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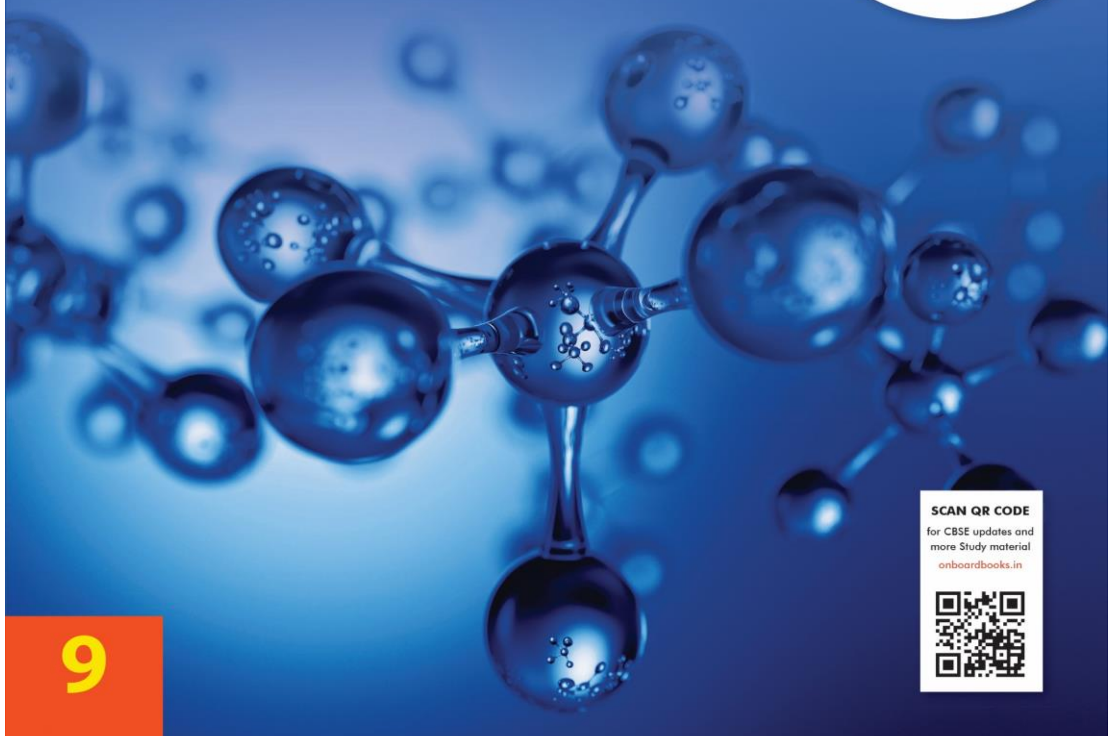

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CBSE LIVING SCIENCE CHEMISTRY

CLASS 9

Chapter 2

Is Matter Around Us Pure?

Learning Objectives

- ❖ Chemical classification of matter
- ❖ Elements, compounds and mixtures
- ❖ Heterogeneous and homogeneous mixtures
- ❖ Solutions
- ❖ Suspensions
- ❖ Colloids
- ❖ Separating the components of a mixture
- ❖ Water purification system for city water supply
- ❖ Physical and chemical changes

INTRODUCTION

To common people, a pure substance means a substance without any adulteration. But chemically, even a purest substance is not pure. This is because, chemically, a pure substance is the one which consists of a single type of particles having the same chemical nature. Thus, pure ghee, pure milk, pure butter and pure honey are not chemically pure substances, rather they are all mixtures of various Substances. A pure substance cannot be separated into its chemical constituents by physical means. For example, sugar cannot be separated into its chemical constituents (C, H and O) by physical means, since it is a pure substance.

Most of the matter around us is a mixture of two or more pure substances. For example, soil, air, sea water, spices, honey, milk, butter, common salt, etc. are all mixtures.

CHEMICAL CLASSIFICATION OF MATTER

Matter is classified into either a **pure substance** or a **mixture** of two or more substances. The characteristics of a pure substance are:

1. A pure substance contains only one type of particles.
2. A pure substance has a definite composition which does not change with time.
3. A pure substance is perfectly homogeneous.
4. A pure substance has definite melting point, boiling point and density.

A pure substance is further classified into:

a. element b. compound

An **element** is the simplest form of a pure substance which cannot be split up into two or more simpler substances by any physical or chemical method. Examples are carbon, silicon, copper, iron, etc.

A **compound** is a pure substance which is made up of two or more elements combined in a definite proportion by mass. Examples are water, carbon monoxide, carbon dioxide, sulphur dioxide, calcium oxide, etc.

Elements are further classified into:

1. metal – Examples are iron, nickel, cobalt, copper, silver, etc.
2. non-metal – Examples are carbon, oxygen, sulphur, nitrogen, etc.
3. semi-metal – Examples are silicon, germanium, arsenic, etc.

Compounds are further classified into:

1. inorganic compounds – Examples are sodium chloride, washing soda, etc.
2. organic compounds – Examples are glucose, sugar, etc.

Mixture: A mixture is a material which contains two or different kinds of particles which do not react chemically but are physically mixed together in any proportion.

On the basis of appearance of matter, a mixture is further classified into the following types:

a. **Homogeneous matter**: A substance which is perfectly uniform in its composition throughout the mass. Examples are water, glucose solution, clean air, etc.

b. **Heterogeneous matter:** A substance which has different composition and different properties in the different parts of a sample. Examples are muddy water, dusty air, cement, etc.

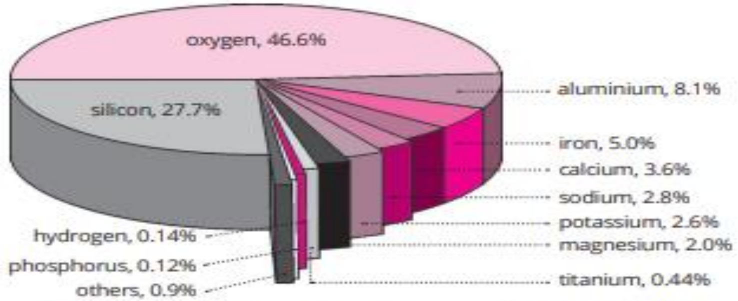
H**omogeneous matter is further classified into:**

1. **Pure substance** – Examples are sugar, sodium chloride, iron, gold, silver, etc.
2. **Homogeneous mixture** – Examples are a solution of salt and sugar, alloys, air, etc.

ELEMENT

The term 'element' was first used by Robert Boyle in 1661. Lavoisier (1743–1794), a French chemist defined 'element'. According to him, an element is the simplest form of a pure substance which cannot be split up into simpler substances by any physical or chemical means.

There are 118 elements known to us today. Out of these, 91 elements are naturally occurring and the rest have been prepared artificially in the laboratory. The majority of elements are solid. The number of solid elements is 104, number of liquid elements is 2 (bromine and mercury) and the number of gaseous elements is 12.The most abundant element is oxygen (relative abundance–46.6%).



a. Relative abundance of elements in the earth's crust

Some facts about elements

1. Most stable element: Tellurium (half-life period = 2 × 1021 years).
2. Element having the smallest atomic size: Hydrogen
3. Element having the largest atomic size: Francium
4. First man-made element: Technetium
5. Hardest element: Carbon (as diamond)
6. Most abundant element in the earth's crust: Oxygen
7. Rarest element in the earth's crust: Astatine
8. Heaviest naturally occurring element: Uranium
9. Element which sublimes on heating: Iodine
10. Most abundant element in the universe: Hydrogen
11. Element which constitutes 90% mass of sun: Hydrogen
12. Element with the lowest melting point: Caesium (28.44 °C)

Classification of Elements

Elements are classified into:

1. metals 2. non-metals and 3. semi-metals

Semi-metals

The elements which behave both like metals and nonmetals are called semi-metals. These elements have intermediate properties between those of metals and non-metals. They are also called metalloids. Some examples of semi-metals are: germanium, silicon, arsenic, antimony, tellurium, etc.

Metals

The elements (except hydrogen) which form positive ions by losing electrons ($M - ne^- \rightarrow M^{n+}$) are called metals. There are 91 metals

Characteristics of metals

1. Metals are electropositive elements because they have a tendency to lose electrons.
2. Metals are generally malleable (can be beaten into very thin sheets) and ductile (can be drawn into wires).
3. Metals are sonorous, i.e. they produce sound when beaten.
4. Metals are good conductors of heat and electricity.
5. Metals exhibit shining surfaces (metallic lustre) and high reflectivity.
6. All metals (except mercury) are solid at room temperature.
7. Metals have high melting and boiling points.

Some examples of metals are: iron, copper, nickel, cobalt, titanium, calcium, etc,

Some facts about metals

1. Most reactive metal: Francium
2. Heaviest metal: Osmium (density = 22.57 g/mL)
3. Lightest metal: Lithium (density = 0.534 g/mL)
4. Metal having the lowest melting point: Mercury (M.P. = –38.8 °C)
5. Metal having the highest melting point: Tungsten (M.P. = 3422 °C)
6. Most poisonous metal: Plutonium

Non-metals

The elements which tend to gain electrons ($N + ne^- \rightarrow N^{n-}$) to form negative ions during chemical reactions are called non-metals. There are 20 non-metals.

Characteristics of non-metals

1. The non-metals are electronegative elements as they have a tendency to gain electrons.
2. Non-metals (except graphite) are poor conductors of heat and they do not conduct electricity.
3. Non-metals are neither malleable nor ductile.
4. Non-metals are neither lustrous nor sonorous.
5. Non-metals have low melting and boiling points.

Some examples of non-metals are: hydrogen,carbon, nitrogen, phosphorus, oxygen, sulphur, fluorine, etc. Bromine is the only non-metal which is liquid at room temperature.

Some facts about non-metals

1. Most reactive non-metal: Fluorine
2. Non-metal having the lowest melting and boiling points: Helium (B.P. = –268.9 °C).
3. Non-metal having the highest melting and boiling points: Carbon (as diamond)
4. Liquid non-metal: Bromine
5. Best conductor among non-metals: Carbon (as graphite)
6. Non-metals having metallic lustre: Iodine, Carbon (as graphite and diamond)
7. Heaviest solid non-metal: Astatine

COMPOUND

A pure substance which is made up of two or more elements combined chemically in a definite proportion by mass is called a compound.

Characteristics of compounds

1. A compound is composed of two or more elements combined together chemically in a fixed proportion by mass.
2. The constituent elements of a compound cannot be separated by physical methods.
3. A compound is a homogeneous substance. This means that a compound has the same properties and composition throughout the mass.
4. A compound has a fixed set of physical properties such as density, melting point and boiling point, solubility, etc.
5. Properties of a compound are different from those of its constituent elements.
6. Formation of a compound is accompanied by the evolution or absorption of energy.

Differences between an element and a compound

Element	Compound
1. An element consists of the same kind of atoms	A compound is composed of different kinds of atoms.
2. A monoatomic element cannot be split up by physical or chemical method.	A compound can be split up into new substances by chemical methods.
3. Only limited number of elements are known.	Number of known compounds are quite large.
4. The property of an element is the property of its atom.	The property of a compound is quite different from that of its constituent atoms.

MIXTURE

A mixture is a form of matter in which two or more pure substances (elements or compounds) are simply mixed together in any proportion.
A mixture of two components is called a **binary mixture**. A mixture of three components is called a **ternary mixture**.

Types of mixtures

Mixtures are of two types.
1. Homogeneous mixtures 2. Heterogeneous mixtures

Homogeneous mixtures

A homogeneous mixture is the one which has a uniform composition throughout its mass. Homogeneous mixtures are called solutions.
Some examples of homogeneous mixture are:
a. A solution of sodium chloride in water. It is is equally salty in taste
b. A solution of sugar in water. Every part of the solution is equally sweet in taste.

Heterogeneous mixtures

A heterogeneous mixture is the one which does not have a uniform composition throughout its mass.All parts of a heterogeneous mixture are not alike. Some examples of heterogeneous mixture are:
a. Muddy water: The particles of mud can be observed distinctly in the mixture.
b. Smoke: It is a mixture of air and carbon particles but distribution of carbon particles varies throughout

Types of mixtures

Type of mixture	Homogeneous mixture	Heterogeneous mixture
1. Gas in gas	Clean air	—
2. Gas in liquid	Aerated water (water + carbon dioxide + oxygen)	—
3. Gas in solid	Hydrogen in palladium	—
4. Liquid in liquid	Alcohol and water	Oil and water
5. Liquid in solid	Mercury in amalgamated zinc	—
6. Solid in liquid	Sodium chloride in water	Chalk in water
7. Solid in solid	Alloys, e.g. bronze, brass	Iron filings and sand, gun powder

Characteristics of a mixture

1. Mixtures (except solutions) are heterogeneous.
2. The constituents of a mixture can be separated by simple physical methods such as filtration, sublimation, evaporation, magnetic effects, etc.
3. A mixture does not have a fixed composition.
4. A mixture does not have a fixed set of physical properties such as density, melting point, boiling point, etc.
5. A mixture shows the properties of all its constituents.
6. Energy is neither absorbed nor evolved in the preparation of a mixture.
7. The forces of attraction holding the components of a mixture are weak.

Differences between a compound and a mixture

Compound	Mixture
1. A compound is a homogeneous substance.	A mixture may be homogeneous (solution) or heterogeneous.
2. The components of a compound do not retain their properties.	The components of a mixture retain their individual properties.
3. The components of a compound are always present in a definite proportion by mass.	A mixture does not have a definite composition.
4. A compound exhibits definite physical constants such as density, melting point, boiling point, etc.	A mixture does not have definite physical constants such as density, melting point, boiling point, etc.
5. When a compound is prepared, energy changes in the form of heat, light and sound are observed.	When a mixture is prepared, energy changes in the form of heat, light and sound are not observed.
6. The components of a compound cannot be separated by physical methods.	The components of a mixture can be separated by physical methods.
7. A compound has a definite formula.	A mixture does not have a definite formula.
8. The constituents in a compound are held together by strong forces of attraction.	The components in a mixture are held together by only weak forces of attraction.

Differences between an element and a mixture

Element	Mixture
1. An element is homogeneous as it is made up of one kind of atoms or molecules.	A mixture except solution is generally heterogeneous.
2. An element has a constant composition since it is made up of only one kind of matter.	Mixtures are made up of different elements and compounds. They do not have a definite composition.
3. An element has definite physical properties such as density, melting point, boiling point, etc.	A mixture does not have definite physical properties such as density, melting point, boiling point, etc.
4. The atoms of an element are held together by strong forces of attraction.	The components in a mixture are held together by only weak forces of attraction.

SOLUTION

A solution is a homogeneous mixture of two or more substances. When a solution is a homogenous mixture of two components, it is a mixture of a solute and a solvent. Thus,

Solution = Solute + Solvent

The component of the solution that dissolves the other component in it (most often present in larger amount) is called the solvent. The component of the solution that is dissolved in the solvent (generally present in smaller amount) is called the solute.

A solution in which the solute particles are of very small size (diameter $< 10^{-9}$ m) is called a true solution.

Types of solutions

Aqueous solution: A solution in which a substance is dissolved in water is called an aqueous solution. Inorganic compounds dissolve in water. Since water can dissolve a wide variety of substances, water is called the **universal solvent**.

Solution of two liquids: A solution in which two miscible liquids are mixed is called solution of two liquids. For example, solution of water in ethanol.

Solution of two solids: A solution in which two solids are mixed is called a solution of two solids. For example, in the alloy bronze which contains 80% copper and 20% tin by mass, tin is solute and copper is solvent.

Non-aqueous solution: A solution obtained by dissolving a substance in a liquid other than water is called a non-aqueous solution. The examples of nonaqueous solution is bromine dissolved in carbon tetrachloride.

Characteristics of a solution

1. A solution is homogeneous in nature.
2. The particles of solute in solution pass easily through a filter paper.
3. The diameter of particles in a solution is less than 10^{-9} m.
4. The particles of a solution are so small that they are not visible even through a high power microscope.
5. The solute particles in solution do not settle on keeping. Therefore, a solution is a stable one.
6. The properties of solute are retained in solution.For example, a solution of sugar in water is sweet in taste.
7. A solution is transparent to light and does not scatter light because of very small particle size.

Importance of a solution

The molecules in a solution can undergo a large number of collisions per second and this is the reason for faster reaction in solutions.The solvents are used in industry to dissolve different types of substances and to carry out various chemical reactions. In the laboratories, most reactions are carried out in solutions. Many medicines are solutions of various compounds in aqueous or non-aqueous solvents .For example, tincture of iodine is a solution of iodine and potassium iodide in 95% ethanol. Saline-glucose solution administered to patients suffering from dehydration is a solution of glucose and various salts in water.

Concentration of a solution

The concentration of a solution is expressed in several ways such as:

1. Mass by mass percentage of solute in solution:

In this system, the concentration of a solution is expressed as the mass of solute in grams present per 100 g of the solution.

Thus, concentration of solute in mass by mass

$$\text{percentage} = \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 100$$

2. Mass by volume percentage of solute in solution:

In this system, the concentration of a solution is expressed in terms of mass of solute per 100 units of the volume of the solution. Thus,

Concentration of solute in mass by volume percentage

$$= \frac{\text{Mass of solute}}{\text{Volume of solution}} \times 100$$

3. Volume by volume percentage of solute in solution:

The concentration is expressed in terms of volume of solute per 100 units of volume of solution.

Thus, concentration of solute in volume by volume percentage

$$= \frac{\text{Volume of solute}}{\text{Volume of solution}} \times 100$$

4. In parts per million (ppm):

This system of expressing concentration is used when a solute is present in a very small quantity.

Thus, concentration of solute in parts per million of the solution

$$= \frac{\text{Mass of solution in gram}}{1000000 \text{ g of solution}}$$

SUSPENSION

A heterogeneous mixture which contains very fine particles of solute (of the diameter of >10–6 m) dispersed throughout the solvent without getting dissolved in it, is called suspension. The examples of suspension are chalk-water, smoke coming out of chimneys, paints, etc. These dispersed particles are visible to the naked eye.

Properties of suspension

1. **Heterogeneous nature**: Suspension is heterogeneous in nature.
2. **Particle size**: The diameter of the particles in a suspension is in the range of $>10^{-6}$ m. The particles of suspension can be seen with naked eye.
3. **Separation with the help of a filter paper**: The particles of suspension do not pass through the pores of a filter paper and thus a filter paper can be used to separate the components.
4. **Appearance**: A suspension is hazy to opaque in appearance.
5. **Transparency**: A suspension is not transparent to light.
6. **Sedimentation**: The particles of a suspension settle down under gravity. The heavier particles settle down faster than the finer particles. Very fine particles, however remain suspended in the solution

COLLOID

A mixture in which the diameter of the solute particles is intermediate between that of a true solution and a suspension is called colloidal solution.The examples of colloidal solution are milk, toothpaste, blood, ink, etc.A colloidal solution consists of two phases:

1. **Dispersed phase**: The component of a colloidal solution which is present in smaller proportion and consists of particles of colloidal dimension (10^{-9} to 10^{-6} m), constitute the dispersed phase.
2. **Dispersion medium**: The component of a colloidal solution which is present in excess and acts as a medium in which the solute particles are dispersed, forms the dispersion medium.

Types of colloidal solution

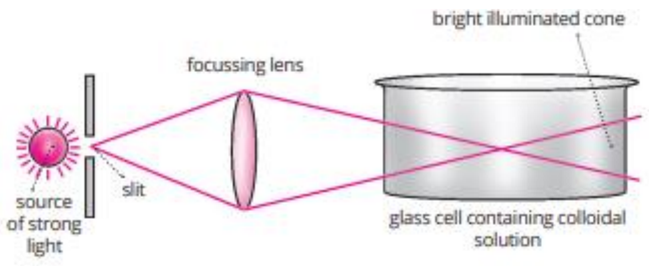
Dispersed phase	Dispersion medium	Common name	Examples
Liquid	Gas	Aerosol	Sprays, beer foam, fog, fire extinguisher foam, cloud, mist
Solid	Gas	Solid aerosol	Smoke, automobile exhaust, dust-storm
Gas	Liquid	Foam	Whipped cream, shaving cream, soap lather
Liquid	Liquid	Emulsion	Milk, mayonnaise, face cream
Solid	Liquid	Sol	Paint, ink, milk of magnesia, mud, paints
Gas	Solid	Solid foam	Marshmallow, foam rubber, sponge, pumice
Liquid	Solid	Gel	Butter, cheese, jelly, curd
Solid	Solid	Solid sol	Pearls, opals, ruby, milky glass

The colloidal solutions in water are called **hydrosols**. The colloidal solutions in benzene are called **benzosols**. The colloidal solution in air is called **aerosol.**

Properties of a colloidal solution

1. **Filterability**: The size of the colloidal particles is smaller than the size of the pores of a filter paper. Therefore, the colloidal particles pass through a filter paper.
2. **Heterogeneity**: Colloidal solution is heterogeneous in nature.
3. **Visibility**: The particles in a colloidal solution are not visible to the naked eye.
4. **Sedimentation**: The colloidal particles, on long standing, settle down slowly under gravity.
5. **Inability to pass through animal membrane**: The colloidal particles cannot pass through animal membrane or parchment paper.
6. **Diffusion**: The colloidal particles diffuse from a region of higher concentration to a region of lower concentration.
7. **Brownian movement**: The colloidal particles seem to move randomly in a zig-zag motion in all directions, when seen under a microscope. This zig-zag motion of colloidal particles is called the Brownian movement.
8. **Optical property – Tyndall effect**: When a beam of light is passed through a colloidal solution, the colloidal particles scatter light in all directions, and the path of light becomes visible when seen from a direction at right angle to that of the incident light. The phenomenon of scattering of light by colloidal particles as a result of which the path of the beam of light becomes visible is called the Tyndall effect.

Tyndall effect



Application of colloids

1. In medicines: Colloidal medicines are easily absorbed by our body tissues and hence are more effective than medicines in the form of tablets.
2. In food: Many of our food items are in the form of colloids. For example, milk, protein solutions, starch solutions, fruit-jellies, cheese, butter, ice cream, whipped cream, marshmallow, mayonnaise, jello and curd are all colloids.
3. In cleansing action of soap: An aqueous solution of soap is a colloidal solution which is used to remove greasy material sticking to the clothes or utensils.
4. In the production of rubber: Rubber is obtained from latex which is a colloidal solution of rubber particles in water.

Test of colloids

When a strong beam of light is passed through a colloidal solution, the light gets scattered and the path of light becomes visible. This serves as a test for colloids.

Importance of colloids in nature

Nature uses colloids extensively. The raw natural rubber and muddy water are nothing but colloids. The formation of deltas at the river mouth occurs due to the coagulation of colloidal clay particles in the presence of sea water containing salts such as sodium chloride, potassium chloride, etc

Comparison of distinguishing features of a true solution, a colloidal solution and a suspension

Property	True solution	Colloidal solution	Suspension
1. Nature	Homogeneous	Heterogeneous	Heterogeneous
2. Particle size	$< 10^{-9}$ m	10^{-9} to 10^{-6} m	$> 10^{-6}$ m
3. Appearance	Transparent	Generally transparent but may also show translucence.	Hazy to opaque
4. Visibility	Particles are neither visible with naked eye nor under microscope.	Particles are not visible with naked eye but are visible under a powerful microscope.	Particles are visible with naked eye.
5. Settling of particles under gravity	No settling	Very slow settling. Reasonable settling under high speed centrifugation.	Particles settle down under gravity. Heavier particles settle down faster than lighter particles.
6. Filterability	Particles pass through filter paper and parchment paper.	Particles do not pass through parchment paper but pass through filter paper.	Particles do not pass through parchment or filter paper.
7. Brownian movement	Not observed	Observed	Possible only with very fine suspensions.
8. Tyndall effect	Does not exhibit Tyndall effect.	Exhibits Tyndall effect.	Tyndall effect may be observed.

SEPARATING THE COMPONENTS OF A MIXTURE

Most of the substances available in our surroundings are not chemically pure. On many occasions we need pure substances. Individual components of a mixture can be separated by different techniques. The method of separation used depends on the differences in the properties of the components of the mixture.

Reasons for separating the components of a mixture

1. To get a pure sample of a substance
2. To remove any undesirable or harmful components
3. To obtain the useful components of a mixture

Methods used for separating the components of a mixture

There are various methods employed for separating the components of a mixture. The method used depends on the difference in the properties of the components of the mixture. These are:

- Separating a solid from other solids
- Separating a solid that sublimes
- Separating an insoluble solid from a liquid
- Obtaining a pure solid from an impure solid sample
- Separating a soluble solid from its solution
- Separating a magnetic substance from a nonmagnetic substance
- Separating a pure solvent from the solution of a soluble salt
- Separating miscible liquids
- Separating immiscible liquids
- Separating very fine particles present in a liquid
- Separating the coloured components of a mixture

Separating a solid from other solids

The properties commonly used to separate solids from a mixture of solids are – weight, size, shape and colour, etc. Common methods used are threshing, winnowing, hand-picking and sieving.

Threshing and winnowing: The first step is to separate the grains from the stalks. This is known as threshing. It is done by beating the stalks on the ground or by using a mechanical thresher. The wheat grains are then separated from the mixture of grain and chaff (by using the property that grain is heavier than chaff). The mixture is allowed to fall from a height. The breeze blows away the chaff, while the grain falls down almost vertically. The process of separation of grains from husk and hay with the help of blowing wind is called winnowing.

Separating wheat grains from chaff

Drop a mixture of wheat and chaff slowly from a height. The lighter chaff is carried away by the blowing wind and it forms a heap at some small distance away. The heavier wheat grains fall almost vertically and form a separate heap nearby (Fig. 2.5).

Hand-picking: Undesirable substances such as pieces of stones in rice or cereal can be separated by hand-picking. This is possible because the particles of the undesirable substances are different from the foodgrains in shape, size and colour.

Sieving: When the constituents of a mixture have particles of different sizes, a sieve can be used to separate them. The size of the pores of the sieve depends on the size of the constituents to be separated.

Separating a solid that sublimes

Sublimation: Some solid substances, when heated, change directly into vapours. The process during which a solid on heating changes directly into the vapour phase without passing through the intermediate liquid state is called sublimation. On cooling the vapour, a solid is obtained. The solid obtained by sublimation is called sublimate. Sublimation is described by the following equation:

$$\text{Solid} \underset{\text{cool}}{\overset{\text{heat}}{\rightleftharpoons}} \text{Vapour}$$

For example, the components of a mixture of iodine and sand can be separated by sublimation.

Separating an insoluble solid from a liquid

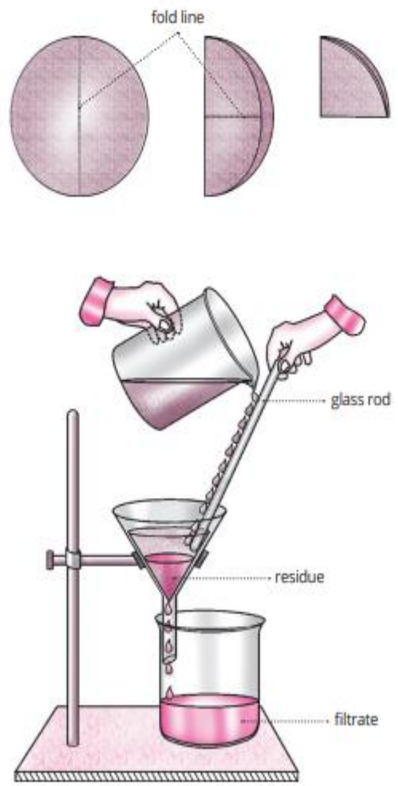
The methods used for the separation of insoluble solids from liquids are decantation and sedimentation, and filtration. Decantation and sedimentation: An insoluble solid constituent of a mixture is separated from its liquid constituent by allowing it to settle down at the base followed by transferring the clear liquid to another vessel. The settling down of the particles of the insoluble solid is called sedimentation. The upper clear liquid is called supernatant. The insoluble solid is called the sediment. The method of gradually pouring off liquid from one container into another without disturbing the sediment is called decantation.

a. Mixture of sand and water b. Sand settles down after some time c. Transferring the supernatant water

Separating clay/sand particles from muddy water by decantation and sedimentation

Take a mixture of sand and water (or a small quantity of muddy water) in a beaker (Fig a) and allow it to stand undisturbed for some time (Fig. b). Transfer the supernatant water carefully to another beaker (as shown in Fig. c) without disturbing the sediment

Filtration: The method of separating insoluble solid particles from a liquid by passing it through a filter paper is called filtration. A filter paper is first folded into a semi-circle and then again folded to obtain a quarter circle. The filter paper is opened to form a cone and is then placed in a glass funnel (Fig. 2.8) which is supported on a funnel stand. A few drops of water are added to the filter paper so that the filter paper stays in place on the glass funnel and also to prevent the formation of any air bubble in between the filter paper and glass funnel. The mixture containing solid and liquid is stirred with the help of a glass rod and is then poured into the glass funnel, a little at a time, using the glass rod. The clear liquid is collected in a beaker kept below the funnel and the solid particles remain on the filter paper.



Process of filtration

Obtaining a pure solid from an impure solid sample

Crystallisation: An impure solid is purified by crystallisation. If the solubility of two solids in a solvent is different, fractional crystallisation is used to separate two solids. The impure solid is dissolved in a suitable solvent to get its nearly-saturated solution at a temperature higher than the room temperature. The cooling of such a solution leads to the formation of crystals of pure substance. The solution left behind is called mother liquor. All the impurities are left behind in the mother liquor. Impure common salt is purified by crystallisation.

Separating a soluble solid from its solution

Evaporation: Evaporation is used for separating a soluble solid substance from its solution. The process of evaporation can be made quicker by heating the solution.
A solution is evaporated on a water bath till only one-fourth of the solution is left. The solution is then cooled at room temperature or in an ice bath and the separated solid particles are filtered and washed with a suitable solvent and dried at room temperature or in an air oven at 110 °C.

Separating common salt from its solution in water by evaporation

Take about 50 mL solution of common salt in a china dish and heat the china dish with a Bunsen burner (Fig. 2.10). When water boils, reduce the flame. When all the water is evaporated, turn off Bunsen burner, cool the china dish at room temperature and scrape the common salt with a stainless steel spatula to a container.

a. Water boils leaving behind the salt
b. Scraping the salt with spatula

Evaporation

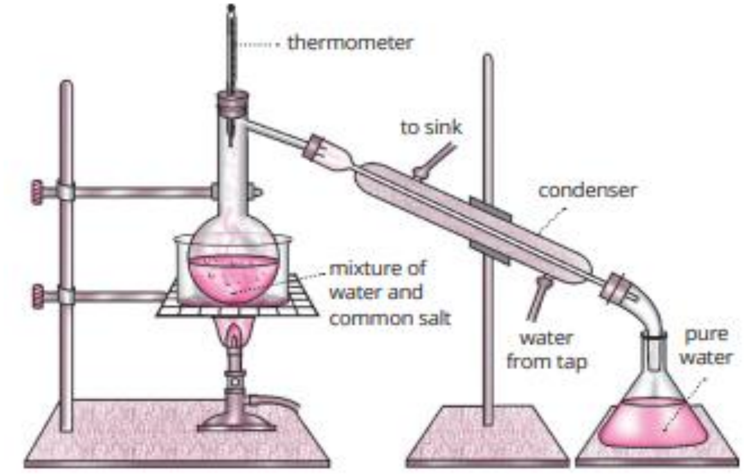
Separating a magnetic substance from a non-magnetic substance

A mixture of iron filings and sulphur can be separated by using a magnet (Fig.). In many industries, the waste materials often contain scrap iron. Large electromagnets fitted to a crane are used to separate the scrap iron, which is then recycled by melting and is put to us

Magnetic separation

Separating a pure solvent from the solution of a soluble salt

Simple distillation: The conversion of a liquid into vapours by heating followed by condensation of the vapours by cooling to obtain the pure liquid is called distillation.The method is used for separating a heat-stable nonvolatile solid from a liquid which is sufficiently stable at its boiling point. The mixture to be distilled is taken in a round-bottomed distillation flask, the side tube of which is connected to a Liebig's condenser (Fig.). Water is circulated continuously through the outer tube of the Liebig's condenser in order to condense the vapours. The distillation flask is heated by a Bunsen burner. The temperature of the mixture rises gradually and it starts boiling. The vapours of the liquid, as they pass through the condenser are condensed to form liquid drops which are collected in a receiver. The liquid obtained by condensing the vapours is called distillate. The solid is left behind as the liquid is evaporated. This method can be used to separate the components of a mixture of common salt and water



Separation of water from a solution of water and common salt by distillation

Separating miscible liquids

Fractional distillation:

This method is used for separating the components of a mixture containing two or more miscible liquids whose boiling points differ by less than 25 °C. The liquid mixture is taken in a round-bottomed distillation flask which is connected to a fractionating column (Fig. 1).

The fractionating column is a tube full of glass beads. The purpose of the fractionating column is to increase the cooling surface area and to provide obstructions to the ascending vapours and descending liquid. The side tube of the fractionating column is fitted with a Liebig's condenser. Water is circulated continuously through the outer tube of the Liebig's condenser in order to condense the vapours.

A few small pieces of porcelain are added to the distillation flask to prevent bumping. The distillation flask is heated on a Bunsen burner. The temperature of the mixture rises gradually and the liquid starts boiling.

The vapours of the more volatile component (low boiling component) leave the fractionating column from the exit near the top, while the vapours of the low volatile component (high boiling component) get condensed in the fractionating column and return to the distillation flask.

The vapours of the more volatile component enter the Liebig's condenser and get condensed. The distillate consisting of pure but more volatile component is collected in the receiver. The less volatile component distils afterwards at a higher temperature. A new receiverplaced collects the second distillate.

Fractional distillation is used to separate the following:

Benzene (boiling point 80 °C) and toluene (boiling point 110 °C)

The components (petrol, kerosene, diesel, lubricating oil, etc.) of crude petroleum (Fig. 2).

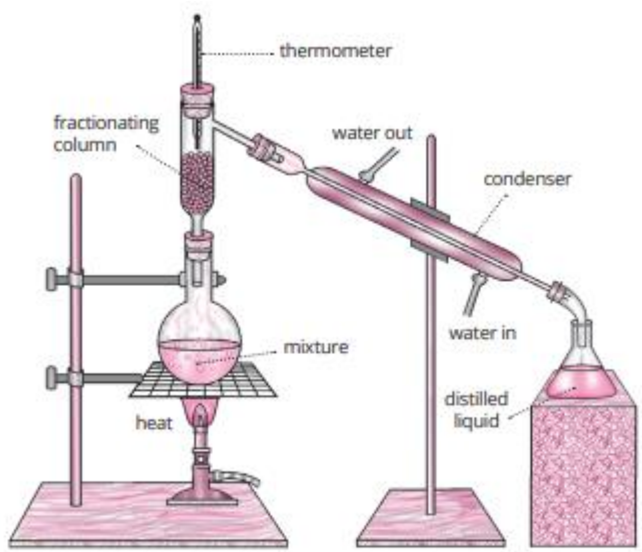


Fig. 1 Apparatus for fractional distillation

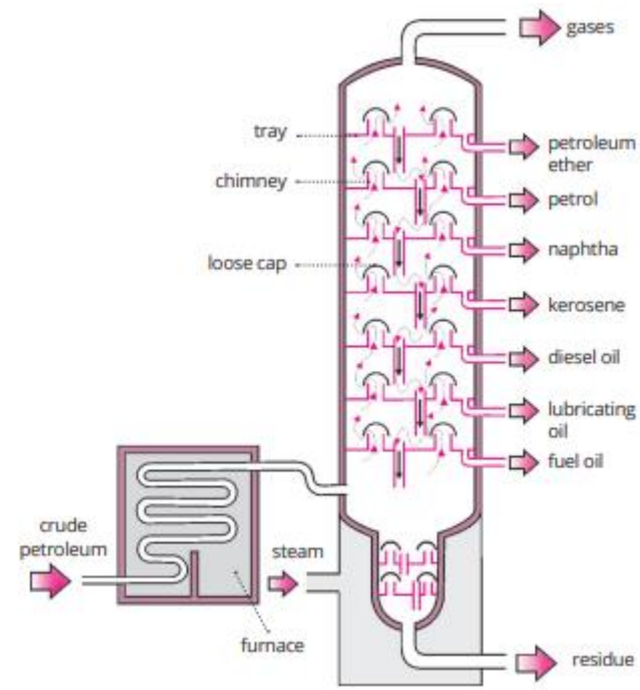
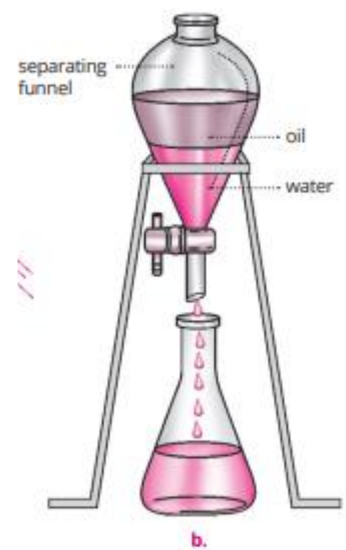


Fig. 2 Separation of various components of crude petroleum by fractional distillation

Separating immiscible liquids

The liquids which do not dissolve in each other are called immiscible liquids. The fact that these liquids have different densities is used to separate them. To separate two immiscible liquids (such as water and vegetable oil), we make use of a separating funnel. A mixture of two immiscible liquids is taken in a separating funnel. The separating funnel is stoppered and the contents are shaken thoroughly. The separating funnel is allowed to stand for some time when two separate layers are formed. The liquid with lower density forms the upper layer and the liquid with higher density forms the lower layer. The stopper is taken out and the lower layer is run out into a beaker by opening the tap of the separating funnel. When the liquid in the lower layer flows out completely, the tap is closed to retain the lighter liquid in the separating funnel. This method is also used to recover an organic compound (liquid or solid) by extracting it with an organic solvent from its aqueous solution. For example, the benzene layer forms the upper layer and the water layer forms the lower layer. This method is also used to separate a mixture of oil and water

a. Mixing of oil and water by vigorous shaking

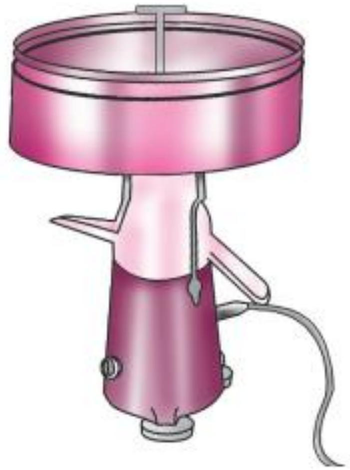


b. Separation of two layers forms the oil layer at the top and water layer at the bottom

Separating very fine particles present in a liquid

Centrifugation: If the solid particles in a liquid are very small, they pass through the filter paper. For such mixtures the filtration technique is not useful for separation of the components. Fine particles suspended in a liquid can be separated by centrifugation. In this method, the mixture is rotated at a high speed in a machine called the centrifuge. The heavier suspended particles are forced to move down and the lighter liquid particles remain on top.

Centrifugation is used in dairies to separate the lighter cream from milk. The milk is rotated at high speed in a container. The lighter cream separates and collects in the centre. It floats on top of the milk and is separated. The components of such a mixture cannot be separated by simple filtration through a filter paper since such fine particles easily pass through the filter paper.



Churning electric machine to separate cream from milk

Applications of the centrifugation method

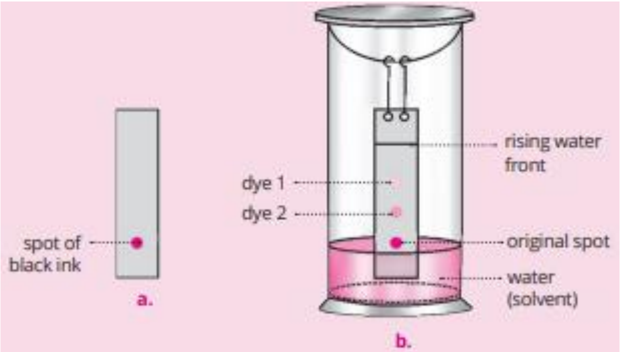
1. Separating butter from curd.
2. Separating coagulated blood and blood plasma in pathological laboratories.
3. Separating fine precipitates during urine test.
4. Separating water from wet clothes in washing machines

Separating coloured components of a mixture

The process of separation of the components of a mixture based on the difference in adsorption of different components on the surface of a solid is known as chromatography (Greek: kroma = colour, graphe = writing).This separation technique was originally confined to separating coloured substances (e.g., dyes, pigments, etc.). In this separation technique, the components retain their individuality during the separation process. But the coloured components of the mixture to be separated must be soluble in the same solvent.

Separating coloured components (dyes) of black ink by paper chromatography

Take a strip of filter paper (25 cm long and 1.5 cm wide) and mark a line on it with a pencil about 5 cm from one end (Fig. a). Put a small drop of black ink at the centre of the line using a capillary tube and dry the spot in air. Suspend the filter paper into a gas jar containing water (solvent) so that the spot is slightly above the water level (Fig. b). Stopper the gas jar so that the space inside the gas jar becomes saturated with water vapour. Allow the arrangement to stand for some time. Water rises along the filter paper due to the adsorption of water molecules on the cellulose molecules of filter paper. Water reaches the spot and removes the components of ink at various speeds. After water has reached a suitable height (15–20 cm), open the gas jar, remove the paper and dry the filter paper in air. Two or three coloured spots are observed at different distances from the reference line. The coloured component which is more soluble in water rises faster than the other components. This paper with coloured spots at different heights is called chromatogram. This activity shows that black ink is a mixture of several dyes.Separation of different components present in ink occurs on a chromatographic paper due to the different solubilities of the components in water

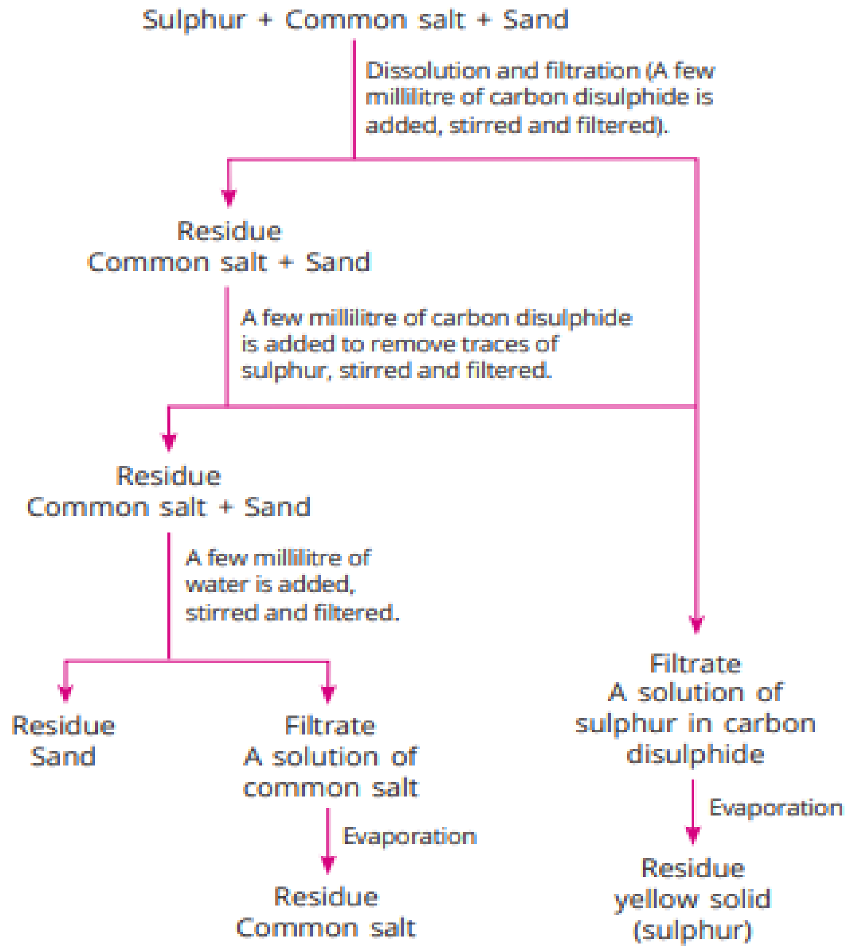


a. Strip of filter paper with a spot of black ink
b. Separating the components of black ink using water as solvent

Separating the components of mixtures using more than one method

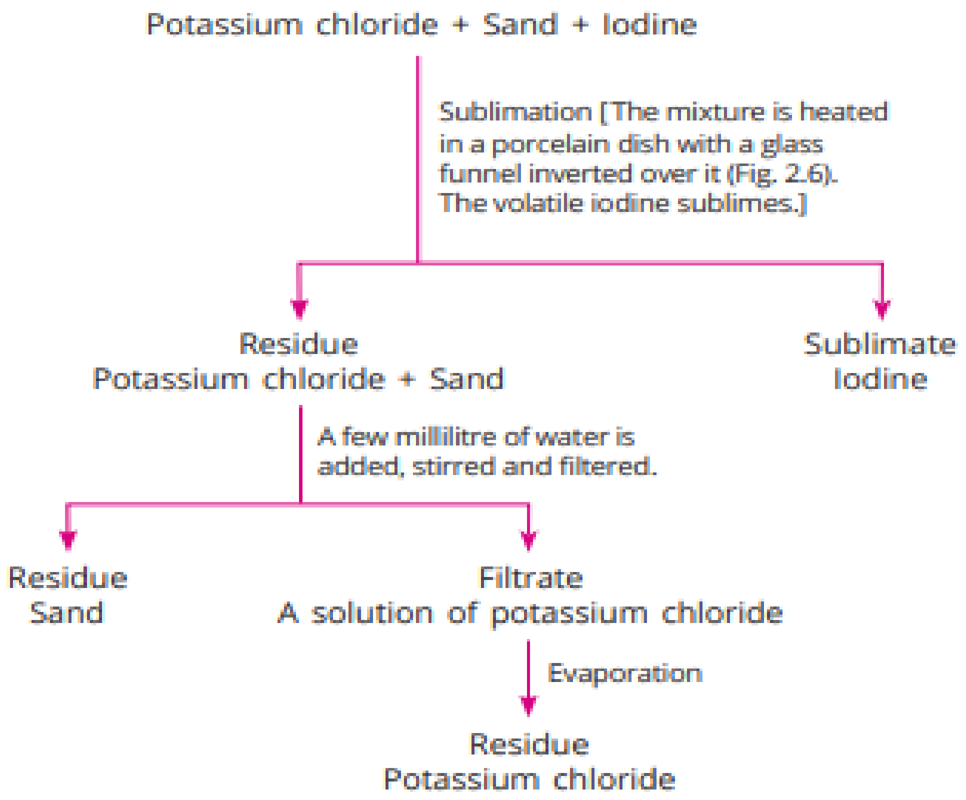
Separating a mixture of sulphur, common salt and sand

When a mixture containing two solids, one of which is soluble in a solvent and the other is insoluble in that solvent, dissolution followed by filtration is the method used for separating the mixture. The flow chart of the process is shown in the following figure.



Separating a mixture of potassium chloride, sand and iodines

Iodine sublimes on heating, potassium chloride is soluble in water and sand is insoluble in water. These properties are made use of in the separation. The flow chart of the process is shown in the following figure.



Separating the components of gunpowder

Gunpowder is a mixture of charcoal, sulphur and nitre (potassium nitrate). Potassium nitrate is soluble in water, sulphur is soluble in carbon disulphide and charcoal is insoluble in both the solvents. These properties are made use of in the separation. The flow chart of the process is shown in Fig. a.

Separating a mixture of sulphur, carbon and potassium chloride

Sulphur is soluble in carbon disulphide, potassium chloride is soluble in water and carbon is insoluble in both the solvents. These properties are made use of in the separation. The flow chart of the process is shown in Fig. b.

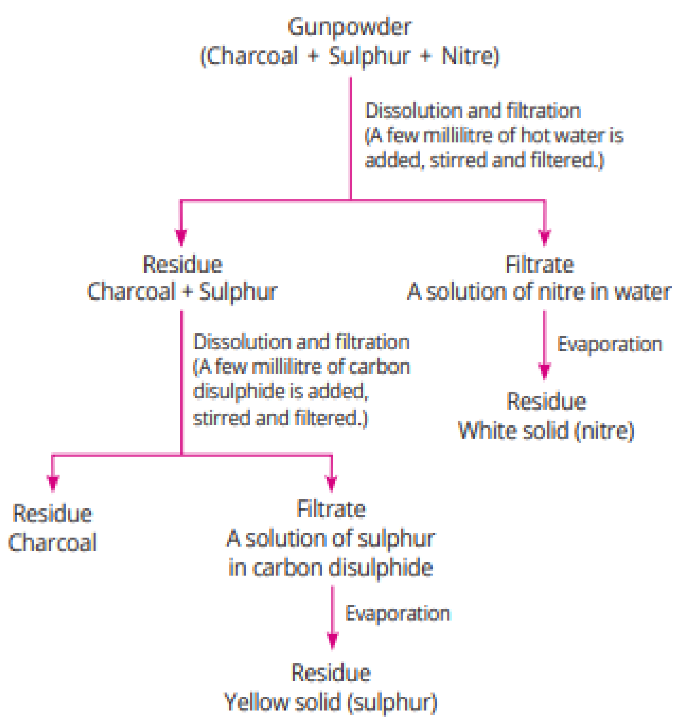


Fig. a.

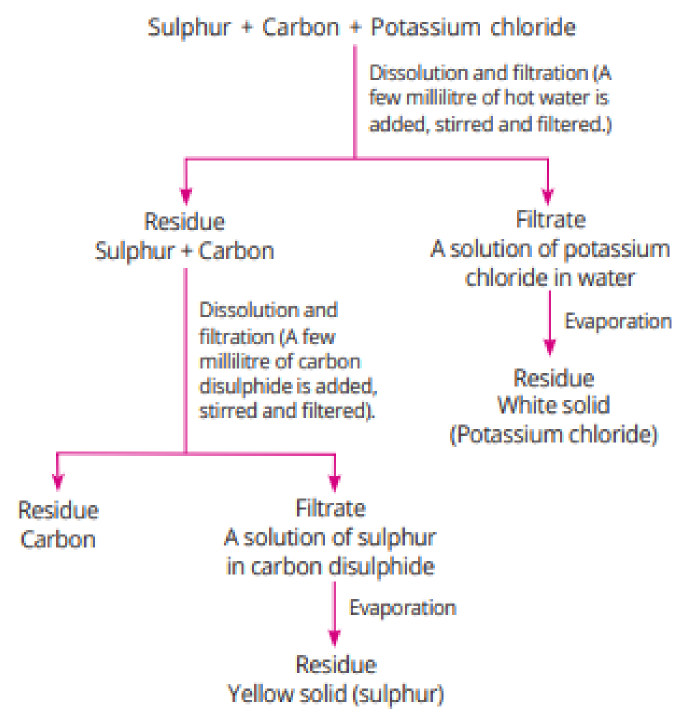
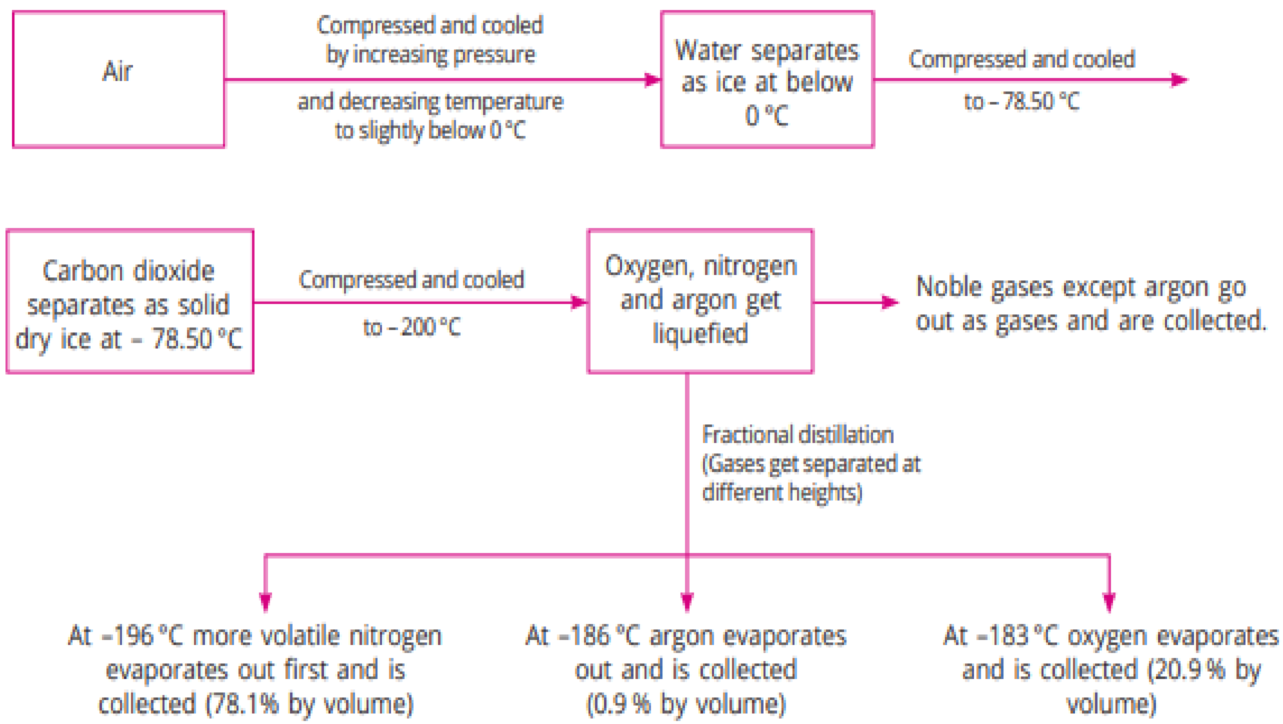


Fig. b.

Separating the components of air

Clean air is a homogeneous mixture of various gases such as oxygen, nitrogen, carbon dioxide, water vapour and noble gases (namely, helium, neon, argon and krypton). Since these gases have different freezing and boiling points, these gases can be separated by liquefaction of air followed by fractional distillation of liquid air in a specially designed column. The flow chart of the process is shown in the following figure.



WATER PURIFICATION IN WATERWORKS

Water from various sources is processed to make it suitable for human consumption:

1. Screening: Water from river/lake is passed through screens having large number of holes. Here, the floating matter is retained by these screens.

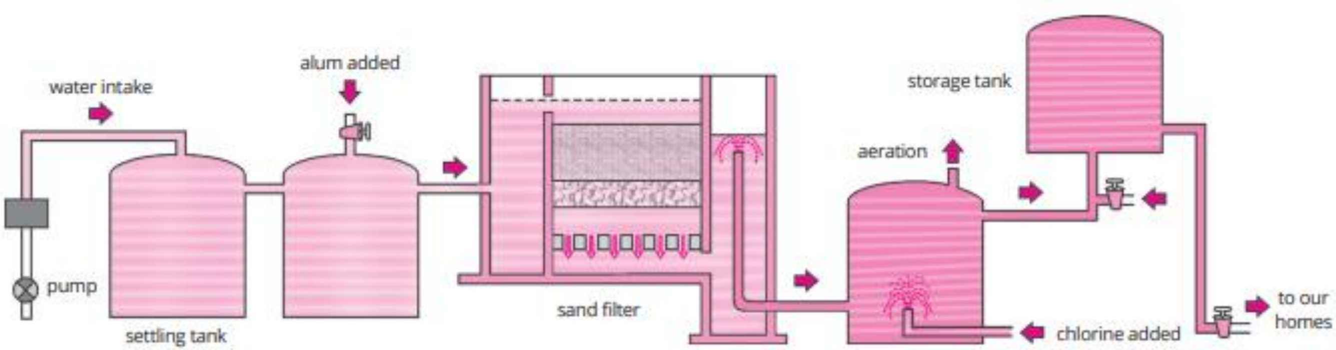
2. Sedimentation: Water is then pumped into a settling tank where most of the suspended particles settle down at the bottom due to the force of gravity. The supernatant water is then sent to another tank called the loading tank.

3. Loading: A solution of alum, which acts as a coagulant, is added to the water in the loading tank. Alum forms insoluble gelatinous and flocculent precipitate which absorbs and entangles very fine suspended particles as well as colloidal particles, which settle down easily under gravity. Alum also removes colour, odour and unwanted taste from the water.

4. Filtration: The supernatant water from the loading tank is passed through a filtering set containing beds of fine sand, coarse sand and coarse gravel. Filtration removes all the suspended impurities including colloidal matter and most of the bacteria and microorganisms.

5. Aeration: The filtered water is passed through an aeration tank where air is passed to kill microorganisms and to saturate water with oxygen.

6. Chlorination: A calculated concentrated solution of chlorine is mixed with aerated water. Chlorine acts as a disinfectant and kills the harmful disease causing microorganisms.



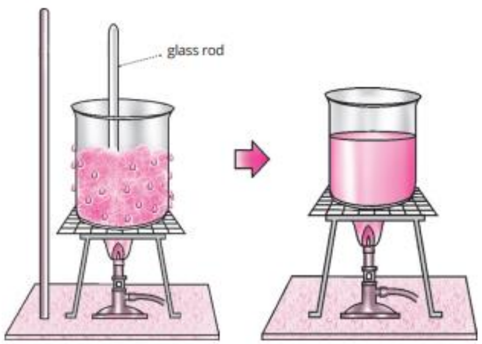
Water purification system in waterworks

PHYSICAL AND CHEMICAL CHANGES

Physical changes

A temporary change in which no new substance is formed and the composition of the original substance is not altered after the change, although certain specific physical properties may be changed, is called a physical change. The examples are:

1. Conversion of ice into water (Fig.) or vice versa in which a change in state occurs.
2. Dissolution of sugar in water in which a change in state occurs.
3. Sublimation of iodine on heating in which a change in state and colour (violet-black to violet) occurs.
4. Change of colour of zinc oxide from white to yellow on heating.
5. Expansion and contraction of substances on heating and cooling, respectively.
6. Melting of gallium metal (M.P. = 29.78 °C) on the palm of our hand (temperature = 37 °C).



Physical change – melting of ice into water on heating

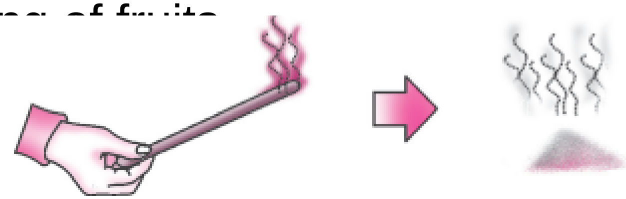
Characteristics of physical change

1. No new substance is formed. Only the physical properties of the substance change.
2. Physical change is temporary and reversible.
3. The mass of a substance undergoing a physical change remains the same.
4. Energy change does not occur in a physical change.

Chemical changes

A permanent change in which the original substance gives rise to one or more new substances with different properties, is called a chemical change. The examples are:

1. Burning of wood to give gases such as carbon dioxide and water vapour, and ash (Fig.). It is not possible to get back the wood from ash and the released gases.
2. Rusting of iron on exposure to moist air leading to the formation of a new substance,hydrated iron(III) oxide (rust).
3. Digestion of food.
4. Electrolysis of acidulated water giving colourless and odourless gases (hydrogen and oxygen) at the electrodes.
5. Ripening of fruits.



Chemical change – burning of a piece of wood producing smoke and ash

Characteristics of chemical change

The following are the characteristics of a chemical change:

1. One or more new substances are formed.
2. The chemical change is permanent and quite often, it is irreversible.
3. The chemical composition and the chemical properties of the substance undergoing a chemical change get completely changed.
4. A chemical change is most often accompanied with energy change.

Differences between physical and chemical changes

Physical change	Chemical change
1. Physical change is temporary.	Chemical change is permanent.
2. Physical change can be easily reversed.	Chemical change cannot be reversed.
3. In physical change, no new substance is formed.	In chemical change, new substances are formed.
4. In physical change, no change in mass occurs.	The mass of the substance undergoing chemical change is altered. But the total mass of the reacting substances is equal to the total mass of the products formed.
5. Energy change does not occur in a physical change.	Energy change occurs in a chemical change.

On Board! BOOKS

SUMMARY

1. **Pure substance:** A sample of matter containing only one substance is called a **pure substance**.
2. **Element:** An element is a pure substance which cannot be split up into two or more substances. Nitrogen is an element.
3. **Compound:** A compound is a pure substance made up of two or more elements combined in a definite proportion by mass. Water is a compound.
4. **Mixture:** A mixture is that form of matter in which two or more homogeneous pure substances (elements or compounds) are simply mixed together in any proportion by mass. Mixtures can be separated into pure substances using suitable separation techniques. A mixture shows the properties of its constituent elements or compounds.
5. **Solution:** A solution is a homogeneous mixture of two or more substances. The major component of a solution is called **solvent** and the minor component of a solution is called **solute**.
6. A solution in which a substance is dissolved in water is called an **aqueous solution**.
7. A solution obtained by dissolving a substance in a liquid other than water is called a **non-aqueous solution**.
8. A solution in which the solute particles are of very small size (diameter $< 10^{-9}$ m) is called a **true solution**.
9. A solution in which no more solute can be dissolved at a particular temperature and pressure is called a **saturated solution**.

10. A solution in which more quantity of solute can be dissolved at a particular temperature and pressure is called an **unsaturated solution**.

11. **Suspension:** A heterogeneous mixture which contains small insoluble particles of solute spread throughout the solvent without getting dissolved in it, is called **suspension**.

12. **Sedimentation:** The process in which the suspended particles in a mixture settle down under the action of gravity is called **sedimentation**.

13. **Colloidal solution:** A solution in which the diameter of the solute particles is intermediate between that of a true solution and a suspension, is called a **colloidal solution**. A homogeneous-looking heterogeneous mixture in which the size of the solute particles is in the range 10^{-9} to 10^{-6} m is called a **colloid**. Colloids are useful in our daily life and industry.

    A colloidal solution consists of dispersed phase and dispersion medium. The component of a colloidal solution which is present in smaller proportion and consists of particles of colloidal dimension (10^{-9} to 10^{-6} m) is called **dispersed phase**. The component of a colloidal solution in which the solute particles are dispersed, is called **dispersion medium**.

14. Colloidal particles pass through a filter paper, exhibit heterogeneity, are not visible to the naked eye, undergo slow sedimentation on long standing, undergo diffusion and exhibit **Brownian movement** and **Tyndall effect**.

15. **Brownian movement:** The zig-zag motion of the colloidal particles in a colloidal solution is called the **Brownian movement**.

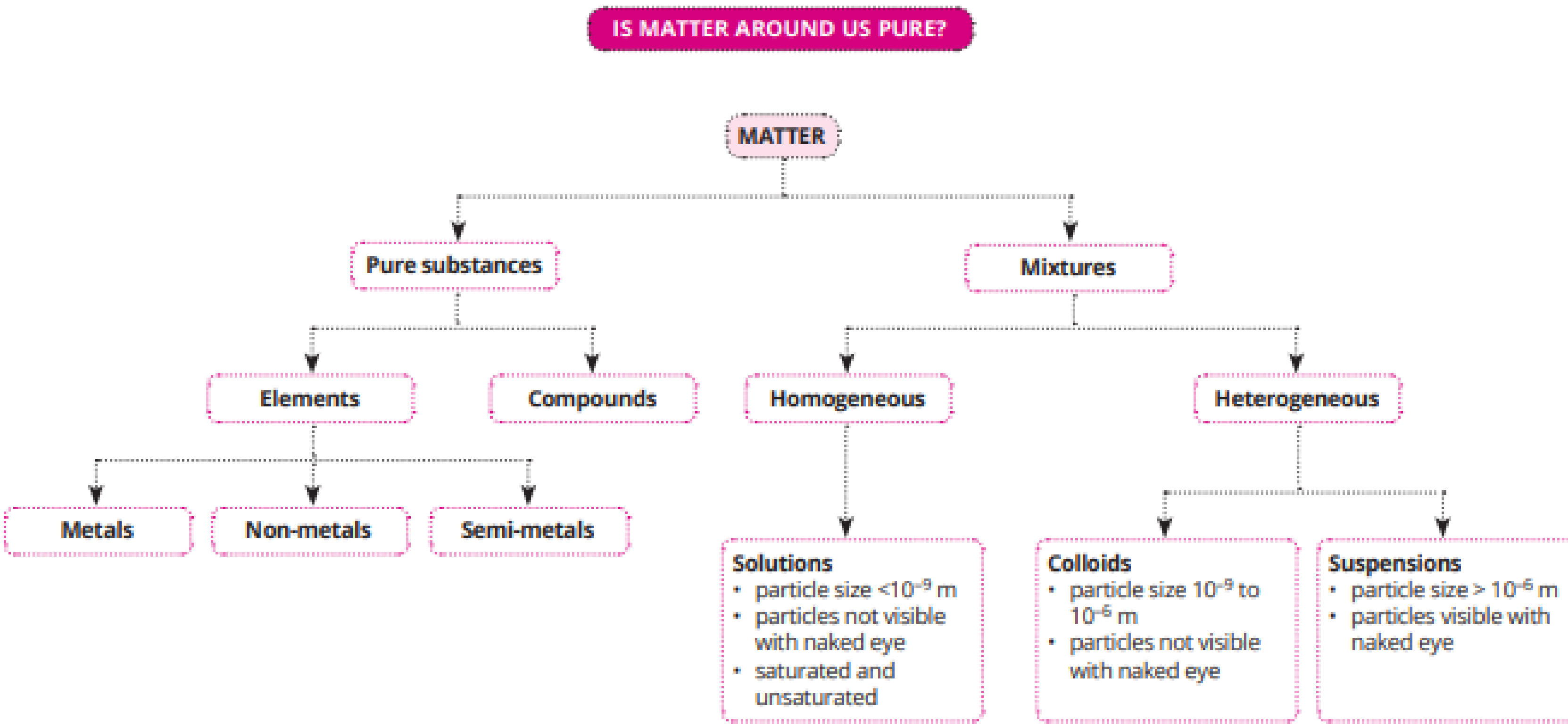
16. **Tyndall effect:** The phenomenon of scattering of light by colloidal particles as a result of which the path of the beam of light becomes visible is called the **Tyndall effect**.

17. **Chromatography:** The process of separation of the components of a mixture based on the difference in adsorption of different components on the surface of a solid is known as **chromatography**.

18. **Physical change:** A temporary change in which no new substance is formed and the composition of the substance is not altered, though certain specific physical properties may be changed, is called a **physical change**. A physical change is reversible in nature.

19. **Chemical change:** A permanent change in which the original substance gives rise to one or more substances with different properties is called a **chemical change**. A chemical change is irreversible in nature.

MIND MAP



IS MATTER AROUND US PURE?
MATTER
Pure substances
Mixtures
Elements
Compounds
Homogeneous
Heterogeneous
Metals
Non-metals
Semi-metals
Solutions
• particle size $<10^{-9}$ m
• particles not visible with naked eye
• saturated and unsaturated
Colloids
• particle size 10^{-9} to 10^{-6} m
• particles not visible with naked eye
Suspensions
• particle size $> 10^{-6}$ m
• particles visible with naked eye

MIND MAP

SEPARATING THE COMPONENTS OF A MIXTURE

For Solid Mixtures

Hand-picking
- for undesirable substances in food grains, etc.
- e.g., stones in rice

Sieving
- for mixture constituents with different particle size
- e.g., wheat flour and gram

Sublimation
- for mixtures that contain one sublimable volatile component
- e.g., camphor and salt

Magnetic separation
- for mixtures that can be separated using a magnet
- e.g., sand and iron

For Solid-liquid Mixtures

Sedimentation
- e.g., pumice stone and water

Evaporation
- e.g., salt and water

Chromatography
- e.g., colours in a dye

Filtration
- e.g., mud and water

Centrifugation
- e.g., butter from curd

Distillation
- e.g., water and salt

For Liquid Mixtures

Separating funnel
- for two immiscible liquids
- e.g., kerosene oil and water

Distillation
- for two miscible liquids
- e.g., ethanol and water

Fractional distillation
- e.g., benzene (b.pt. 80 °C) and toluene (b.pt. 110 °C)

PHYSICAL CHANGES

- temporary
- reversible
- no energy change

CHEMICAL CHANGES

- permanent
- irreversible
- energy change occurs