

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

(*a*) Water is an element. ....

(*b*) Alum is commonly used for removing suspended impurities. ....

(*c*) Tap water does not contain dissolved impurities. ....

(*d*) Distillation is a good method for purifying water for town supply. ....

MULTIPLE CHOICE QUESTIONS

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

1. Water content in human body is

(*a*) 70% (*b*) 75%

(*c*) 80% (*d*) 90%

2. The purest form of natural water is

(*a*) sea water (*b*) river water

(*c*) rain water (*d*) lake water

3. When the water vapour changes into tiny droplets of water near the ground, it is called

(*a*) mist (*b*) dew

(*c*) fog (*d*) frost

4. Water is a

(*a*) compound (*b*) element

(*c*) mixture (*d*) none of the above

5. Common salt is obtained from sea water by

(*a*) distillation (*b*) crystallisation

(*c*) evaporation (*d*) sublimation

6. Jaundice affects

(*a*) heart (*b*) lungs

(*c*) liver (*d*) kidney

7. Chlorination of water is done

(*a*) to kill the germs

(*b*) to remove the suspended impurity

(*c*) to remove the dissolved impurities

(*d*) none of the above.

Project

1. Collect some water from any of the three sources listed here : tap water, bottled mineral water, pond water, well water, river water.

   (a) Try to find (i) the pollution in water, *i.e.* suspended impurities, if any, in the collected samples

   (ii) the probable sources of pollution, if any.

   (b) Add small amount of potash alum to each of them and record your observations.

   (c) List the effects of polluted water on the health of people using it.

2. Prepare a table of amount of water used for different purposes at home : drinking, bathing, washing, toilets, cleaning floors, car washing, etc. per day. Identify ways to reduce water consumption at home.

3. (a) In how many ways can you reuse the water given out by an R.O. purifier ? Prepare a list.

   (b) How would you convince your relatives and neighbours to reuse this water.

GLOSSARY

- **Air pollution :** The process by which air gets mixed with undesirable substances.
- **Atmosphere :** A thick layer of air surrounding the earth.
- **Atom :** An *atom* is the smallest possible particle of any matter. It may or may not have independent existence, but it always takes part in a chemical reaction.
- **B.H.C. :** Benzene hexachloride
- **Breathing :** The process of taking in oxygen and giving out carbon dioxide.
- **Chalk :** One of the natural forms of calcium carbonate
- **Chemical change :** A permanent change in which new substance(s) are formed whose compositions are completely different from those of the original substance(s).
- **CNG :** Compressed Natural Gas.
- **Coal :** A solid black coloured fossil fuel mainly containing carbon.
- **D.D.T. :** Dichloro diphenyl trichloroethane
- **Diarrhoea :** A disease which causes the loss of water from our body.
- **Evaporation :** The process of converting a liquid into a gas at an average temperature.
- **Exhaled air :** The air we breathe out.
- **Experiments :** Activities performed to draw scientific conclusions followed by discussion.
- **Explosives :** Substances which burst violently with a loud noise.
- **Fertilizers :** Chemicals which help in improving both growth and yield of crops by increasing the soil fertility.
- **Fossil fuels :** Fuels formed by dead and decaying organic matter over millions of years in earth crust.
- **Fuel :** The substance which burns in air to produce a large amount of heat and light.
- **Fungicides :** Chemicals used to kill a group of plants called fungi are called fungicides.
- **Gastroenteritis :** A water-borne disease that affects the digestive system.
- **Humus :** A substance formed from dead and decaying organic matter through the action of micro-organisms within the soil.
- **Inhaled air :** The air, we breathe in.
- **Insecticides :** Chemicals used to kill insects.
- **Interconversion of states of matter :** The phenomenon of change of matter from one state to another.
- **Irreversible :** A change that cannot be reversed on reversing the conditions.
- **L.P.G. :** Liquefied petroleum gas, commonly known as cooking gas.
- **Marble :** A form of calcium carbonate.
- **Matter :** Anything that has mass, occupies space and can be perceived by our senses is called matter.
- **Molecule :** A *molecule* is the smallest particle of any matter, having independent existence. It exhibits all the properties of that pure substance.
- **Observations :** What we see during experiments.
- **Oxidation :** The process in which a substance combines with oxygen.
- **Pesticides :** Chemicals used to kill pests (all kind of insects).
- **Photosynthesis :** The process in which green plants use carbon dioxide and water to prepare food with the help of chlorophyll in the presence of sunlight.
- **Physical change :** A change in which no new substance is formed.
- **Pollutants :** The substances which cause pollution.

- **Potable water :** Water suitable for drinking.
- **Preservatives :** Chemicals used to store food products for longer time.
- **Product :** The new substance formed in a chemical reaction.
- **Reactant :** The original substance that takes part in a chemical reaction.
- **Respiration :** A chemical process in which oxygen present in inhaled air reacts with simple and digested food materials like sugar in the living cells, to release energy, with carbon dioxide and water.
- **Reversible :** A change which can be reversed by changing the conditions.
- **Rusting :** Slow oxidation of iron in presence of moisture and oxygen to form hydrated iron oxide.
- **RDX :** Rapid Detonating Explosive.
- **Saturated solution :** A solution which cannot dissolve any more of a given solute at a particular temperature.
- **Solute :** The dissolved substance in a solution.
- **Solution :** The mixture of solute and solvent.
- **Solvent :** The liquid which dissolves the substance called solute.
- **Surface water :** The water present on the surface of the earth, like in seas, rivers, *etc*.
- **Synthetic :** Artificially prepared.
- **Underground water :** The water which percolates through the upper layer of the earth's surface and gets collected on the solid rocks beneath.
- **Universal solvent :** A solvent which dissolves different kinds of solid, liquid and gaseous substances.
- **Unsaturated solution :** A solution which can dissolve more of the solute at a given temperature.
- **Water cycle :** The change of water from one state to another in nature that is repeated again and again.