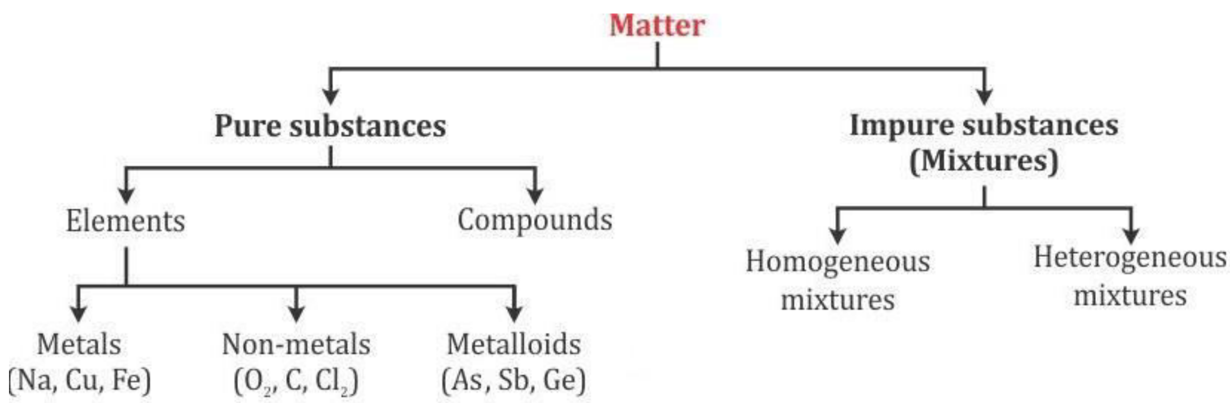
CHEMISTRY

Is Matter Around Us Pure



Pure Substance

- A pure substance is a homogeneous material with definite, invariable chemical composition and physical and chemical properties.
- A pure substance consists of only one type of atoms or molecules.
- On the basis of their chemical composition, pure substances are classified into elements and compounds.

Impure Substance

- Impure substances are mixtures of two or more elements, compounds or both, and they generally have different compositions and properties in their different parts.

What is a Mixture?

- A mixture contains more than one substance mixed in any random proportion.
  For example: milk, soil, lemon juice etc.
- Mixtures are constituted by more than one kind of pure form of matter known as a substance.
- A substance cannot be separated into other kinds of matter by any physical process.
  Example: Dissolved sodium chloride can be separated from water by the physical process of evaporation. However sodium chloride itself is a substance and cannot be separated by physical processes into its chemical constituents.

Properties of a Mixture

- In a mixture, two or more elements or compounds are not chemically combined together.
- The constituents of a mixture retain their original properties.
- The constituents of a mixture can be separated by using a physical process such as hand picking, filtration, holding a magnet etc.

Types of Mixtures

Homogeneous mixture

A mixture which has uniform composition and properties throughout its mass is called a homogeneous mixture.

Example: All **solutions** such as sugar solution, salt solution etc.

Heterogeneous mixture

A mixture which has a different composition and properties in different parts of their mass is called a heterogeneous mixture.

Example: Suspension (sand mixed with salt, sugar in oil) and colloids (milk in water).

Solution

- A homogeneous mixture of two or more substances which are chemically non-reacting, whose composition can be varied within certain limits, is called a solution.

Solution = Solute + Solvent

- Solute: A substance which gets dissolved in a solvent is called a solute.
- Solvent: A substance in which a solute gets dissolved is called a solvent.

Concentration of a Solution

- The properties of a solution depend upon the nature of the solute and the solvent, and also on the proportion of the dissolved solute.
- A solution which has a high quantity of solute is said to be a concentrated solution, and a solution which has comparatively lesser quantity of solute is said to be a dilute solution.
- The concentration of a solution is the amount of solute present in a given amount (mass or volume) of solution or the amount of solute dissolved in a given mass or volume of solvent.

$$\text{Concentration of Solution} = \frac{\text{Amount of Solute}}{\text{Amount of Solution}}$$

Or

$$\text{Concentration of Solution} = \frac{\text{Amount of Solute}}{\text{Amount of Solvent}}$$

Methods of Expressing the Concentration of a Solution

$$\text{Mass by Mass percentage of a Solution} = \frac{\text{Mass of Solute}}{\text{Mass of Solution}} \times 100$$

$$\text{Mass by Volume percentage of a Solution} = \frac{\text{Mass of Solute}}{\text{Volume of Solution}} \times 100$$

Saturated Solution

A solution, in which more solute cannot be dissolved at that temperature, is called a saturated solution.

Unsaturated Solution

A solution, in which more quantity of solute can be dissolved without raising its temperature, is called an unsaturated solution.

Solubility

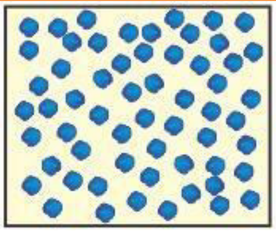
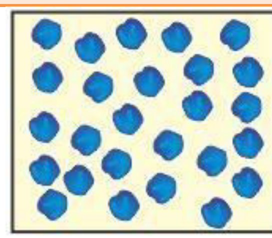
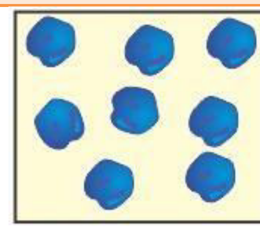
The maximum amount of a solute which can be dissolved in 100 grams of a solvent at a specified temperature is known as the solubility of that solute in that solvent at that temperature.

Effect of Temperature and Pressure on Solubility

The effect of temperature and pressure on the solubility of a substance is as follows:

- The solubility of solids in liquids usually increases on increasing the temperature and decreases on decreasing the temperature.
- The solubility of solids in liquids remains unaffected by changes in pressure.
- The solubility of gases in liquids usually decreases on increasing the temperature and increases on decreasing the temperature.
- The solubility of gases in liquids increases on increasing the pressure and decreases on decreasing the pressure.

Distinguishing Properties of Solution, Suspension and Colloidal Solution

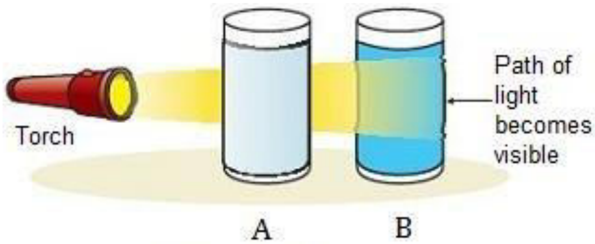
<table>
<tr><th colspan="3">Properties</th></tr>
<tr><th>Solution</th><th>Suspension</th><th>Colloids</th></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>A solution is a homogeneous mixture.</td><td>A suspension is a heterogeneous mixture.</td><td>A colloid is a homogeneous looking heterogeneous mixture.</td></tr>
<tr><td>The dispersion medium is generally liquid.</td><td>Solids are dispersed in any medium such as liquid or gas.</td><td>Particles are dispersed in a continuous medium.</td></tr>
<tr><td>Size of the particle is about 10^{-10} m.</td><td>Very fine particles, about 10^{-7} m.</td><td>Particles having a size between 10^{-10} m and 10^{-7} m.</td></tr>
<tr><td>Due to very small particle size, they do not scatter a beam of light passing through a solution. So, the path of light is not visible in a solution.</td><td>The particles of a suspension scatter a beam of light passing through it and make its path visible.</td><td>Colloids are big enough to scatter a beam of light passing through it and make its path visible.</td></tr>
<tr>
<td>Dispersed substance:
Can pass through a filter paper and a semi-permeable membrane.
It is not visible to the naked eye.
They do not settle down.
Example:
<table>
<tr><th>Solution</th><th>Solute</th><th>Solvent</th></tr>
<tr><td>Salt solution</td><td>NaCl</td><td>Water</td></tr>
<tr><td>Sugar solution</td><td>Sugar</td><td>Water</td></tr>
<tr><td>Copper sulphate solution</td><td>$CuSO_4$</td><td>Water</td></tr>
</table></td>
<td>Dispersed substance:
Cannot pass through a filter paper or through a semi-permeable membrane.
It is visible to the naked eye.
They settle down after sometime.
Example:
<table>
<tr><th>Solution</th><th>Solute</th><th>Solvent</th></tr>
<tr><td>Chalk in water</td><td>Chalk</td><td>Water</td></tr>
<tr><td>Sand in water</td><td>Sand</td><td>Water</td></tr>
<tr><td>Coagulated matter</td><td>Coagulated matter</td><td>Water</td></tr>
</table></td>
<td>Dispersed substance:
Can pass through a filter paper but not through a semi-permeable membrane.
It is not visible to the naked eye.
They do not settle down.
Example:
<table>
<tr><th></th><th>Dispersed phase</th><th>Dispersion medium</th></tr>
<tr><td>Emulsion</td><td>Liquid</td><td>Liquid</td></tr>
<tr><td>Sol</td><td>Solid</td><td>Liquid</td></tr>
<tr><td>Aerosol</td><td>Liquid</td><td>Gas</td></tr>
</table></td>
</tr>
</table>

Dispersion System in Colloids

- A system consisting of a substance distributed as very small particles of a solid, droplets of liquids or tiny bubbles of a gas in a suitable medium is called as **dispersion system**.
- The distributed substance in the solution is called as **dispersed phase**.
- The medium in which the distributed substance is dispersed is referred to as the **dispersion medium**.

Tyndall Effect

- Tyndall effect can be defined as the scattering of a beam of light by colloidal particles present in a colloidal solution.



Tyndall Effect

- This effect can be observed when a fine beam of light passes through a small hole in a dark room. This effect occurs due to the scattering of light by particles of dust or smoke present in the air.
- The Tyndall effect can also be observed when sunlight passes through the canopy of a dense forest. In the forest, the mist contains tiny droplets of water which act as colloidal particles dispersed in the air.

Separating the Components of a Mixture

- **To obtain the coloured component of a dye from blue/black ink**

Evaporation
PRINCIPLE: This method is based on the evaporation of the liquid component in a soluble solid-liquid mixture.
TECHNIQUE: The mixture is heated such that the liquid component evaporates and the solid remains behind.
DIAGRAM: 
OBSERVATION: Ink is a mixture of a dye in water. Thus, we can separate the volatile component (solvent) from its non-volatile solute by the method of evaporation.

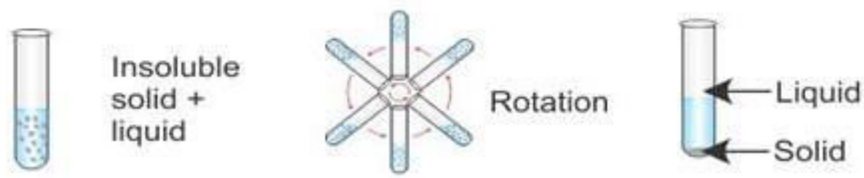
- **Separation of Cream from Milk**

Centrifugation

PRINCIPLE: This method is based on the principle of settling down under mechanical rotation, where insoluble heavier solid particles are present in an insoluble solid-liquid mixture.

TECHNIQUE: The mixture is placed in a test-tube and kept in a centrifugation machine. On centrifugation, the solid particles settle down under the influence of an outward centrifugal force and the liquid component of the mixture floats above it.

DIAGRAM:



EXAMPLE- Separation of cream from milk.

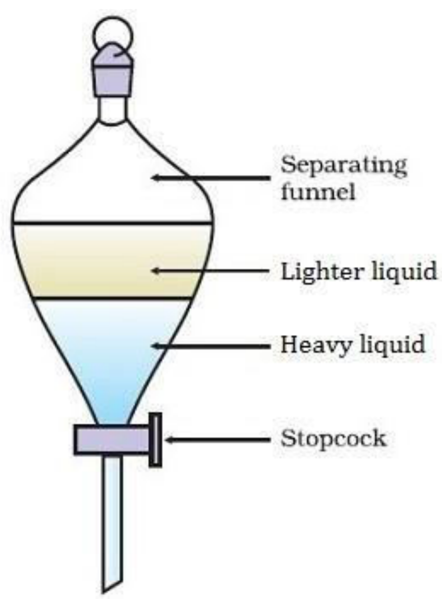
- **To separate a mixture of two Immiscible liquids**

Separating funnel

PRINCIPLE: This method is based on the separation of a mixture containing two immiscible liquids, containing a heavy and a light liquid.

TECHNIQUE: The liquid-liquid mixture is added to the separating funnel and the funnel is allowed to stand for some time without any disturbance. The heavier immiscible liquid settles down and the lighter liquid floats above it. The two liquids can be removed separately with the help of the tap provided at the bottom of the funnel.

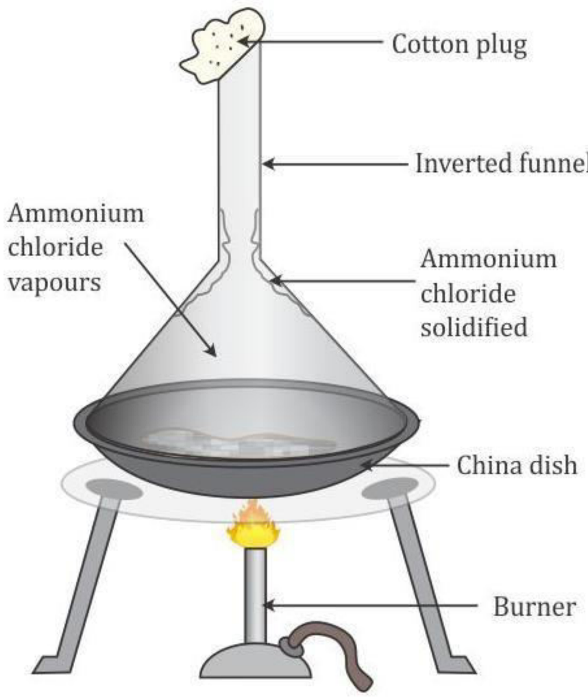
DIAGRAM:



EXAMPLE:

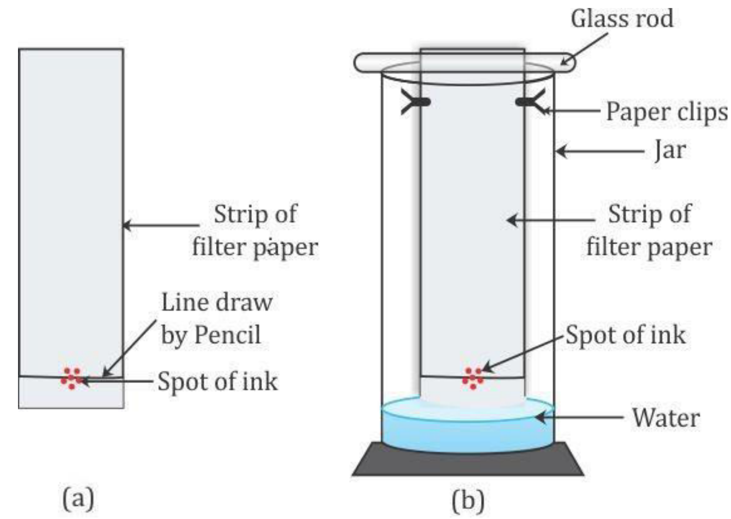
Separation of kerosene and water. Separation of oil and water

- **To separate a mixture of Salt and Ammonium chloride**

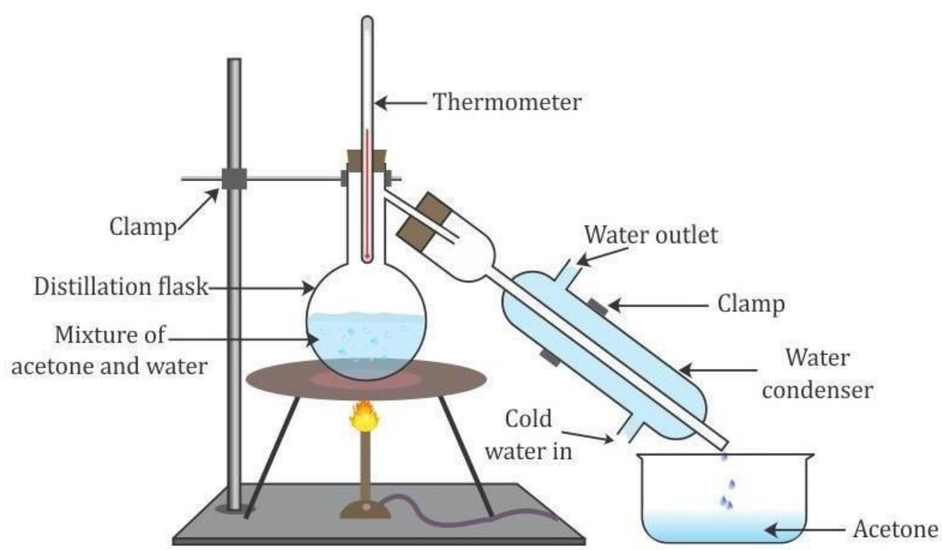
Sublimation
PRINCIPLE: This method is based on the sublimable and non-sublimable nature of solids.
TECHNIQUE: The mixture of a sublimable and non-sublimable substance is heated in an evaporating dish covered with an inverted funnel. This results in the evaporation of the sublimable solid and further condensation on the side of the funnel, leaving the non-sublimable solid behind in the dish.
DIAGRAM: 
EXAMPLE: Separation of ammonium chloride and sodium chloride in the laboratory. Separation of iodine and sodium chloride in the laboratory.

- **Separation of Components of Dye**

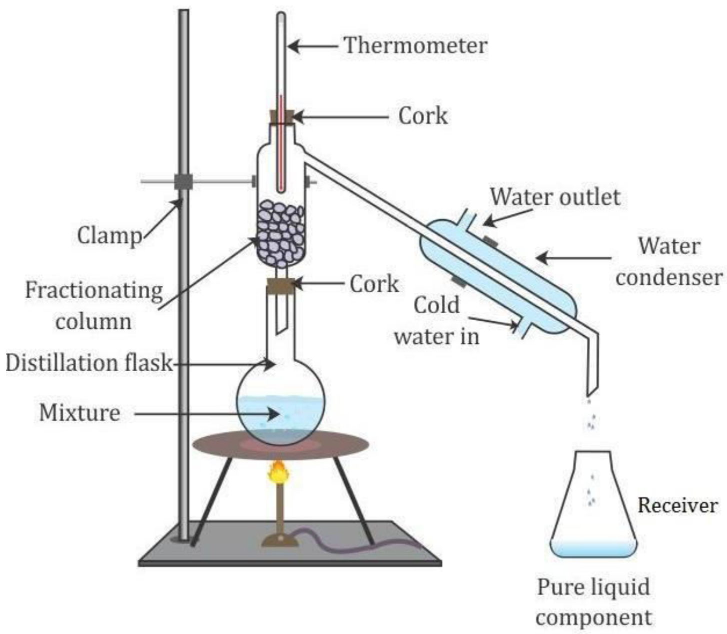
Paper Chromatography
PRINCIPLE: This method is based on the solubility of different components in solvent. The ink which we use has water as the solvent with the dye dissolved in it. As water rises on the filter paper it carries along with it the dye particles. The colour component which is more soluble in water rises faster and in this way the colours get separated.
TECHNIQUE:- • Place a spot of ink with the help of a capillary tube in the centre of a base line, about 2-3 cm away from the lower edge of a paper. • Allow the spot to dry and hang it in a glass jar with its lower end immersed in the solvent. **Separation of Compounds** • The solvent runs over the spot and carries the components to a distance along the paper, indicated by the colored spots.

DIAGRAM: 
EXAMPLE: Different component dyes in ink. Pigments from natural colours. Drugs from blood.

- **To separate a mixture of two miscible liquids**

Distillation
PRINCIPLE: This method is used for the separation of components of a mixture containing two miscible liquids which boil without decomposition and have a sufficient difference in their boiling points.
TECHNIQUE: Take the mixture in a distillation flask and fit in the thermometer. Arrange the apparatus as shown in the given figure. Heat the mixture slowly, keeping a close watch on the thermometer. The liquid with a low boiling point will vaporise and condense in the condenser and can be collected from the condenser outlet. The liquid with a higher boiling point will be left behind in the distillation flask.
DIAGRAM: 
EXAMPLE: Separation of a mixture of acetone and water.

- **To separate a mixture of two miscible liquids having the temperature difference less than 25°C.**

Fractional Distillation
PRINCIPLE: This method is used for the separation of a mixture containing two miscible liquids, for which the difference in their boiling points is less than 25°C.
TECHNIQUE: The mixture is kept in a distillation flask attached with a fractionating column, having glass beads. The flask is then carefully heated. The mixture first evaporates and later condenses. The glass beads present in the fractional column provide a larger surface area for the vapours to cool down. This technique is used to separate mixtures made up of two miscible liquids with a difference in their boiling points less than 25°C. **Separation of Compounds** The liquid with a higher boiling point remains in the distillation flask after condensation. The liquid with a lower boiling point collects in the receiver after condensation.
DIAGRAM: 
EXAMPLE: Separation of a mixture of benzene and toluene. Separation of a mixture of water and carbon tetrachloride. Crude oil can be separated into its fractions by fractional distillation.

- **To obtain different gases from air**

Fractional Distillation

PRINCIPLE: This method is used for the separation of gases at different heights depending upon their boiling points.

TECHNIQUE: Air is a homogeneous mixture and can be separated into its components by fractional distillation.
Air is first compressed and then cooled by increasing the pressure and decreasing the temperature.
Air gets liquefied. This liquid air is allowed to warm up slowly in the fractional distillation column. Gases get separated at different heights.
Flow chart and table

Air

↓

Compressed and cooled by increasing pressure and decreasing temperature.

↓

Liquid Air

↓

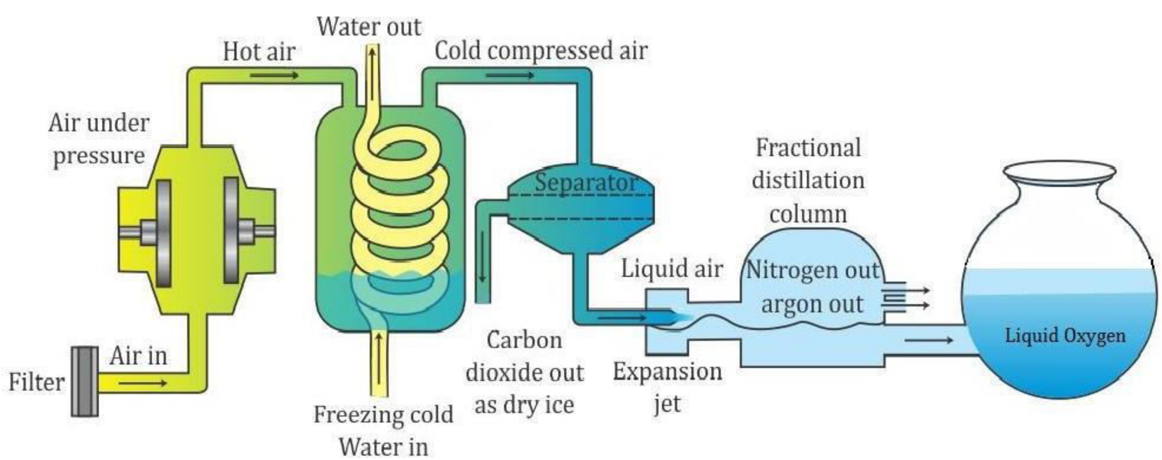
Allowed to warm up slowly in fractional distillation column.

↓

Gases get separated at different heights.

	Oxygen	Argon	Nitrogen
Boiling point (°c)	-183	-186	-196
% Air by volume	20.9	0.9	78.1

DIAGRAM:



EXAMPLE: To obtain different gases from air.

- **To Obtain Pure Copper sulphate Crystals From An Impure Sample**

Crystallisation and Fractional Crystallisation

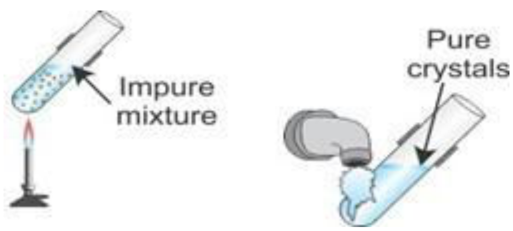
PRINCIPLE: This method is based on the difference in the solubilities of solids in a liquid.

TECHNIQUE: This method involves dissolving the mixture completely in water and heating this mixture. Further, cooling of this mixture results in the formation of crystals of a less soluble solid on the surface of the solution.

Crystallisation: The process of formation of crystals from a hot saturated solution by cooling.

Fractional crystallisation: The process of separation of two solids with different solubilities.

DIAGRAM:



EXAMPLE: Preparation of pure copper sulphate crystals in the laboratory.
Purification of salt obtained from the sea.
Separation of crystals of alum from impure samples.

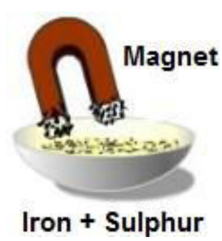
- **To Separate The Mixture of Iron Filings and Sulphur Powder**

Magnetic Separation

PRINCIPLE: This method is based on the magnetic and non-magnetic properties of the solid particles.

TECHNIQUE: This method involves the separation of magnetic particles from non-magnetic particles using a magnet.

DIAGRAM:

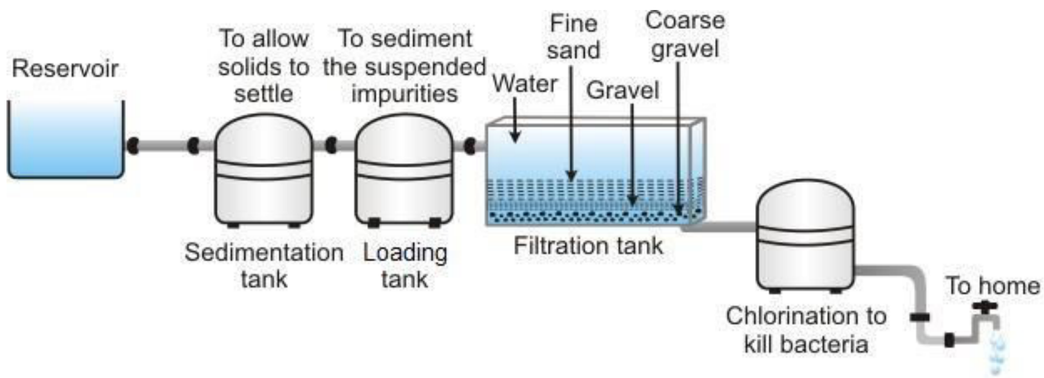


EXAMPLE: Separation of iron particles from unwanted pieces of glass, plastic or other metallic thrash.

Purification of Drinking Water

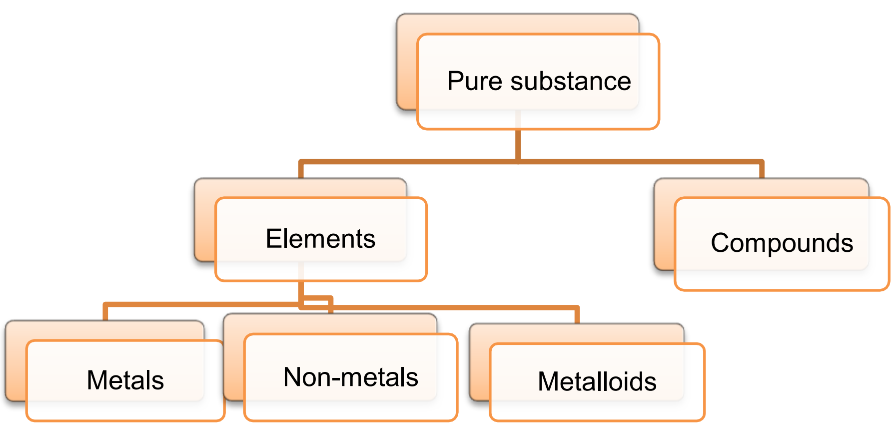
Purification of drinking water is done at the following four stages:

- Water from a river or lake is brought through canals or long pipes to the water work, where it is mixed with the required quantities of alum and soda lime solutions. These substances react with one another to form aluminium hydroxide, a jelly-like, sticky solid.
- It is then pumped into big settling tanks, where most of the suspended impurities settle down in two or three days.
- The clear water still containing some suspended matter is passed through successive filters of boulders, gravel, coarse sand and fine sand.
- The clear water from the filters is chlorinated and then passed to the reservoirs for distribution in the city.



Water purification system in water works

Physical and Chemical Changes



Element

- An element can be defined as a basic form of matter which cannot be broken down into simpler substances by any physical or chemical means.

Characteristics of an Element

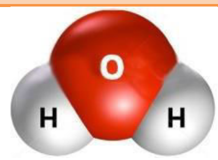
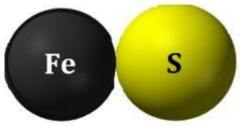
- An element is made up of only a single type of atoms.
- It is a pure and homogeneous substance.
- It has a fixed melting and boiling point.
- An atom is the smallest particle of an element which takes part in a chemical reaction.
- An element may chemically react with other elements or compounds.
- An element can occur in the solid, liquid or gaseous state.

Classification of Elements

Metals	Non-metals	Metalloids
• Have metallic lustre. • Are good conductors of heat and electricity. • Are malleable and ductile. • Are solids. • Contain one kind of atoms.(Mono-atomic) Examples: Iron, copper, sodium, calcium etc. Exceptions: 1. Zinc is non-malleable and non-ductile. 2. Mercury is a liquid at room temperature. 3. Tungsten is a poor conductor of electricity. 4. Sodium and potassium are not hard. They are so soft that they can be cut easily with a knife.	• Do not have lustre. • Are bad conductors of heat and electricity. • Are neither malleable nor ductile. • Are solids, liquids and gases. • Contain two kinds of atoms. (Mono-atomic or di-atomic) Examples: Solid: Carbon, silicon, phosphorous etc. Liquid: Bromine Gas: Hydrogen, chlorine etc. Exceptions: 1. Carbon fibre is ductile but not malleable. 2. Graphite is a good conductor of electricity. 3. Iodine and graphite are lustrous.	• Properties are midway between metals and non-metals. • Contain one kind of atoms. (Mono-atomic) Examples: Boron, germanium, silicon, arsenic, antimony, bismuth etc.

Compound

- A compound is a pure substance composed of two or more elements combined chemically in a fixed proportion by mass.
- The properties of compounds are different from the properties of their constituent elements. Example: H_2O, CO_2 etc.
- The smallest part of a compound is a molecule. All the molecules of a compound are alike and have properties similar to that of the compound.

Compound	Molecular Formula	Composition of molecule	Structure
1. Water	H_2O	2 atoms of hydrogen and 1 atom of oxygen	
2. Iron sulphide	FeS	1 atom of iron and 1 atom of sulphur	

Characteristics of Compounds

- Components in a compound are present in a definite proportion.
- A compound has a homogeneous composition.
- Particles in a compound are of one type.
- A compound is made up of one or more atoms of the same or different elements.
- In a compound the elements are present in a fixed ratio by mass.
- A compound can be divided into simpler substances by a chemical process.
- The physical and chemical properties of a compound are completely different from those of its constituents.