SEMESTER–I (Period–I)

C10CH2

2 TOPIC

Matter and its Properties

Learning Objectives

By the end of this topic, learners will be able to:

- Discuss the states of matter.
- Identify physical and chemical changes.
- Make use of separation techniques to purify impure substances.
- Utilize various techniques to separate mixtures.

Introduction

Anything that occupies space and has mass is called **matter**. All the materials present in this world such as air and water, hydrogen and oxygen, sugar and sand, silver and steel; copper and coal, iron and wood, ice and alcohol, milk and oil, kerosene and petrol, carbon dioxide and steam, carbon and sulphur, rocks and minerals are different kinds of matter as they all occupy space and have mass. There are also things such as television signals, radio signals, electricity, light, sound, friendship, love, affection, hatred, thoughts, ideas, taste and smell that do not occupy space and do not have mass. Such things are not matter. This is one way of classifying things. There are other ways of classifying things such as on the basis of their physical properties and chemical properties. On the basis of physical properties, the matter is classified into solids, liquids, and gases. On the basis of chemical properties, matter is classified into elements, compounds, and mixtures.

2.1. STATES OF MATTER AND THEIR CHANGES

Observe different types of matter around you. What are its different states? We can see that matter around us exists in three different states—solids, liquids and gases.

(a) Ice is a solid

(b) Water is a liquid

(c) Steam is a gas

Fig. 2.1. Three States of Matter

Let us classify the substances around us into solids, liquids and gases.

ACTIVITY 2.1

Grouping Substances into Solid, Liquid and Gas

Group the following substances into solid, liquid, and gas in your exercise book.

Solid	
Liquid	
Gas	

2.1.1. Changes of States of Matter

We now know that matter exists in three physical states—solid, liquid, and gaseous state. The physical state of matter can be changed by changing the temperature, *i.e.* by heating it or cooling it. Let's perform the following activity to understand this.

ACTIVITY 2.2

To Demonstrate the Change of States of Matter

Materials Required:

A kettle, a frying pan, ice cubes, water, a beaker and a burner.

Procedure:

Take some water in the kettle and few ice cubes in the frying pan and arrange the set-up as shown in Fig 2.2.

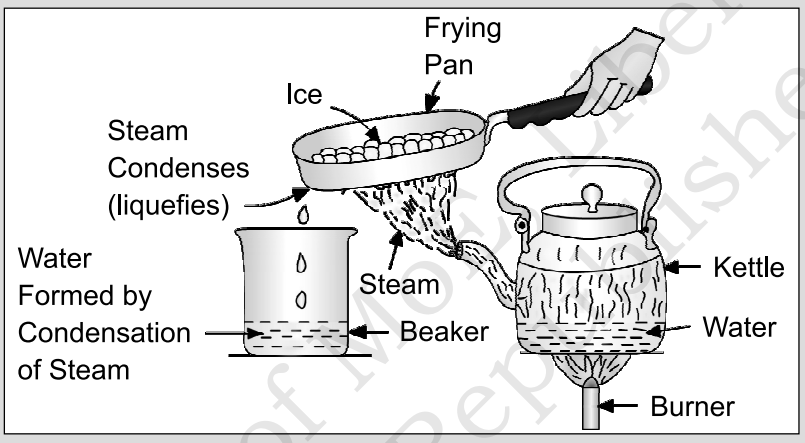


Fig. 2.2. Set-up to Demonstrate Change of State of Matter

Observation:

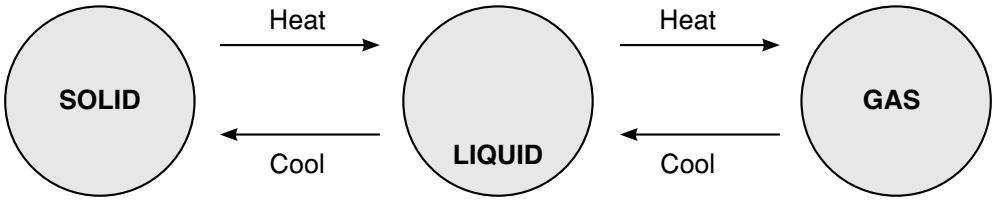
On heating the kettle, you will see steam coming out of the spout of the kettle. When the hot steam coming out of the spout comes in contact with the ice-cold bottom of the frying pan, it gets cooled and converts to liquid water.

Conclusion:

The formation of steam by boiling of water is a change of state of matter from liquid to gas. The formation of water drops by cooling the steam is a change of state of matter from gas to liquid.

As observed in the Activity 2.2, above, when water is heated, it converts into steam (liquid to gas change). The steam when cooled, converts into liquid (gas to liquid change). Thus, depending on the temperature, a substance can exist in all the three physical states—solid, liquid, and gas.

When a solid melts to form a liquid or a liquid evaporates to form a gas, we say that there is a **change of state**. There is also a change of state when a gas is cooled, and this change from gas to a liquid is called **condensation**. The change of state from solid to liquid is called **melting**.



2.2. PROPERTIES AND CHANGES OF MATTER

2.2.1. Properties of Matter

The states of matter have different properties. The properties of matter depend upon the arrangement of atoms or molecules in them. The atoms or molecules may be tightly packed or loosely packed. The arrangement of particles decides whether a given substance will exist as a solid, a liquid or a gas.

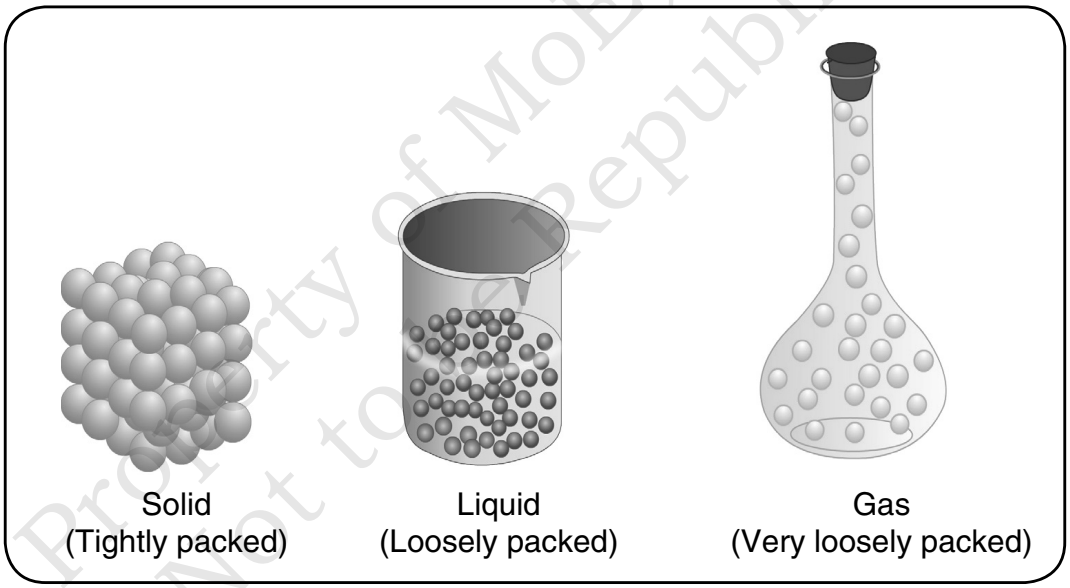


Fig. 2.3. Arrangement of Particles in Solids, Liquids and Gases

2.2.1.1. Properties of Solids

Some of the characteristic properties of solid are:

(i) Particles in a solid are closely packed.

(ii) The matter in solid state possesses *a definite volume*, *a definite shape*, distinct boundaries and *a definite mass*.

(iii) Solids are *rigid* and *almost incompressible*.

(iv) Solids generally possess *high densities*.

(v) Solids *do not exhibit diffusion*.

Some common **examples** of solids are: table, chair, common salt, silver, ice, diamond, etc.

Solids generally do not exhibit diffusion due to smaller interparticle spaces and absence of translatory motion. However, on rare occasions we can observe diffusion of solid materials, but to a very limited extent. It is observed that if we write something with chalk on a blackboard and leave it as such for a few days, it becomes difficult to clean. This is probably due to diffusion of chalk particles into the surface of the blackboard.

2.2.1.2. Properties of Liquids

Some of the characteristic properties of liquids are:

(i) Particles in a liquid are loosely packed.

(ii) The matter in liquid state possesses *a definite volume*, *a definite mass*, but *no definite shape*.

(iii) Liquids are also *almost incompressible* but are *not rigid*. In fact, they can flow and acquire the shape of the container in which they are kept.

(iv) Liquids can *undergo diffusion*.

(v) Liquids also have *high densities* but less than that of solids.

Some **examples** of liquids are: milk, water, alcohol, petrol, kerosene, fruit juices, etc.

Solids, liquids as well as gases can diffuse into liquids. This is due to the fact that the interparticle spaces in liquids are larger and the particles in liquid state move freely. For example, when we add a few crystals of sugar to water they intermix (dissolve) with water spontaneously. Similarly, when we add few drops of ink to water, the colour of the ink gets dispersed evenly in the entire liquid. The gases also diffuse into liquids. Aqueous solution of ammonia contains ammonia diffused in water.

2.2.1.3. Properties of Gases

Some of the characteristic properties of gases are:

(i) Particles in a gas are very loosely packed.

(ii) The matter in gaseous state *has neither definite volume nor definite shape but it has definite mass*. It acquires the shape and volume of the container.

(iii) *Gases are highly compressible*. For example, natural gas in compressed form is used as fuel (Compressed Natural Gas—**CNG**) in internal combustion engines. Oxygen supplied to hospitals in cylinders is also in compressed form.

(iv) *The gases exhibit the property of diffusing very fast into other gases. This is because the particles in gases move very fast in all directions and there are large interparticle spaces.*

(v) *Gases exert pressure on the walls of the container in which they are stored.*

Some common **examples** of gases are: air, hydrogen, carbon dioxide, hydrogen sulphide, ammonia, oxygen, nitrogen, etc.

A comparison chart of the characteristic properties of solids, liquids and gases are given in Table 2.1.

Table 2.1. Comparison of Characteristic Properties of Solids, Liquids and Gases.

Property	Solids	Liquids	Gases
Arrangement of particles	Tightly packed	Loosely packed	Very loosely packed.
Shape	Definite	Take the shape of the container, but do not necessarily occupy all of it.	Take the shape of the container by occupying whole of the space available to them.
Volume	Definite	Definite	Not definite, take the volume of the container.
Compressibility	Almost nil	Almost nil	Very large. Gases are highly compressible
Fluidity or Rigidity	Rigid	Fluid	Fluid
Density	Large	Large	Very small.
Diffusion	Generally do not diffuse	Diffuse slowly	Diffuse rapidly.
Free surfaces	Any number of free surfaces	Only one free surface	No free surface.

2.2.2. Changes of Matter

Every matter exists in particular state under ordinary conditions. However, it can be changed from one state to another by changing the conditions. The changes are of two types—(i) Physical change and (ii) Chemical change.

2.2.2.1. Physical Changes

ACTIVITY 2.3

Demonstrating Physical Changes of Matter

Cut a piece of paper in four square pieces. Cut each square piece further into four square pieces. Lay these pieces on the floor or a table so that the pieces acquire the shape of the original piece of paper.

Obviously, you cannot join the pieces back to make the original piece, but is there a change in the property of the paper?

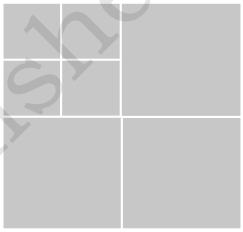


Fig. 2.4.

In Activity 2.3 above, you saw that paper underwent changes in size.

Properties such as shape, size, colour and state of a substance are called its **physical properties**. *A change in which a substance undergoes a change in its physical properties is called a* ***physical change***. A physical change is generally reversible. In such **a change no new substance is formed**.

Some more examples of **physical changes** are:

1. Evaporation of alcohol.
2. Formation of crystals on cooling a saturated solution of sugar.
3. Melting of ice.
4. Evaporation of sea water.

2.2.2.2. Chemical Changes

If you leave some iron nails in the open for sometime, it acquires a film of brownish substance (Fig. 2.5). This substance is called **rust** and the process is called **rusting**.

At home you must have seen hoe and spades getting rusted when exposed to the atmosphere for some time (Fig. 2.6).Rust is not iron. It is different from iron on which it gets deposited.

Fig. 2.5. Rusted nails

Fig. 2.6. Rusted hoe

Let us consider a few more changes where new substances are formed.

ACTIVITY 2.4

Demonstrating Chemical Changes of Matter

This activity can be demonstratered by the teacher.

CAUTION: Be careful while handling a flame.

Get a small piece of a thin strip or ribbon of magnesium. Clean its tip with sandpaper. Bring the tip near a candle flame. It burns with a brilliant white light (Fig. 2.7).

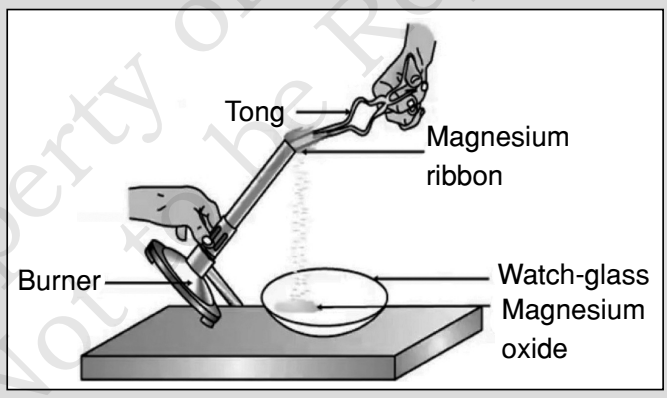


Fig. 2.7. Burning of Magnesium Ribbon

When it is completely burnt it leaves behind a powdery ash.

Does the ash look like the magnesium ribbon?

Collect the ash and mix it with a small amount of water. Stir the mixture (aqueous solution) well. Test the mixture with blue and red litmus papers.

Does the mixture turn red litmus blue?

Does the mixture turn blue litmus red?

When we burn the ribbon of magnesium with flame it forms a new substance (ash). This change can be written in the form of following equation:

Magnesium (Mg) + Oxygen (O_2) → Magnesium oxide (MgO)

On dissolving the ash in water it forms a new substance. This change can be written in the form of the following equation:

Magnesium oxide (MgO) + Water (H_2O) → Magnesium hydroxide [$Mg(OH)_2$]

Here, magnesium oxide and magnesium hydroxide are two new substances.

A change in which one or more new substances are formed is called a ***chemical change.*** A chemical change is also called a **chemical reaction**.

Some examples of chemical changes are:

1. Digestion of food
2. Burning of coal
3. Setting cement
4. Cooking of food

Some differences between physical and chemical changes are shown in Table 2.2.

Table 2.2. Differences between Physical and Chemical Change.

	Physical Change	Chemical Change
1.	It is temporary change.	It is a permanent change.
2.	No new substances are formed.	New substances with quite different properties are formed.
3.	Only the physical properties of the substance undergo change. Composition remains same.	Both the chemical composition and properties of the substance change.
4.	It can be reversed by physical means.	It cannot be reversed by physical means.

2.3. MIXTURE AND ITS CLASSIFICATION

2.3.1. What is Mixture?

Most substances around us are not pure. They are mixtures of two or more pure substances—elements or compounds. The pure substances can be mixed in different ways. The air we breathe is not a single, pure

substance rather it is a mixture of different gases. River water consists of solid particles. Thus, *a **mixture** is a substance which consists of two or more elements or compounds not chemically combined together.* All the mixtures are impure substances because they contain more than one kind of particles. Some examples of mixtures are:

- Sea water—it has several salts dissolved in water
- Sugar solution—a mixture containing mainly sugar and water
- Air—a mixture of several gases such as oxygen, carbon dioxide, nitrogen, rare gases, water vapours and dust particles.

Fig. 2.8. Some Examples of Mixtures

2.3.2. Classification of Mixtures

We now know that different substances are present in a mixture. These substances are called **components** or **constituents of the mixture**. These constituents may be completely mixed together, or may remain separate, or a substance is diffused throughout another substance.

*The mixtures containing its constituents completely mixed together in a way not distinguishable from one another are called **homogeneous mixtures**,* for example, sugar solution in water.

In some mixtures, the constituents are not completely mixed and are distinguishable from each other. Such mixtures are known as ***heterogeneous mixtures***, for example, the mixture of sugar and sand. This is one way of classifying mixtures.

The mixtures are also classified on the basis of the nature of their constituents. The constituents may be solid-solid, solid-liquid, liquid-liquid, solid-gas, gas-liquid and gas-gas.

Solid-solid Mixtures

Mixtures of this class consist of two or more solid substances that have been physically combined.

Examples

- Brass (copper and zinc)
- Steel (copper and iron)
- Sulphur and iron filings
- Sand and salt

Solid-liquid Mixtures

Mixtures of this class consist of a solid and a liquid in which the solid is soluble.

Examples

- Sugar and water
- Salt and water
- Sugar and milk
- Chalk and water

Liquid-liquid Mixtures

Mixtures of this class consist of two liquids which are miscible.

Examples

- Oil and water
- Petrol and kerosene

Solid-gas Mixtures

Mixtures of this class consist of a solid and a gas.

Examples

- Smoke
- Hydrogen gas absorbed by palladium

Gas-liquid Mixtures

The mixtures of this class consist of a gas and a liquid.

Examples

- Foam, hair spray, shaving cream
- Soda water (Water and carbon dioxide gas)
- Hydrochloric acid (Water and HCl gas)

Gas-gas Mixtures

The mixtures of this class consist of two or more gases which are diffusible into each other.

Examples

- Air (Mixture of oxygen, nitrogen, carbon dioxide, argon and water vapour)

2.4. STANDARD SEPARATION TECHNIQUES FOR MIXTURE

Most of the substances around us are not pure. They are mixture of two or more pure substances.

Let us discuss some techniques of separating constituent of different types of mixtures.

2.4.1. Separating Constituents of Solid-Solid Mixtures

This type of mixtures can be separated by the following methods:

2.4.1.1. Sieving

This method is used to separate mixtures that contain substances mostly of different sizes. The mixture is passed through the pores of the sieve. All the smaller substances pass through easily while the bigger components of the mixture are retained.

Fig. 2.9.Sieving

2.4.1.2. Magnetic Separation

This method is applied when one of the components of the mixture is magnetic. For example, a mixture of iron filings and sand can be separated by using a magnet.

Let us demonstrate this activity to understand the technique of magnetic separation.

ACTIVITY 2.5

Demonstrating the Process of Magnetic Separation

1. Mix up the iron filings and the sand in glass jar (Fig. 2.10).
2. Bring the magnet closer to the mixture.
   What do you observe?

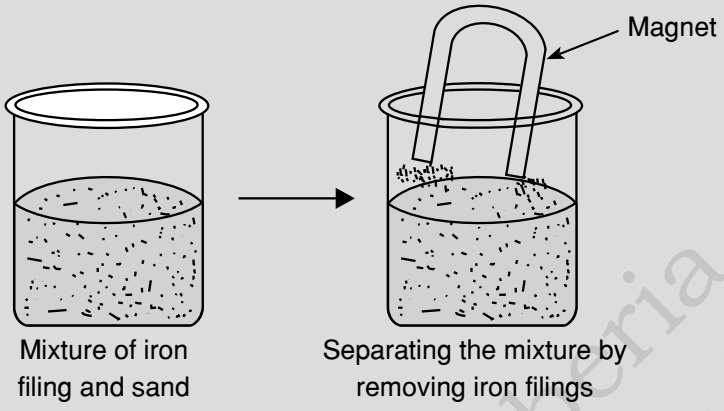


Fig. 2.10. Magnetic Separation of Mixtures

We observe that iron filings get stuck to the magnet.

2.4.2. Separating Constituents of Solid-Liquid Mixtures

This type of mixtures can be separated by the following methods:

2.4.2.1. Filtration

This method is applied for separating a heterogeneous mixture containing a solid component suspended in liquid component. A mixture containing sand and water can be separated by this method.

Let us demonstrate this activity to understand the technique of filtration.

ACTIVITY 2.6

Demonstrating the Separation of a Mixture Using Filtration

1. Take a filter funnel and fold it in the form of a cone as shown in Fig. 2.11.

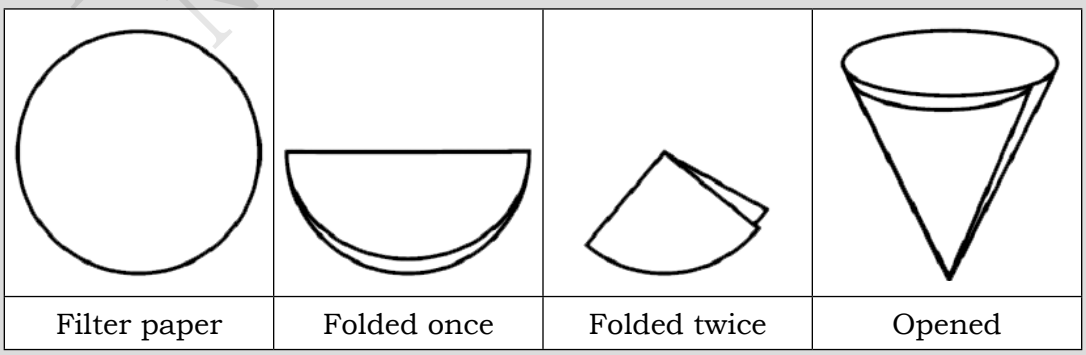


Fig. 2.11. Making Filter Paper cone

2. Fit the cone in a funnel and moisten so that it sticks to the surface of the funnel.

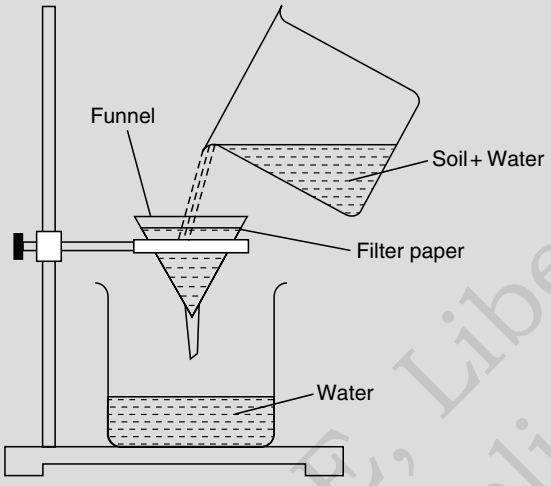


Fig. 2.12. Method of Filtration

3. Place the funnel in a funnel stand(Fig. 2.12).
4. Carefully pour some of the mixture down a glass rod (stirrer) and into the filter funnel.
5. The purpose of the glass rod is to prevent any splashing and to make sure that the mixture does not get between the paper and the funnel.
6. Open the filter paper and allow the soil (the residue) to dry.

   What is the basis for separation of this mixture?

The soil remains behind on the filter paper. The water passes through the filter paper.

2.4.2.2. Evaporation

This method is applied when the solvent is volatile liquid and the solute is non-volatile solid or liquid. For example, sodium chloride can be separated from its aqueous solution by evaporation. Similarly, the coloured dye present in the blue or black ink can be separated by evaporation (Fig. 2.13). The volatile component evaporates leaving behind non-volatile component.

Let us demonstrate this activity to understand the techniques of evaporation.

ACTIVITY 2.7

Demonstrating Separation of Mixture Using Evaporation

1. Place an evaporating dish on a beaker containing some water.
2. Put a few drops of the ink on the evaporating dish.
3. Place the beaker along with the evaporating dish on a tripod stand. (Fig. 2.13)

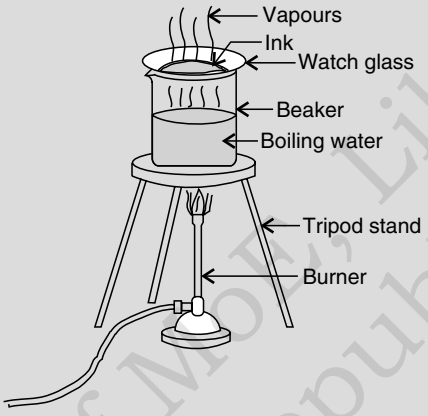


Fig. 2.13. Separation by Evaporation

4. Start heating.
5. The ink on the evaporating dish starts evaporating.
6. Continue heating. Finally, a residue is left on the dish. This is the dye present in the ink.

2.4.3. Separating Constituents of Liquid-Liquid Mixtures

This type of mixtures can be separated by the following methods:

2.4.3.1. Distillation

This method is applied for the separation of a mixture containing two miscible liquids having large difference in their boiling points or a mixture containing solid dissolved in liquid. Distillation involves vaporization followed by condensation. In this method both the components are recovered.

Let us study the separation of a mixture containing petrol and kerosene.

ACTIVITY 2.8

Demonstrating Separation of Mixture Using Distillation

1. Take the mixture in a distillation flask and fit it with the thermometer (Fig. 2.14).

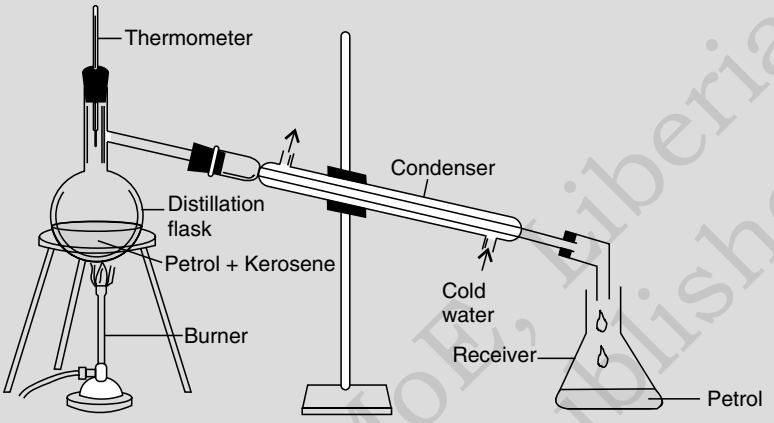


Fig. 2.14. Separation by Distillation

2. Heat the mixture slowly.
   What do you observe?

As the boiling point of petrol is lower than that of kerosene, so, petrol vaporises first. It condenses in the condenser and is collected from the outlet.

And thus kerosene is left in the flask.

2.4.3.2. Using a Separating Funnel

A mixture of two immiscible liquids can be separated into its components by using a separating funnel. The separating funnel has a tap in its stem and a stopper in its mouth (Fig. 2.15). It can be used for separating the mixtures such as kerosene and water, water and benzene, water and carbon tetrachloride, etc.

The principle of this method is that immiscible liquids separate out in layers depending on their densities.

ACTIVITY 2.9

Demonstrating Separation of Mixture Using a Separating Funnel

In this activity, you will study the separation of components of a mixture containing kerosene oil and water using a separating funnel.

1. Pour the mixture of kerosene oil and water in a separating funnel (Fig. 2.15).

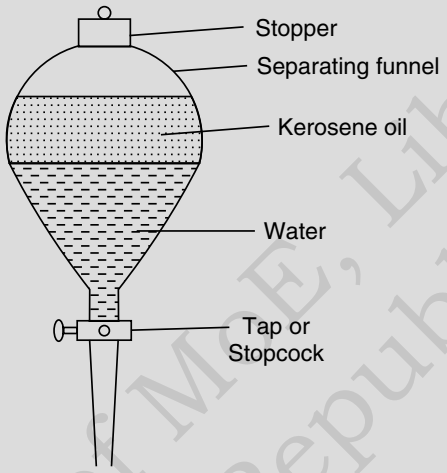


Fig. 2.15. Separation of a mixture of two immiscible liquids.

2. Allow the mixture to stand for some time so that separate clear layers of oil and water are formed. Water being heavier forms the lower layer.
3. Open the stopcock of the separating funnel and pour out the lower layer in a beaker.
4. Close the stopcock when the oil reaches the stopcock. The kerosene oil remains in the separating funnel.

GLOSSARY

- **Condensation:** The process in which water vapour changes to liquid water on cooling.
- **Diffusion:** The movement of molecules from a region of higher concentration to a region of lower concentration.
- **Distillation:** A method of separating mixtures based on differences in their volatilities in a boiling liquid mixture.
- **Evaporation:** The process in which liquid water changes to vapour on heating.

- **Filtration:** Method of separating heterogeneous mixture containing a solid component suspended in liquid components.
- **Matter:** Anything that occupies space and has mass.
- **Translatory motion:** Motion in which all points of a moving body move uniformly in the same direction.

SUMMARY

- Anything that occupies space and has mass is called matter.
- On the basis of physical properties, the matter is classified into solids, liquids, and gases.
- On the basis of chemical properties, matter is classified into elements, compounds, and mixtures.
- Matter around us exists in three different states—solids, liquids and gases.
- When a solid melts to form a liquid or a liquid evaporates to form a gas, we say that there is a change of state.
- Matter can be changed from one state to another by changing the conditions. Changes can be of two types—
  (i) physical change and
  (ii) chemical change.
- Properties such as shape, size, colour and state of a substance are called its physical properties.
- A change in which a substance undergoes a change in its physical properties is called a physical change.
- A change in which one or more new substances are formed is called a chemical change.
- A mixture is a substance which consists of two or more elements or compounds not chemically combined together.
- The mixtures containing its constituents completely mixed together in a way not distinguishable from one another are called homogeneous mixtures, for example, sugar solution in water.
- The mixture in which, the constituents are not completely mixed and are distinguishable from each other are known as heterogeneous mixtures, for example, the mixture of sugar and sand. This is one way of classifying mixtures.

- Based on the nature of constituents, mixtures are of the following types:
  (i) Solid-solid (ii) Solid-liquid
  (iii) Liquid-liquid (iv) Solid-gas
  (v) Liquid-gas (vi) Gas-gas

EVALUATION

I. Multiple Choice Questions

1. Which of the following is a matter?
(a) Love (b) Thought
(c) Cold (d) Cold drink.

2. The state of the matter that can be rapidly diffused is
(a) solid (b) liquid
(c) gas (d) none of these

3. Which of the following are physical properties of a matter?
(a) shape (b) colour
(c) size (d) All of these

4. In which change, one or more new substances are formed?
(a) Physical change (b) Chemical Change .
(c) Biological change (d) None of these

5. Which of the following is an example of gas-gas mixture?
(a) Air (b) Sugar solution
(c) Sea water (d) None of these

II. State True or False

1. Gaseous state of matter is highly compressible.
2. Particles in a liquid are closely packed.
3. Physical change is reversible.
4. The change of state from solid to liquid is called condensation.
5. Sieving is used to separate mixture containing substances of different sizes.

III. Answer the Following Questions

1. Define matter. Give some examples of matter.
2. What are the three states of matter?

3. State at least two characteristic properties each of:

(a) a solid (b) a liquid

(c) a gas.

4. What do you mean by a physical change? State any two examples of physical change.

5. What do you mean by a chemical change? State any two examples of chemical change.

6. Distinguish between physical and chemical changes.

7. Explain the term 'Mixture'. State four examples of mixture.

8. State the main points of differences between homogeneous and heterogeneous mixtures.

9. Define the following:

(i) Solid-solid mixture (ii) Solid-liquid mixture

(iii) Liquid-liquid mixture (iv) Gas-gas mixture

10. What is magnetic separation? Explain with the help of an activity.

11. What is evaporation? Explain with the help of an activity.

12. What is distillation? Explain with the help of an activity.

PROJECT

Cut out a mineral water bottle and make a filtration apparatus for yourself.