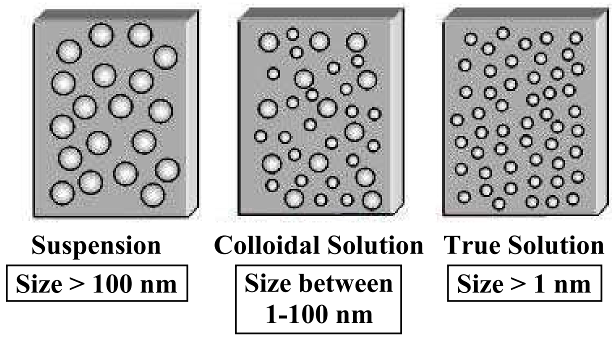
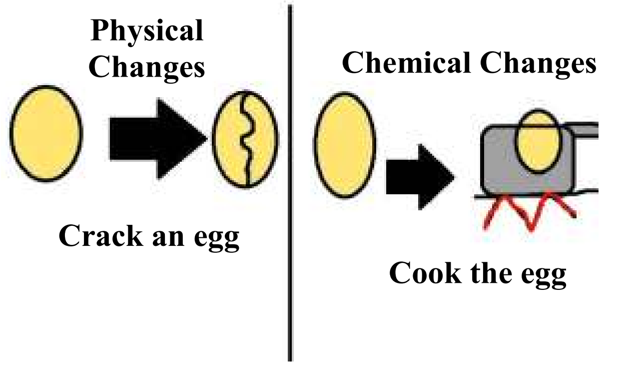
Exploring Mixtures and their Separation

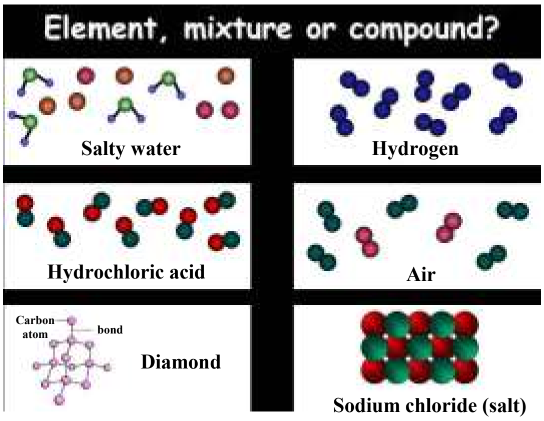
Chapter Outline

- Pure substances
- Elements
- Compounds
- Mixtures
- Solutions
- Concentration of solution
- Suspension
- Colloidal solution
- Separation Techniques
- City water supply
- Physical and Chemical change

Three types of Solutions







INTRODUCTION

People often talk of pure milk, pure butter, pure honey, etc. To a chemist none of them is a pure substance. For a common man, pure actually means having no adulteration. But for a chemist pure substance is a homogeneous material that has a fixed composition and invariable properties.

There are two kinds of substances: Element and compounds. All materials which are not pure substances are necessarily mixtures of two or more elements or compounds or both. Most matter around us consist of mixtures.

SUBSTANCES

- A substance consists of a single type of particles.
- Substances are always homogeneous.
- All the elements and compounds are pure substances because they contain only one kind of particles.
- A pure substance cannot be separated into other kinds of matter by any physical process.
- A pure substance has a fixed composition as well as a fixed boiling point and melting point.

Ex. Hydrogen, Oxygen, Copper, Gold, Silver etc.

Substances can be divided into two types -

(A) Elements **(B) Compounds**

ELEMENTS

- An element is a substance which cannot be split up into two or more simpler substances .
- An element cannot be split up into two (or more) simpler substances because it is made of only one kind of atoms.

Some facts about elements :

(i) The earth's crust is made mainly of two elements i.e. oxygen 46.6 % and silicon 27.7 %.
(ii) First three elements namely oxygen 65%, Carbon 18 % and Hydrogen 10 % account for more than 90 % mass of human body.
(iii) As many as 118 elements are known.
(iv) 92 elements occur in nature and the rest are artificially made. These man-made elements are called synthetic elements.
(v) Majority of the elements are solids.
(vi) Eleven elements are in gaseous state at room temperature .
(vii) Two elements are liquid at room temperature i.e. mercury and bromine.
(viii) Elements gallium and cesium become liquid at room temperature slightly above room temperature (at 30ºC)

Classification of elements

I. On the basis of properties :

(a) Metal **(b) Non-metal** **(c) Metalloid**

Physical Properties	(a) Metals	(b) Non-Metals
State	Metals are solids at room temperature. **Exception :** Mercury (Hg) is a liquid at ordinary temperatures.	The non-metals are either solids or gases at room temperature. **Exception :** Bromine is a liquid at ordinary temperature.
Lustre	Metals are generally lustrous, i.e., they have a shining surface and can be polished, e.g., gold, silver, copper, etc.	Non-metals generally do not have any lustre. e.g., the non-metals sulphur and phosphorus are non-lustrous, i.e., dull. **Exception :** Iodine has a lustrous appearance.
Melting and Boiling Points	Metals have generally high melting points and boiling points, e.g., the melting point of iron is 1535ºC **Exceptions :** Sodium, potassium and gallium have low melting points. Their melting points are less than 100ºC. The melting point of gallium is so low that it occurs in liquid state of temperature greater than 35ºC	Non-metals have low melting pints and boiling points. **Exceptions :** Carbon and silicon, which have high melting points and boiling points.
Density	Metals have high densities, i.e., they are heavy, e.g., the density of mercury is 13.58 gm/cm^3 which is quite high. **Exceptions :** Sodium, potassium, calcium and magnesium are light weight and so light that they can float.	Non-metals have low densities. i.e., they are light substances. For example, the density of sulphur is 2 g/cm^3, which is quite low. **Exception :** The density of diamond (an allotropic form of carbon) is high.
Ductility	Metals are ductile, i.e., they can be drawn into thin wires. Gold and silver are the most ductile metals. Other examples are copper and aluminium which are drawn into wires and the used in elecricity wiring.	Non-metals are non-ductile, i.e., they cannot be drawn into thin wires, e.g., sulphur and phosphorus when stretched do not form wires but break into pieces.
Malleability	Metals are generally malleable, i.e., they can be beaten into thin sheets with a hammer e.g., silver foils are used for decorative purposes on sweets.	Non-metals are non malleable but brittle, i.e., when beaten with a hammer, they break into pieces.
Conduction	Metals are good conductors of heat and electricity. Silver is the best conductor of heat and electricity whereas lead is the poorest conductor of heat. Metals are good conductors of electricity because they contain free electrons to conduct electricity.	Non-metals are generally bad conductors of heat and electricity, e.g., the non-metals like sulphur. Phosphorus, etc, do not conduct heat and electricity. **Exception :** Graphite (an allotroic form of carbon) is a good conductor of electricity.
Hardness	Metals are hard (except sodium and potassium which are soft metals) but not brittle. Sodium and potassium are so soft that they can be cut with a knife.	Non-metals are generally soft except diamond (an allotropic form of carbon) which is the hardest substance known.
Sonority	Metals are said to be sonorous, i.e. they make noise when they are hit.	Non-metals are not sonorous.

Boost your knowledge

- Mercury is the only metal which is liquid at room temperature.
- Aluminium is the most abundant element in the earth's crust.
- Magnesium is present in chlorophyll while iron is the constituent of haemoglobin.

(c) Metalloids :

The elements which show some properties of metals and some other properties of non-metals are called metalloids. Their properties are intermediate between the properties of metals and non-metals. Metalloids are also sometimes called semi-metals.

Ex. Boron (B), Silicon (Si), and Germanium (Ge).

II. On the basis of stability :

(a) Normal elements :

The elements present in groups 1,2,13 to 17, in which all shells except the outermost shell are completely filled are called normal or representative elements. Elements of group 1 and 2 are called alkali metals and alkaline earth metals respectively. Elements present in group 17 are called halogens. The elements of 18^{th} or zero group are called noble gases.

(b) Radioactive elements : The elements subject to spontaneous degeneration of its nucleus accompanied by the emission of α-particles, β-particles or γ-rays are known as radioactively. Radium, Thorium, Uranium are naturally occurring radioactive elements whereas Curium, Americium, Berkelium and Californium are synthetic radioactive elements.

COMPOUNDS

A compound is a substance made up of two or more elements chemically combined in a fixed proportion by mass. A compound is formed as a result of chemical reaction, between the constituent elements. The properties of compound are different from the properties of the elements from which it is formed.

Ex. Water (H_2O) is a compound made up of two elements, hydrogen and oxygen, chemically combined in a fixed proportion of 1 : 8 by mass.

Characteristics of a compound :

(i) In a compound constituents are present in definite proportion by mass.
(ii) The properties of a compound are different from the properties of its constituents.
(iii) The constituents of a compound cannot be separated by simple physical processes.
(iv) Formation of a compound is generally accompanied by change in energy in the form of heat or light.
(v) A compound has a fixed melting point and boiling point.
(vi) A compound is always homogeneous in nature.

Classification of Compounds :

(I) On the basis of properties :

(a) Acids : Compounds which give hydronium ion in aqueous solution for e.g. hydrochloric acid, sulphuric acid, nitric acid, formic acid etc.

(b) Bases : Compounds which give hydroxide ion in aqueous solution for e.g. Sodium hydroxide, Potassium hydroxide

(c) Salts : It is formed by the chemical reaction between acids and bases for e.g. ammonium chloride, zinc sulphate etc.

(II) On the basis of Origin :

(a) Inorganic compounds :

These compounds have been mostly obtained from non-living sources such as rocks and minerals. A few examples of inorganic compounds are : common salt, marble, washing soda, baking soda, carbon dioxide, ammonia, sulphuric acid etc.

(b) Organic compounds :

The word 'organ' relates to different organs of living beings. Therefore, organic compounds are the compounds which are obtained from living beings i.e., plants and animals. It has been found that all the organic compounds contain carbon as their essential constituent. Therefore, the organic compounds are quite often known as **'carbon compounds'.** A few common examples of organic compounds are : methane, ethane, propane (all constituents of cooking gas), alcohol, acetic acid, sugar, proteins, oils, fats etc.

Boost your knowledge

- Number of compounds are not limited like number of elements.

We know that there are only a limited number of elements (about 118). But the number of compounds are unlimited. Actually, a number of options are available for the elements to combine in different ways. In other words, same elements can combine in different ways. This happens when their atoms join together in different proportion and in different arrangements. For example, hydrogen and oxygen combine to give two different compounds. Water and hydrogen peroxide. In water, two atoms of hydrogen unite with one atom of oxygen to form a molecule, in hydrogen peroxide two atoms of hydrogen combine with two atoms of oxygen to form molecule.

$$\underset{\text{Water}(H_2O)}{H-O-H} \quad \underset{\text{Hydrogenperoxide}H_2O_2}{H-O-O-H}$$

The elements carbon and hydrogen combine together to form more than sixty different compounds. For example, methane (CH_4), ethane (C_2H_6), propane (C_3H_8), butane (C_4H_{10}) etc.

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.	An element cannot be split up by physical or chemical method.	A compound can be split up into new substances only by chemical methods.
3.	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.

MIXTURES - IMPURE SUBSTANCE

A mixture is a substance which consists of two or more elements or compounds not chemically combined together. All the solutions are mixtures. The various substances present in a mixture are known as "constituents of the mixture" or "components of the mixture".

e.g. Lemonade (nimbu pani) is a mixture of water, lemon juice, sugar and salt.

A mixture consists of two or more different type of particles having different chemical nature. Mixture may be homogeneous or heterogeneous. A mixture does not have a fixed composition or a fixed melting point and boiling point.

Properties of mixture :

(i) A mixture can be separated into its constituents by physical or chemical processes.
(ii) A mixture shows the properties of all the constituents present in it.
(iii) Formation of mixture may or may not be accompanied with energy change.
(iv) The composition of a mixture is variable, the constituents can be present in any proportion by mass.
(v) A mixture does not have a definite melting point, boiling point.
(vi) A mixture may be homogeneous or heterogeneous.

Types of mixtures :

Based on the composition, mixture are of two types :

(A) Homogeneous mixtures :

Those mixtures in which the substances are uniformly mixed together and are indistinguishable from one another, are called homogeneous mixtures.

All the homogeneous mixtures are called solutions.

Ex. A mixture of sugar in water (called sugar solution) is a homogeneous mixture because all the parts of sugar solution have the same sugar-water composition and appear to be equally sweet. There is no visible boundary of separation between sugar and water particles in a sugar solution.

(B) Heterogeneous mixtures :

Those mixtures in which the components are not mixed uniformly and there is a boundary of separation between them, called heterogeneous mixtures.

Ex. The mixture of sugar and sand is a heterogeneous mixture because different parts of this mixture will have different sugar-sand composition. Some parts of this mixture will have more of sugar particles whereas other parts will have more of sand particles. There is a visible boundary of separation between sugar and sand particles. The suspensions of solids in liquids are also heterogeneous mixtures. A mixture containing two (or more) immiscible liquids is also a heterogeneous mixture.

Differences between mixtures and compounds

	Mixture		Compound
1.	A mixture can be separated into its constituents by physical processes like filtration, evaporation, sublimation, distillation, magnetic separation, etc.	**1.**	A compound cannot be separated into its constituents by physical processes. It can be separated into its constituents by chemical processes only.
2.	A mixture shows the properties of its constituents.	**2.**	The properties of a compound are entirely different from those of its constituents.
3.	Energy (in the form of heat, light, etc.) may or may not be given out or absorbed in the preparation of a mixture.	**3.**	Energy (in the form of heat, light, etc.) is always given out or absorbed during the preparation of a compound.

4.	The composition of a mixture is variable, the constituents can be present in any proportion by mass. A mixture does not have definite formulae.	**4.**	The composition of a compound is fixed, the constituents are present in fixed proportion by mass.
5.	A mixture does not have a fixed melting point, boiling point.	**5.**	A compound has a fixed melting point, boiling point.
6.	A mixture can be homogeneous or heterogeneous.	**6.**	A compound is always homogeneous.

Boost your knowledge

Criteria of purity of compounds

Pure compounds have fixed melting points and fixed boiling points. Therefore, this criteria is used to check the purity of pure solids and liquids. Addition of impurities lower the melting point while elevate the boiling point of a pure substance. For example, pure water boils at 100ºC (373 K) at one atmospheric pressure. However, the boiling points of sea water is higher than 100ºC (373 K) because it is impure and contains a number of dissolved salts.

TRUE SOLUTIONS, SUSPENSIONS AND COLLOIDAL SOLUTIONS TRUE SOLUTION

A homogeneous, transparent mixture of two or more substances is called a true solution or solution.

Solution is wide term and includes the homogeneous mixtures of the substances existing in any physical state.

Components of a solution :

The substances which homogeneously mix up together to form a solution are called the components of the solution.

When two substances form a solution, one substance is said to dissolve into the other. The substance which gets dissolved is commonly known as solute and the medium is which it gets dissolved is termed as solvent or the component of a solution present in excess is referred to as the solvent while the other component present in the smaller amount is called the solute.

For example, a small amount of sugar (solid) on dissolution in excess of water (liquid) forms the solution. Therefore, in case of sugar-water solution, water is solvent while sugar is solute.

Properties of Solution :

(i) The solute particles in a solution cannot be seen by naked eyes or even with microscope. This is because the solute particles present in a solution are very small, smaller than 1 nm [1nm = 10^{-9} metre = 10^{-7} cm = 10 Å = 10^{-3} micron (μ) = 1 mμ] in diameter.

(ii) A solution is a homogeneous transparent mixture, i.e., the solution has the same composition and the same properties throughout its bulk.

(iii) The particles of a solution being very small do not scatter light beam passing through the solution. When a beam of light is passed through a solution, light beam is not visible during its passage through a solution.

(iv) A solution is stable, i.e., the solute particles do not settle down due to gravity on keeping the solution undisturbed even for a long time.

(v) The solute particles present in a solution cannot be separated from the solvent by filtration.

Type of Solutions :

(I) On the basis of physical states of solute and solvent :

Any state of matter (solid, liquid or gas) can act both as a solvent and as a solute during the formation of a solution. Therefore, depending upon the physical states of solute and solvent, true solutions are classified as -

Table : Some common Types of Solutions

S.No.	Types of solution	Solute	Solvent	Examples
1.	Solid-Solid	Solid	Solid	Copper dissolved in gold
2.	Solid-Liquid	Solid	Liquid	Solutions of sugar, salt, urea, glucose etc in water.
3.	Liquid-Liquid	Liquid	Liquid	Solution of alcohol in water, solution of benzene in toluene, petrol, diesel etc.
4.	Gas-Liquid	Gas	Liquid	Aerated drinks
5.	Gas-Gas	Gas	Gas	Air, mixture of gases.

(II) On the basis of amount of solute :

Different amount of a given substance may be dissolved in a given quantity of the solvent. Thus solutions of different concentration of a given substance in a given solvent may be prepared. A particular solution may have less amount of the dissolved solute while the other solution may have more amount of dissolved solute in the solution. So depending upon the quantity of solute present in a given mass of the solvent, solutions are classified into three types :

(a) Unsaturated solution (b) Saturated solution (c) Super saturated solution

(a) Unsaturated solution :

An unsaturated solution contains lesser amount of the dissolved solute, and more solute can be dissolved in it without changing the temperature. An unsaturated solution does not contain the maximum quantity of the solute which can be dissolved in it at a given temperature.

Definition : A solution in which more quantity of the solute can be dissolved without changing the temperature is called unsaturated solution.

(b) Saturated solution :

A solution in which no more solute can be dissolved at a particular temperature is called saturated solution.

Activity :

Saturated solution at room temperature : Take some water in a beaker and dissolve some sugar slowly in it. Go on dissolving sugar in it. At first, sugar keeps on dissolving in water to form the solution. Ultimately, a stage is reached when no more sugar dissolves and some of the sugar settles down and remains undissolved. Such a solution is called saturated solution.

(c) Super saturated solution :

A solution that contains more solute than would be necessary to saturate it at a given temperature.

A super saturated solution is metastable. This means that the solute will go to the bottom of the container and a supersaturated solution becomes saturated again by heating up the solutions.

(III) On the basis of nature of solvent :

(a) Aqueous Solutions : The solutions obtained by dissolving various substances in water are called aqueous solutions.

The common examples are :

(i) Common salt dissolved in water.

(ii) Sugar dissolved in water.

(iii) Acetic acid dissolved in water etc.

(b) Non-Aqueous Solutions : The solutions obtained by dissolving the substances in liquids other than water are called non-aqueous solutions. The common non-aqueous solvents are alcohol, carbon disulphide, carbon tetrachloride, acetone, benzene etc.

Examples of non-aqueous solutions are :

(i) Iodine dissolved in carbon tetrachloride.

(ii) Sulphur dissolved in carbon disulphide.

(iii) Sugar dissolved in alcohol etc.

CONCENTRATION OF SOLUTION

Definition :

Concentration describes the amount of solute present in the given quantity of a solution or a solvent.

A solution obtained by dissolving small amount of the solute in a liquid is called dilute solution and has low concentration of the solute. A solution obtained by dissolving large amount of the solute in a liquid is called concentrated solution and has high concentration of the solute.

Concentration of a solution of a solution can be expressed in many ways.

1. Mass by mass percentage of solution (w/w%) :

Mass percentage is defined as the mass of the solute in grams present in 100 g of the solution.

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

The term w/w means the mass of solute in grams per 100 gram of the solution i.e., mass percentage. A 2 % solution of sugar means 2 grams of sugar are present in 100 grams of solution.

Ex.1 A solution contains 40 grams of common salt in 320 gram of water. Calculate the concentration in terms of mass by mass percentage of the solutions.

Sol. Mass of solute (salt) = 40 g

Mass of solvent (water) = 320 g

Mass of solution = 40 + 320 = 360 g

$$\text{Mass \% of solution} = \frac{\text{Mass of solute} \times 100}{\text{Mass of solution}} = \frac{40 \times 100}{360} = 11.1\ \%$$

Ex.2 Calculate the amount of water required to prepare 1000 g of solution, the percentage of solution by mass is 5 %.

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

$$5 = \frac{\text{Mass of solute} \times 100}{1000}$$

or Mass of solute = 50 g

Mass of solution = Mass of solute + Mass of solvent

$\therefore$ Mass of solvent = Mass of solution – Mass of solute

= 1000 – 50 = 950 g

2. Mass by volume percentage of solution (w/v%) :
It is defined as the mass of solute in gram present in 100 mL of solution.

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

Ex.1 Calculate the m/v % of a solution containing 5 g of glucose in 200 mL of the solution .

Sol. Mass of Solute = 5 g

Volume of Solution = 200mL

Mass/volume % = $\frac{\text{Mass of solute} \times 100}{\text{Volume of solution}}$ = 5 × 100 / 200 = 2.5 %

Ex.2 Calculate the mass of solute to be dissolved in water so that the total volume of the solution is 750 mL and mass by volume percentage is 3.5 %

Sol. $3.5 = \frac{x}{750} \times 100$

$\frac{3.5 \times 75}{100} = x$

$\frac{105}{4} = x = 26.25\,\text{gm}$

3. Volume by volume percentage of solution (v/v%) :
It is defined as the volume of solute in ml present in 100 mL of solution.

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

Ex.1 10 mL of ethanol is mixed with 90 mL of water. What is the volume percentage of ethanol in the solutions ?

Sol. Volume of ethanol = 10 mL

Volume of water = 90 mL

Total volume = 10 + 90 = 100 mL

Concentration by volume percentage = $\frac{\text{Volume of solute} \times 100}{\text{Volume of solution}}$

$$= \frac{10 \times 100}{100} = 10\ \%$$

Ex.2 5 mL methanol, 15 mL ethanol and 20 mL of acetone are mixed with 50 mL of water. What is the volume percent of each solute in the solution ?

Sol. Volume of methanol = 5 mL

Volume of ethanol = 15 mL

Volume of acetone = 20 mL

Volume of water = 50 mL

Total volume of solution = 5 + 15 + 20 + 50 = 90 mL

Volume percent of methanol = $\frac{5 \times 100}{90} = 5.56\ \%$

Volume percent of ethanol = $\frac{15 \times 100}{90} = 16.67\ \%$

Volume percent of acetone = $\frac{20 \times 100}{90} = 22.22\ \%$

SOLUBILITY

Definition :

The maximum amount of the solute (in grams) which can be dissolved in 100 grams of the solvent to form the saturated solution is called solubility of the solute in that solvent and at that temperature.

Ex.1 Solubility of sodium chloride (common salt) in water at 20ºC is 36 g / 100 g. This shows that at the maximum 36 grams of sodium chloride can be dissolved in 100 gram of water at 20ºC.

Ex.2 A maximum of 32 grams of potassium nitrate can be dissolved in 100 grams of water at 20ºC. Therefore, solubility of potassium nitrate in water at 20ºC is 32 g / 100 g.

Effect of Temperature on the solubility of a solid in a liquid :

It is wrong to say that solubility of all the solute in a solvent increases with the increase in temperature. The solubility may increase or decrease with the increase in temperature. It depends on the nature of the solute and solvent.

(1) Solubility of sugar, glucose, sodium chloride, potassium nitrate etc. in water increases with the increases in temperature. When such solutes are dissolved in water, the solution gets cooled. It is because heat energy is absorbed during the formation of such solutions. Heat is taken away from the solution. Therefore, solution gets cooled.

(ii) Solubility of KOH, Lithium carbonate (Li_2CO_3), calcium oxide (CaO), calcium acetate $(CH_3COO)_2Ca$, etc., in water decreases with the increase in temperature. When such solutes are dissolved in water, the solution becomes hot. It is because when such solutes are dissolved in water, heat is released.

Therefore, while giving the solubility of a substance it is important to mention the temperature and the solvent.

Effect of Pressure on the Solubility of Solid in a Liquid :

The solubility of a solid (solute) in a liquid does not change with the change in pressure.

Effect of Temperature and Pressure on the Solubility of a Gas in a Liquid :

The solubility of a gas in a liquid decreases with the increase in temperature. It is because when a solution of the gas in a liquid is heated, some of the gas escapes out. When water is heated, the dissolved gases (O_2, CO_2 etc.) escape out and their solubility decreases.

The solubility of a gas in a liquid increases with the increase in pressure, and decreases with the decrease in pressure.

Ex.1 A maximum of 24 g of potassium nitrate can be dissolved in 75 g of water at 20ºC. Calculate the solubility of potassium nitrate in water at this temperature.

Sol. $\because$ 75 g of water dissolves = 24 g of potassium nitrate.

100 g of water dissolves = $\frac{24 \times 100}{75}$ = 32 g of potassium nitrate

SUSPENSION

Those substances which are insoluble in a liquid form suspensions. If we dissolve powdered chalk or sand in water, they do not dissolve in water, but settle down after sometime. These are the examples of suspensions. Muddy water is a suspension of soil in water. Milk of magnesia is a suspension of magnesium hydroxide in water.

Definition :

A suspension is a heterogeneous mixture in which the solute particles do not dissolve but remain suspended throughout the bulk of the medium and tend to settle down with time.

Boost your knowledge

- True solutions are homogeneous and transparent, they are very stable, they do not scatter the light and pass through the filter paper. True solutions cannot be separated by filtration. Suspensions are heterogeneous mixtures, they are not transparent, they are unstable, they scatter the light and can be separated by filtration.

Properties of Suspension :

Important properties of suspension are given below :

(i) Size of the particles : Size of the particles of suspension is quite large (greater than 100 nm).

(ii) Heterogeneous character : Suspension is a heterogeneous mixture which is not transparent.

(iii) Visibility : The particles of suspension can be seen by the naked eyes.

(iv) Scattering of light : The particles of a freshly prepared suspension scatter a beam of light passing through it and make its path visible.

(v) Stability : When the suspension is left undisturbed, the solute particles settle down showing that a suspension is unstable.

(vi) Filtration : The suspension can be separated by filtration, a residue is left on the filter paper. When the particles of suspension are allowed to settle down, the suspension breaks and the clear solution does not scatter the light any more.

COLLOIDAL SOLUTION

A colloidal solution is a heterogeneous mixture in which the size of the solute particles is intermediate between those in true solutions and those in suspensions.

For Example : Smoke, shoe polish, shaving cream, face cream, milk, cheese, butter, jelly, blood, starch solution, solutions of synthetic detergents etc. are the important examples of colloidal solutions. The physical state of the colloidal solutions may be solid, liquid or gas.

Dispersed phase and dispersion medium :

A colloidal solution contains dispersion medium and dispersed phase.

Dispersion Medium :

The medium in which colloidal particles are dispersed in called dispersion medium. Dispersion medium is always present in larger amount.

Dispersed phase :

The solute-like component or the colloidal particles which are dispersed in a solvent are called dispersed phase. Dispersed phase is always present in smaller amount.

For Example :

- In smoke, air is present in larger amount whereas colloidal particles of carbon are present in smaller amount. Therefore, air is the dispersion medium whereas carbon particles are dispersed phase.
- Milk is a colloidal solution in which liquid fat is dispersed in water. Water is present in larger amount whereas liquid fat is present in smaller amount. Water is the dispersion medium and liquid fat is the dispersed phase.

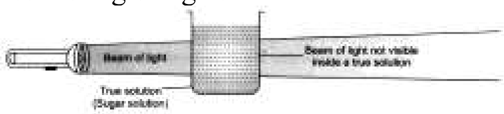
Boost your knowledge

- In gold sol, gold is the dispersed phase and water is the dispersion medium.
- Coloured gem stones, ruby glass etc. are the colloidal solutions in solid form.

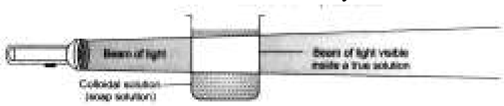
Properties of colloidal solutions :

Important properties of colloidal solutions are given below :

1. **Heterogeneous character :** The particles of colloids are uniformly spread throughout the solution, the mixture appears to be homogeneous. It is due to the relatively smaller size of colloidal particles. But actually, a colloidal solution is a heterogenous mixture.
2. **Size of the colloidal particles :** The size of the dispersed phase ranges from 1 nm to 100 nm in a colloidal solution.
3. **Visibility :** Because of the small size of colloidal particles, we cannot see them by naked eyes. It is difficult to see the colloidal particles even with a microscope.
4. **Tyndall effect :** When a beam of light is passed in a solution of sodium chloride or sugar, the path of light is not visible inside the true solution. But if a beam of light is passed in a colloidal solution of milk or starch, the path of light becomes visible inside the colloidal solution. It is called Tyndall effect. Tyndall effect is due to the scattering of light.



The particles in a true solution do not scatter light.
True solution does not show Tyndall effect.



The particles in colloidal solution scatter light
Colloidal solution shows Tyndall effect

Definition:

Scattering of light by colloidal solutions is called Tyndall effect.

Colloidal particles scatter the beam of light passing through it. Colloidal particles cannot not reflect the light due to their small size. But the size of colloidal particles is fairly large to scatter the light and make the path visible. The phenomenon of scattering of light by colloidal particles is called Tyndall effect. Tyndall effect can be observed when a beam of light enters a room through a small hole. This happens due to the scattering of light by the particles of dust and smoke present in air. Tyndall effect can also be observed when sunlight passes through the canopy of a dense forest. Mist is a colloidal solution in which gas is the dispersion medium and water is the dispersed phase. Tyndall effect observed is due to the scattering of light by the droplets of water present as dispersed phase in mist.

5. **Filtration :** If the colloidal solution is left undisturbed for sometime, it does not settle down. This shows that colloidal solutions are quite stable. But if colloidal solution is left for a long time, the solute particles may settle down.
   It is important to know that though colloidal solutions cannot be separated by filtration but colloidal particles (dispersed phase) can be separated from the colloidal solution by special methods such as heating, cooling, centrifugation etc.

Classification of Colloids :

Colloids are classified on the basis of the physical state of the dispersion medium and dispersed phase. Dispersion medium and dispersed phase may be solid, liquid or gas. Both dispersion medium and dispersed phase cannot be gas because all non-reacting gases mix together and form homogeneous solution whereas colloidal solutions are heterogeneous mixtures. There are 8 types of colloidal systems.

Common Examples of Colloids

Type	Dispersed phase	Dispersion Medium	Examples
Aerosol	Liquid	Gas	Fog, clouds, mist
Aerosol	Solid	Gas	Smoke, automobile exhaust, dust storm, volcanic dust
Foam	Gas	Liquid	Froth, air bubble, soap lather, lemonade
Emulsion	Liquid	Liquid	Milk, face cream, nail polish, shampoo, oil in water, water in oil.
Sol	Solid	Liquid	Milk of magnesia, muddy water, aqueous solution of starch, proteins albumin etc.
Solid foam	Gas	Solid	Foam, rubber, sponge, pumice stone
Gel	Liquid	Solid	Jelly, cheese, butter
Solid Sol	Solid	Solid	Coloured gemstone, milky glass, rock salts, marble.

Differences between the true solutions, colloidal solutions and suspensions :

S.No.	Name of the property	True solution	Colloidal solution	Suspension
1.	Nature	Homogeneous	Heterogeneous	Heterogeneous
2.	Size of particles	The solute particle in true solutions are molecules having diameter less than 1 nm.	The particle size in colloidal solution lies in the range 1nm to 100 nm.	The size of the particles in the case of suspension is greater than 100 nm.
3.	Visibility or Appearance	The solute particles are invisible to the naked eye as well as under the most powerful microscope.	The solute particles are invisible to the naked eye but their scattering effect can be viewed with the help of a microscope.	The solute particles are visible even to the naked eye or can be seen with the help of a microscope.
4.	Sedimentation	The solute particles in the true solution do not settle.	The solute particles in the colloidal solution can be made to settle by centrifugation.	The solute particles in the suspension settle under gravity.
5.	Filtrability	The solute particles in the true solution diffuse rapidly, pass through a parchment membrance as well as filter paper.	The solute particles in the colloidal solution do not pass through a parchment membrane, but pass through a filter paper.	The solute particles in the suspension cannot pass through a parchment membrane or a filter paper.
6.	Diffusion	Diffuse rapidly	Diffuse slowly	Do not diffuse
7.	Tyndall effect	True solution does not show tyndall effect.	Colloidal solution shows tyndall effect.	Suspension may or may not show tyndall effect.
8.	Brownian movement	True solution does not show Brownian movement.	Colloidal solution shows Brownian movement.	Suspension may show Brownian movement.

Common Techniques involved for the separation of components of mixtures

MIXTURES

↓

Separation Technique

(A) Separation of Solid-solid Mixture
- i. Magnetic separation
- ii. Solvent extraction
- iii. By Sublimation
- iv. By crystallisation

(B) Separation of Solid-liquid Mixture
- i. Filtration
- ii. Centrifugation
- iii. Sedimentation
- iv. Evaporation
- v. Distillation
- vi. Chromatography

(C) Separation of Liquid-liquid Mixture
- i. Separating funnel
- ii. Fractional distillation

(D) Separation of Gas-gas Mixture
- i. Diffusion
- ii. By dissolution in a solvent

(E) Separation of Liquid-gas Mixture

(A) Separation of Solid-Solid Mixtures :

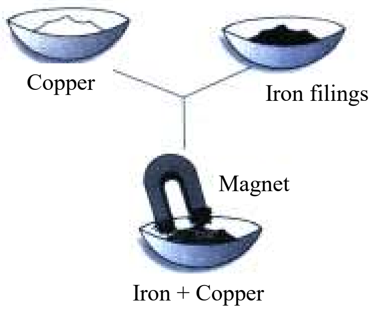
1. Magnetic separation method :

Principle : This method is based on the fact that one of the components of a solid-solid mixture is magnetic while the other is non-magnetic nature.

Experiment : Separation of a mixture of iron fillings and copper turnings.

Method : A solid-solid mixture of iron fillings and copper turning can be separated by this technique because iron is magnetic in nature, whereas copper is non-magnetic in nature.

The given mixture is spreaded in a dish. Now run one end of a strong bar magnet or horse shoe magnet through it. On lifting the magnet, some iron fillings get attracted to this end. Remove them by hand and collect them in a dish. On repeating the process several times, all the iron filings are picked up and collected in the dish. Copper turnings are left behind in the dish.



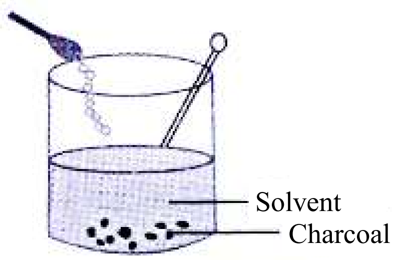
2. By the Use of a suitable Solvent (Solvent Extraction Method) :

Principle : The method is based on the fact that one of the solid components is soluble in particular solvent while the other is insoluble in it.

Experiment: Separation of a mixture of charcoal and sulphur.

Method : A mixture of charcoal and sulhur can be easily separated by using carbon disulphide as the solvent. Sulphur is soluble in carbon disulphide, whereas charcoal is insoluble in it.

The given mixture is added into carbon disulphide taken in beaker and stirred thoroughly with the help of a glass rod. Sulphur being soluble dissolves in carbon disulphide (CS_2) whereas charcoal remains unaffected. The contents are filtered using a filter paper. Charcoal particles are left on the filter paper and are collected separately. Now the filtrate is heated slowly to evaporate CS_2 leaving behind solid sulphur in the dish.



Solvent extraction

Fig. : Separation of sulphur-charcoal mixture by solvent extraction.

Table : Substances and the solvent they dissolve in

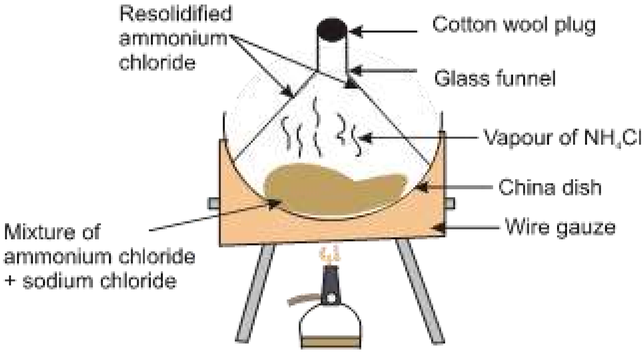
S.No.	Substance	Solvent
1.	Sulphur	Carbon disulphide
2.	Iodine	Ethyl alcohol
3.	Paraffin wax	Terpentine oil
4.	Rubber	Benzene

3. Sublimation Method :

Principle : The method is based on the fact that a solid substance passes directly into its gaseous state. The gaseous state so formed during sublimation is cooled to pass in the solid state without passing through the liquid state. The separation of a solid-solid mixture on the basis of sublimation can be carried out only when one component shows sublimation while the other not.

Experiment : Separation of a mixture of common salt and ammonium chloride.

Method : Such mixture is taken in a porcelain dish covered with a perforated filter paper. An inverted funnel is placed on the filter paper. The stem of the funnel is plugged with cotton wool to prevent the escape of the vapours .On heating the dish for sometime over a sand bath, ammonium chloride sublimes and the vapours thus formed pass through the holes in the filter paper and get deposited on the inner walls of the funnel. Sodium chloride is left behind in the dish. Ammonium chloride is scraped from the funnel and sodium chloride is left in the dish.



Some substances capable of showing sublimation are : Camphor, Naphthalene. Benzoic acid, Ammonium chloride, Iodine, Solid carbon dioxide (dry ice) etc.

4. By Crystallisation :

The process of cooling a hot and concentrated solution to obtain the crystals of a non-volatile solid is called crystallization.

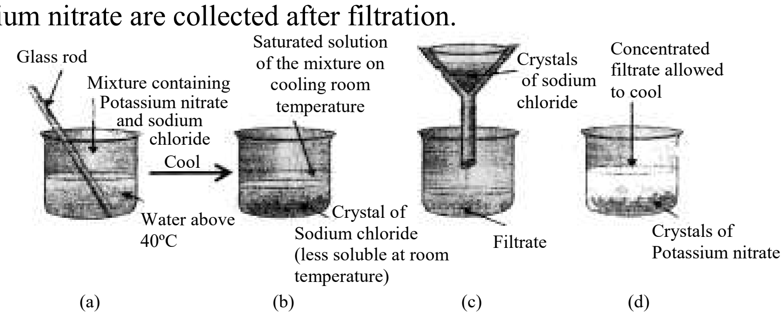
Principle : This method is based upon the difference in the solubilities of the two components of a solid-solid mixture in a particular solvent and can be used when the two components are soluble in the same solvent but their solubilities differ widely.

Experiment : Separation of the components of a mixture of potassium nitrate and sodium chloride (common salt).

Method : A mixture of potassium nitrate and sodium chloride can be separated by fractional crystallization because sodium chloride is much less soluble as compared to potassium nitrate in water.

A beaker with sufficient water is heated to a temperature about 40ºC. The given mixture is added in water and stirred well with a glass rod. The addition of the mixture is continued with stirring till no more of the mixture dissolves to have saturated solution of both salts. This hot saturated solution is filtered in another beaker and allowed to cool to room temperature.

Sodium chloride being less soluble crystallizes out first. The crystals of sodium chloride are filtered out and separated. The process of heating and cooling is repeated two or three times in order to ensure complete crystallization of sodium chloride. When the crystallization of sodium chloride is complete, the filtrate is further concentrated by boiling and then allowed to cool. Now potassium nitrate is crystallized out. The crystals of potassium nitrate are collected after filtration.



Separation of potassium nitrate and sodium chloride mixture by crystallisation

The other solid-solid mixtures such as potassium chloride (less soluble in water) + sodium nitrate (more soluble in water), sodium chloride (less soluble in water) + sodium nitrate (more soluble in water), potassium chlorate (less soluble in water) + potassium nitrate (more soluble in water) etc. can be separated by this technique.

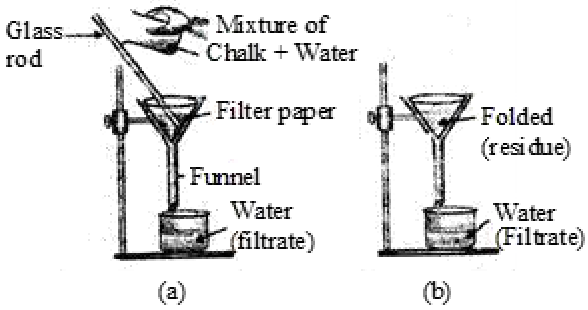
(B) Separation of Solid-Liquid Mixtures

1. By Simple Filtration :

Principle : The process of separating a mixture containing an insoluble solid component and a liquid component by passing it through a filter paper or some other porous medium is called filtration. This method is applicable to those heterogeneous mixtures in which solid component is insoluble in the liquid component.

Experiment : Separation of a mixture of chalk and water.

Method : A mixture of chalk and water can be separated by filtration because chalk is insoluble in water. A circular filter paper, folded first into two halves and then into four quarters and finally in the shape of a cone (as shown) is placed in a funnel. Now the given mixture is poured slowly on the filter paper cone, fitted in the funnel, with the help of a glass rod. The liquid passes through the filter paper and the filtrate is collected in a beaker. The insoluble solid is retained on the filter paper as residue. The filter paper cone is removed from the funnel and on unfolding it, the solid component is collected from it.



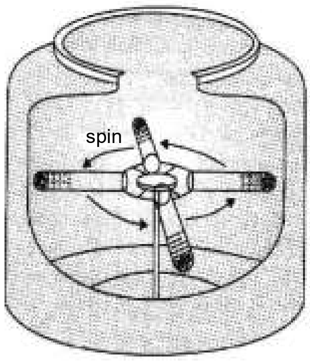
Separation of chalk-water mixture by filtration

Sand + water, silver chloride + water, barium sulphate + water, lead sulphate + water etc. can be separated by this technique.

2. By centrifugation :

Principle : If the solid particles present in a liquid are very small, the filtration technique cannot be used because the solid particles being very small pass through the filter paper. In such cases centrifugation is used.

In centrifugation, the mixture is rotated or spun at a very high speed in a centrifugal machine. As the mixture is rotated in the machine, the lighter particles get collected at the top while the denser particles are pushed towards the bottom. Thus, the two components get separated.



Experiment : Preparation of skimmed milk (an emulsion of little fat in water and other edible materials). Fat particles are in the dispersed form and cannot be separated by filtration. However, they can be separated by centrifugation.

Method : The full fat milk is taken in a closed container in a large centrifugal machine. Switching on the machine, rotates (spins) the milk at a very high speed in the container. On account of the rotatory motion, the fat being lighter gets collected at the top on the cream, in the container whereas the lower layer contains the 'skimmed milk. The machine is switched off and the upper layer consisting of cream is collected. The lower layer gives skimmed milk.

Application : -

(i) This technique is used in milk dairies to separate cream from milk .

(ii) This technique is also used in diagnostic laboratories to test urine and blood samples.

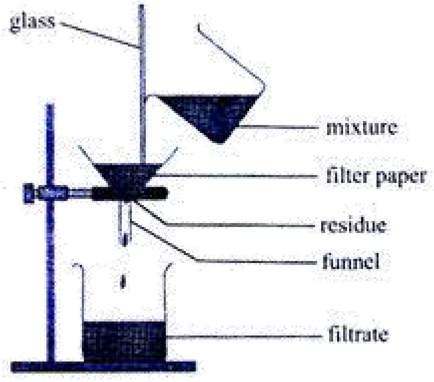
(iii) This technique is used in drying machines to squeeze out water from the clothes.

3. By Sedimentation and Decantation

Principle : Sedimentation is the process of allowing the insoluble solid component of a solid liquid mixture to settle down at the bottom of the container.

Boost your knowledge
The solid component settled down is called sediment.
Decantation is the process of pouring off the upper layer of clear liquid without disturbing the sediment.

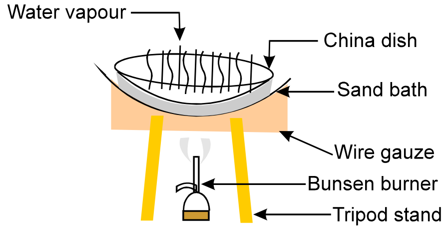
Experiment : Separation of a mixture of sand and water.
Method : Sand being insoluble in water settles down. Thus, a mixture of sand and water can be separated by sedimentation and decantation.
The given mixture is taken in a beaker and allowed to stand undisturbed for long time. After a few hours, all the sand particles are settled at the bottom of the beaker in the form of sediment and clear water (supernatant liquid) collects over it.
Now the entire supernatant liquid i.e. water is transferred to an other beaker with the help of a glass rod. Sand particles are left behind in the first beaker.



Filtration

4. By Evaporation :

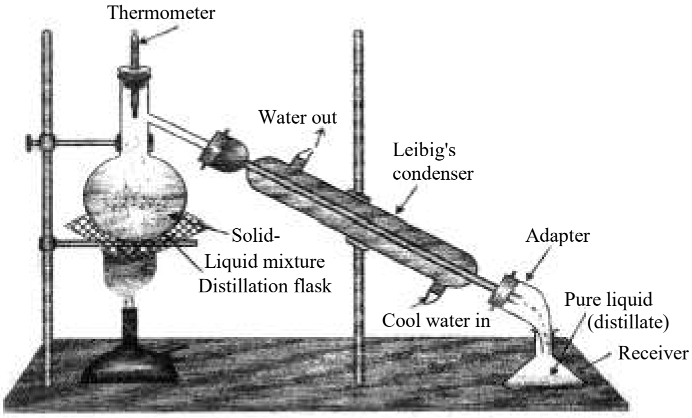
Principle : This method is used for those solid - liquid mixtures in which the solid component is non-volatile and soluble in the liquid component while the liquid component can easily be evaporated.
Experiment : Separation of common salt from a mixture of common salt and water.
Method : The mixture of common salt and water is taken in an evaporating dish and heated gently on a sand bath) till the solvent is almost entirely evaporated. When the contents of the dish become almost dry, reduce the flame to avoid the sprouting out of the solid particles left on the dish. Put off the burner when the residue becomes completely dry. The residue collected from the dish contains common salt.



Salt from sea water, sulphur from a mixture of sulphur and carbon disulphide, sodium sulphate from a mixture of sodium sulphate and water, non-volatile dye from a volatile solvent present in blue/black ink etc. can be separated by using this method.

5. By Distillation

Principle : The process involving the conversion of a liquid into vapours by heating and subsequent condensation of the vapours back into the liquid is called distillation. Liquid organic compounds contaminated with non volatile impurities are purified by simple distillation.
Experiment : Separation of an organic compound associated with nonvolatile impurities.
Method : Distillation is carried out in a distillation assembly shown in figure. The solution of a solid in liquid is taken in a distillation flask having a side tube connected to a Liebig condenser, in which water is continuously circulated in the outer jacket to cool the vapours present in the inner tube. The mouth of the flask is closed with a cork having a thermometer. A suitable vessel is attached to the lower end of the condenser through an adapter. The distillation flask is carefully heated. The vapour formed are condensed in liquid by the water circulating in the outer jacket and are collected in the receiver. This is called distillate. The solid component is left behind in the distillation flask. Thus, both the components get separated.



Separation of a solid-liquid mixture by distillation

Separation of the components of sodium chloride-water mixture, potassium chloride water mixture, etc, can be done by this method.

6. **Paper Chromatography:**

Paper chromatography was introduced by Schonbein (1865).

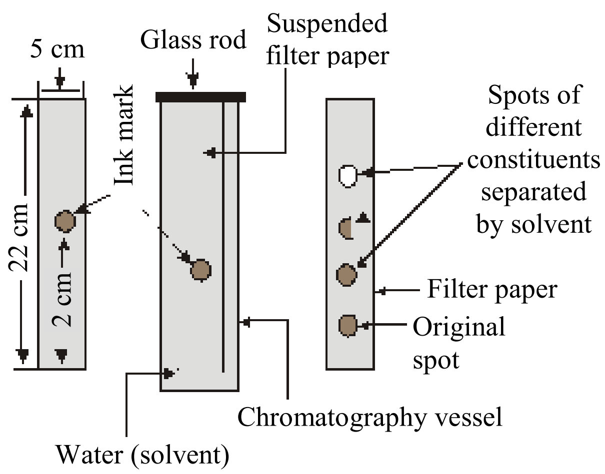
Principle :

Chromatography involves two phenomena i.e. adsorption and partition (or distribution). The basis of separation is the difference in the rates of adsorption of the components on the solid stationary phase as well as on the difference in the extent of partition or distribution of the components of a mixture in case the stationary phase in liquid.

In paper chromatography, a strip of a specially designed filter paper acts as the stationary phase, whereas a pure solvent or a mixture of solvents is used as the moving phase. The moving phase is termed as developed solvent. The moving phase travels through the filter paper on account of capillary action.

Method : Take a filter paper 22 cm long, 5 cm broad and stick its smaller end to a glass rod with the help of gum. On the other end, measure a distance of 2 cm from lower end and mark a small point. On this point pour one or two drop of the ink.

Suspend this filter paper in a wide and tall cylinder as shown in Figure. Gradually, pour water into the cylinder till the lower end of filter paper slightly dips in the water. Cover the cylinder with a glass lid to prevent any evaporation and leave the apparatus undisturbed for an hour. The water rises up the filter paper and reaches the ink mark. This water then dissolves various constituents of the ink, gets adsorbed by the filter paper in different amounts. More the constituent gets adsorbed, the lesser it moves upward and vice versa.



Applications :

(i) It is used to separate colours from dye

(ii) It is used in the separation of amine acids.

(iii) It is used in the separation of sugar from urine.

(iv) It is used in the separation of drugs from the samples of blood.

(C) Separation of Liquid-Liquid Mixtures :

1. By the use of a Separating Funnel :

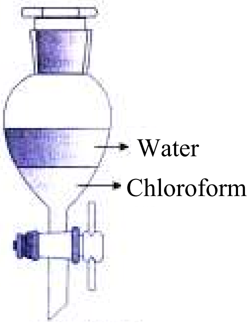
Principle : This method involves the use of the difference in the densities of the two liquid components of a immiscible liquid-liquid mixture.

Experiment : Separation of the components of chloroform and water mixture.

Method : Chloroform and water are immiscible as well as chloroform is heavier than water. The two can therefore be separated by the use of a separating funnel.

Close the outlet stop cock of a separating funnel clamped vertically and pour the given mixture of chloroform and water into it. Allow the funnel to stand for sometime till two distinct layers are formed. Now, the stop cock is opened slowly. the bottom layer containing heavier liquid, i.e., chloroform falls down and is collected in a beaker. When the entire bottom layer has dropped down, the stop cock is closed.

Now, similarly the upper layer containing the lighter liquid, i.e., water is collected in another beaker.



Separating funnel

This method is used to separate mixtures like carbon tetrachloride + water, benzene + water, petrol + water, mercury + water or any other mixture of the immiscible liquids.

Applications :

(i) This method is used for separating any two immiscible liquids.

(ii) This method is used in separation of slag (a waste material) from the molten metals during their extraction. For example, during the extraction of iron from its ore, the molten iron and slag collect at the base of blast furnace. The slag being less dense floats up the surface of molten iron. They are drained out from two different outlets.

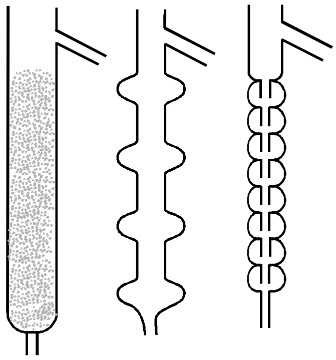
2. By Fractional Distillation :

The process of separation of different fractions one by one by boiling at different temperatures of a miscible liquid-liquid mixture by distillation is called fractional distillation. The miscible liquid organic compounds contaminated with volatile impurities are purified by fractional distillation.

Principle : Fractional distillation is based on the difference in the boiling points (less than 25 units) of the components of the liquid-liquid mixture to be separated.

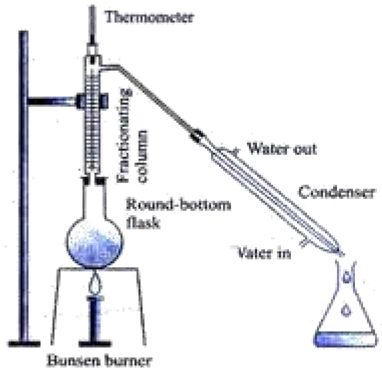
If the boiling points of the two miscible components of a liquid-liquid mixture differ by more than 25 unit, the two components can be separated by simple distillation technique. However, when the difference in the boiling points of the two components is not much (less than 25 units) the fractional distillation is carried out for their separation with fractionating column.

Method : Fractional distillation carried out using fractionating column. Fractionating columns are of various types depending upon the need of distillation.



Different types of fractionating columns

The apparatus used in fractional distillation is shown in figure. It consists of a distillation flask a fractionating column, attached to a Liebig condenser receiver through an adapter. Water is continuously circulated in the outer jacket of the condenser in order to get the vapours condensed. The liquid mixture to be separated is taken in the distillation flask and the flask is heated. Vapours rich in low boiling point component is formed and passed from the bottom to the top of the column. As it rises up the column, the temperature falls and vapours get condensed and the liquid thus formed starts coming down the column. As the heating is continued, fresh vapours enter the column and boil the liquid already condensed giving vapours which condense higher up in the column. The condensed liquid is further boiled by the incoming fresh vapours. Thus, the processes of evaporation and condensation occur automatically several times inside the column. Finally, the vapours of the low boiling point component come in the condenser. Due to cooled condenser, vapours get condensed and fall in the receiver. The more volatile liquid is thus collected in the receiver. The component having higher boiling point is left in the distillation flask as the residue. It is recovered by further heating.



Fractional distillation

Table: Some Miscible Liquid – Liquid Mixtures separated by fractional distillation.

Miscible Liquid-Liquid solution A + B	Boiling Points		Low Boiling component collected as distillate	High Boiling Component left as Residue
	A	B		
Ethyl alcohol + Acetone	78ºC	56ºC	Acetone	Ethyl alcohol
Methyl alcohol + Acetone	64ºC	56ºC	Acetone	Methyl alcohol

Applications :

(i) Fractional distillation is used for the separation of different gases from air.

(ii) Fractional distillation is used to obtain useful products from petroleum. The different products obtained are petrol, diesel, kerosene etc.

(D) Separation of Gas-Gas Mixtures

1. By Diffusion :

Principle : A lighter gas diffuses more rapidly as compared to a heavier gas. This is the basis of separation of a gas-gas mixture by diffusion.

Experiment : Separation of SO_2 and H_2.

Method : The gaseous mixture of SO_2 and H_2 is passed through a porous diaphragm. H_2 being lighter diffuses more rapidly. Therefore, the mixture coming out of the partition is richer in the H_2 gas. The mixture is again passed through the partition when the outcoming mixture becomes further richer in the H_2. The process is repeated several times till the pure components are obtained.

2. By Dissolution in a Solvent :

Principle : This method is based on the fact that one gaseous component of mixture is soluble in a particular solvent while the other is insoluble.

Experiment : Separation of CO_2 and CO from a mixture.

Method : A suitable solvent in which either of the two gases is soluble is selected, say limewater in which CO_2 is absorbed. The limewater is taken in a Wolf's bottle and the gaseous mixture is bubbled through it. Carbon dioxide (CO_2) being soluble in limewater is retained in Wolf bottle whereas carbon monoxide (CO) comes out through a delivery tube and collected in gas jar. Carbon dioxide is recovered back by heating the wolf bottle solution with dil. HCl.

3. By Liquefaction

Principle : This method is based on the different value of critical temperature of the components (responsible for liquefaction) of a gaseous mixture.

> **Boost your knowledge**
> - The critical temperature of a substance is the temperature at and above which vapor of the substance cannot be liquefied, no matter how much pressure is applied. Every substance has a critical temperature.
> - In water, the critical point occurs at around 647 K (374 °C; 705 °F) and 22.064 MPa (3200 PSIA or 218 atm)

Higher is the critical temperature of gas more easily is liquefies.

Experiment : Separation of carbon dioxide (CO_2) and methane (CH_4).

Method : The gas mixture is cooled in freezing mixture of ice containing sodium chloride (at –22ºC) where CO_2 (critical temperature 31.2ºC) is liquefied leaving methane (critical temperature – 82.3ºC) in gaseous form.

SEPARATION OF COMPONENTS OF AIR

Air is a homogeneous mixture of several gases mainly nitrogen, oxygen and argon. Air contains nitrogen (78.1 % by volume), oxygen (20.9% by volume) and argon (0.9 % by volume). They can be separated by liquefaction followed by fractional distillation of liquefied air.

The flow chart of the separation of air is shown in figure.

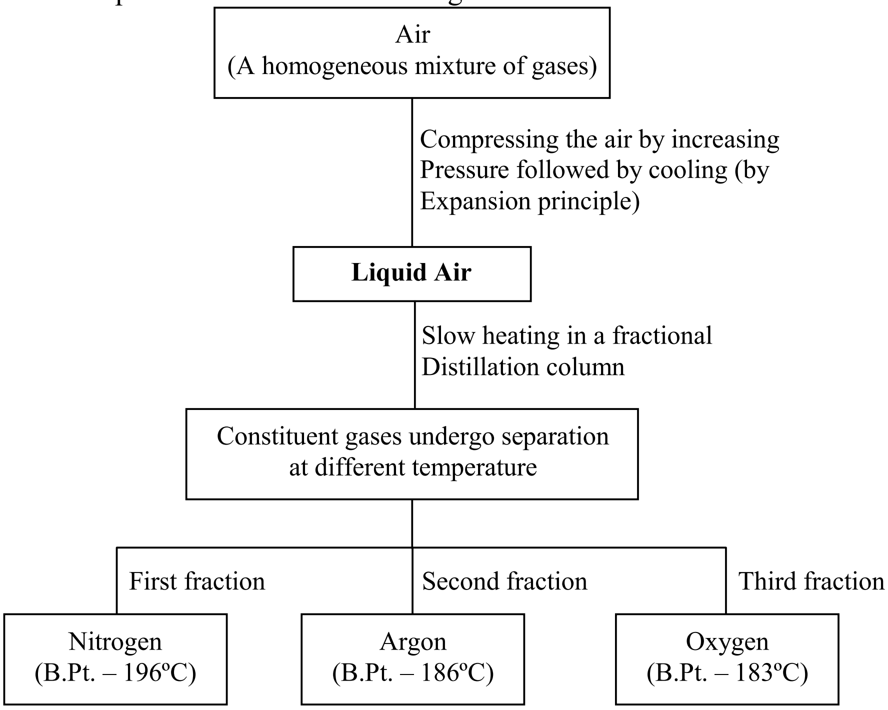
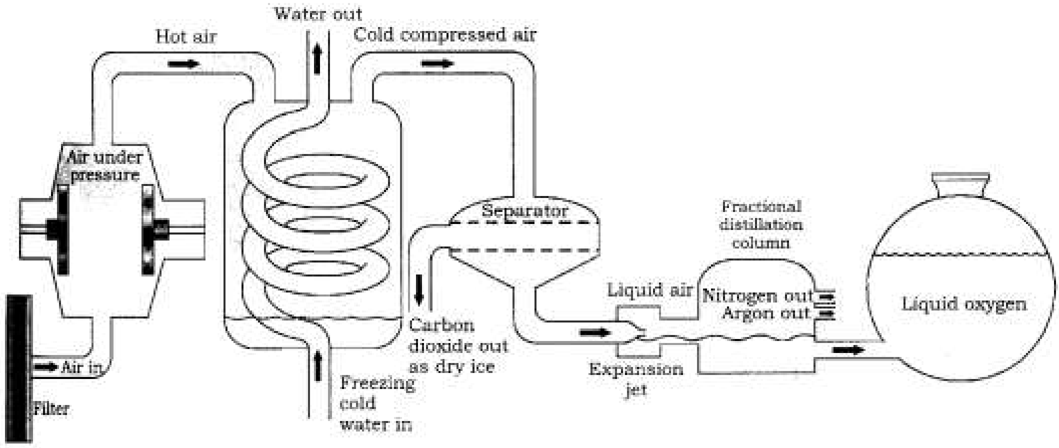


Fig. : Separation of the constituents of air

Nitrogen has the lowest boiling point and boils first and comes out as the first fraction. Second fraction is of argon, distilled after N_2 at – 186ºC. Oxygen having the highest boiling point boils at the end and is collected as third fraction.



Applications :

(i) Large amount of oxygen is required for coal gasification projects; cryogenic plants producing 3000 tons/day are found in some projects.

(ii) In steelmaking oxygen is required for the basic oxygen steelmaking.

(iii) Large amounts of nitrogen with low oxygen impurities are used for inserting storage tanks of ships and tanks for petroleum products, or for protecting edible oil products from oxidation.

(E) Separation of Liquid-Gas Mixtures

Principle : The method is based on the fact that solubility of a gas in liquid decreases with rise in temperature.

Experiment : Separation of carbon dioxide + water from aerated water.

Method : The liquid – gas mixture say CO_2 + H_2O is heated in a container fitted with a delivery tube. On heating, the gas dissolved in the liquid escapes out from the solution and is collected through the delivery tube. The liquid is left in the container.

PHYSICAL AND CHEMICAL CHANGES

Whenever matter is subjected to changes in conditions like temperature, pressure etc, it tends to undergo changes its physical and / or chemical properties.

On the basis of whether new substances are formed or not we can classify all the changes into two groups.

Physical change :

Definition : A change which alters some specific physical property of the matter, like its state, texture, magnetic or electrical conditions or its colour, without causing any change in the composition of its molecules, is called physical change, provided it gets reversed, if the cause producing the change is removed.

Characteristics of Physical Change :

(i) No new or different product is formed : The composition of molecules of the substance remains unaltered.

Ex. Ice melts to form water. In this example only the appearance (state) of matter has changed from solid to liquid. However, the composition of the molecules of ice or water remains same, i.e., for every 1 g of hydrogen there is 8 g of oxygen required . Thus, only a physical change has occurred.

(ii) The change is temporary and reversible : It means the change can be reversed by altering the causes which produce the change.

Ex. The water formed from ice can be changed back to ice by placing it in a freezing mixture (a mixture of ice and common salt).

Note : On altering the experimental conditions, the change which gets reversed, is a physical change.

(iii) There is no net gain or loss of energy : The amount of energy required to bring about a physical change is generally equal to the amount of energy required to reverse the change. Thus, there is no net energy change involved.

Ex. If 1 g of water at 100º C on changing into steam at 100ºC needs 2260 J of heat energy, then 1 g of steam at 100º C on changing into water at 100º C, gives out 2260 J of heat energy. Thus, the net energy change is zero.

(iv) There is no change in the weight of substance : During a physical change it is only the energy which is added or removed. No matter is added during a physical change. Similarly, no matter is removed during a physical change. Therefore, mass of the substance remains same.

Some Common Examples of Physical Changes :

- Formation of dew.
- Evaporation of water.
- Crystallisation of sugar from its solution.
- Ringing of an electric bell.
- Breaking of a glass pane.
- Freezing of ice cream.
- A rock rolling down a hill.
- Bending of a glass tube by heating.
- Melting of wax.
- Sublimation of camphor.

Chemical Change :

Definition : A change which alters the specific properties of a material by bringing about a change in its molecular composition, followed by a change in state, is called a chemical change.

Characteristics of chemical change :

(i) A chemical change results in the formation of one or more new products : The products formed have different properties than the original substance. Thus, the composition of the molecules of products is different from the original substance.

Ex. Heating of sugar

When sugar is gently heated in a test tube, it melts. It gradually changes to brown colour, giving a large amount of steamy fumes. In the end a black mass is left which consists of carbon. Thus, new substances, viz. carbon and water (steam), are formed. In this change, the arrangement between the molecules of carbon, hydrogen and oxygen breaks. The hydrogen and oxygen atoms separate from carbon atoms and join together to form water. The carbon atoms are set free and are left as black residue.

$$\text{Sugar} \xrightarrow{\text{heat}} \text{Carbon} + \text{Steam}$$

(ii) The weight of the substance undergoing chemical change usually changes :

Ex. During the heating of sugar, the weight of the black residue is far less than the actual weight of the sugar. However, this is an apparent change in weight. If we take the weight of steam into account and add to it the weight of carbon, then total weight will be equal to the weight of sugar crystals. Thus, strictly speaking, total weight of substances taking part in a chemical change remains constant.

(iii) The chemical change is permanent and irreversible : It means the change will not reverse by altering the experimental conditions.

Ex. The sugar, which has decomposed on heating to form carbon and steam will not change to sugar on cooling.

(iv) During chemical change energy is either absorbed or given out : The various atoms in a chemical compound are joined by attractive forces commonly called bonds. The making or breaking of the bonds always requires exchange of energy. Thus, some amount of heat is either absorbed or given out during a chemical change.

Some Common Examples of Chemical Changes :

- Burning of wood or charcoal
- Burning of candle
- Digestion of food
- Curdling of milk
- Formation of biogas (Gobar gas)
- Burning of petrol or diesel
- Smoking of cigarette
- Drying of paint
- Rusting of iron
- Ripening of fruit
- Clotting of blood
- Fading of the colour of a dyed cloth
- Baking of cake
- Photosynthesis
- Formation of wine
- Butter turning rancid
- Electrolysis of water into hydrogen and oxygen
- Formation of water from hydrogen and oxygen

Differences between physical and chemical changes

	Physical change		Chemical change
1.	No new substance is formed in a physical change	**1.**	A new substance is formed in a chemical change
2.	A physical change is a temporary change.	**2.**	A chemical change is a permanent change
3.	A physical change is easily reversible.	**3.**	A chemical change is usually irreversible.
4.	Very little heat (or light) energy is usually absorbed or given out in a physical change	**4.**	A lot of heat (or light) energy is absorbed or given out in a chemical change
5.	The mass of a substance does not alter in a physical change.	**5.**	The mass of a substance does alter in a chemical change.