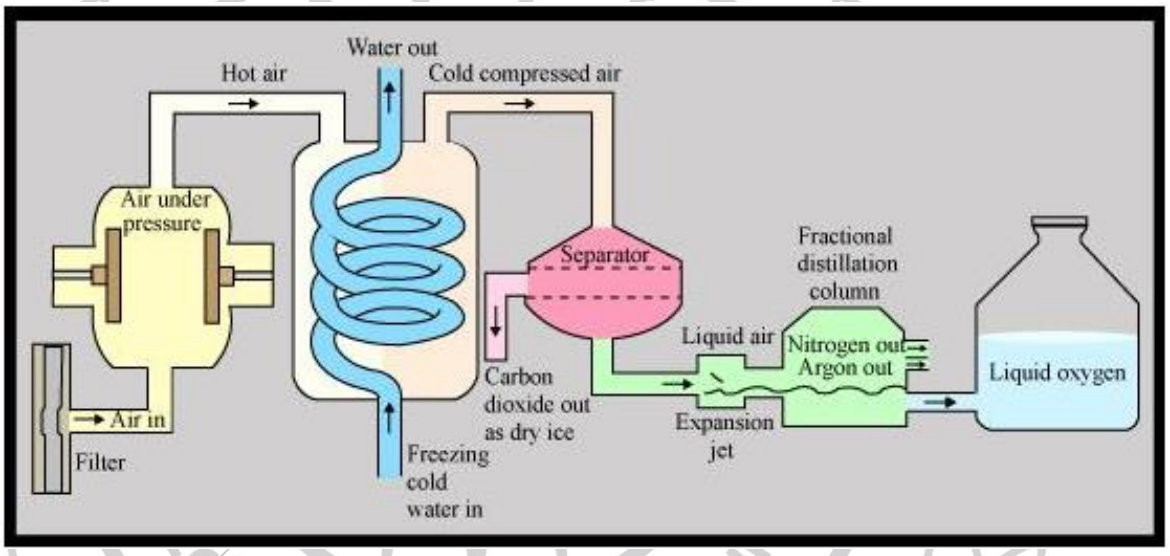
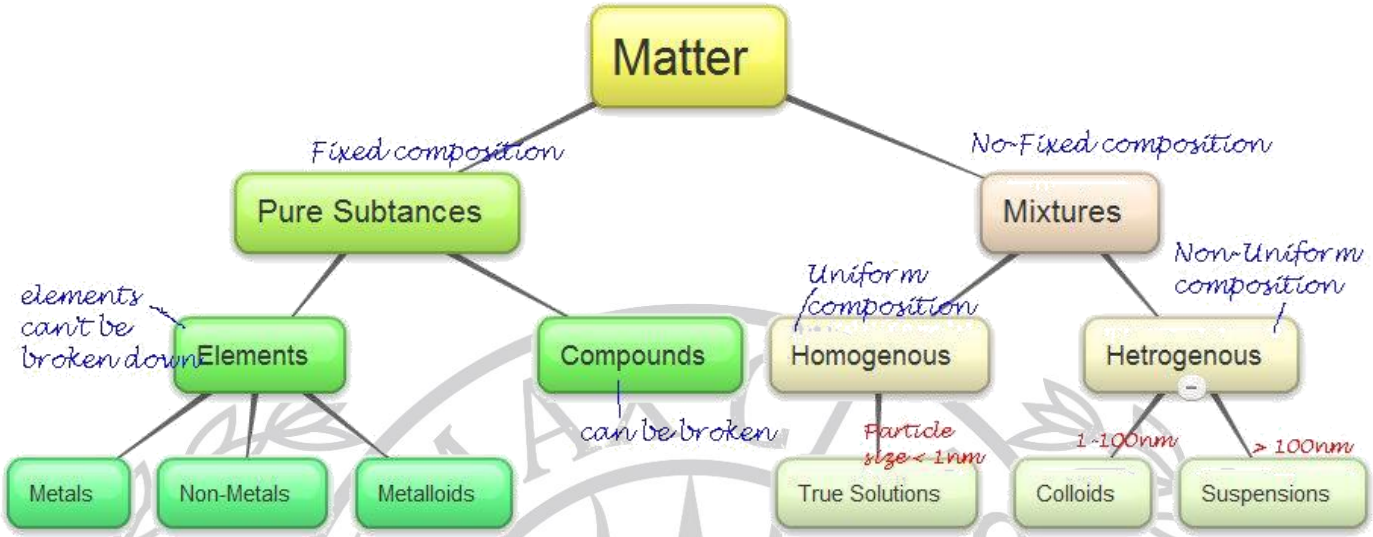
Is matter around us pure?



EDUMAX CLASSES
EDUCATION AT MAXIMUM

What is a substance?

- Anything that cannot be broken into further particles by applying any physical processes is called a **Substance**.
- Matter can be classified into two types of substances – Pure substances and Mixtures



What is a pure substance?

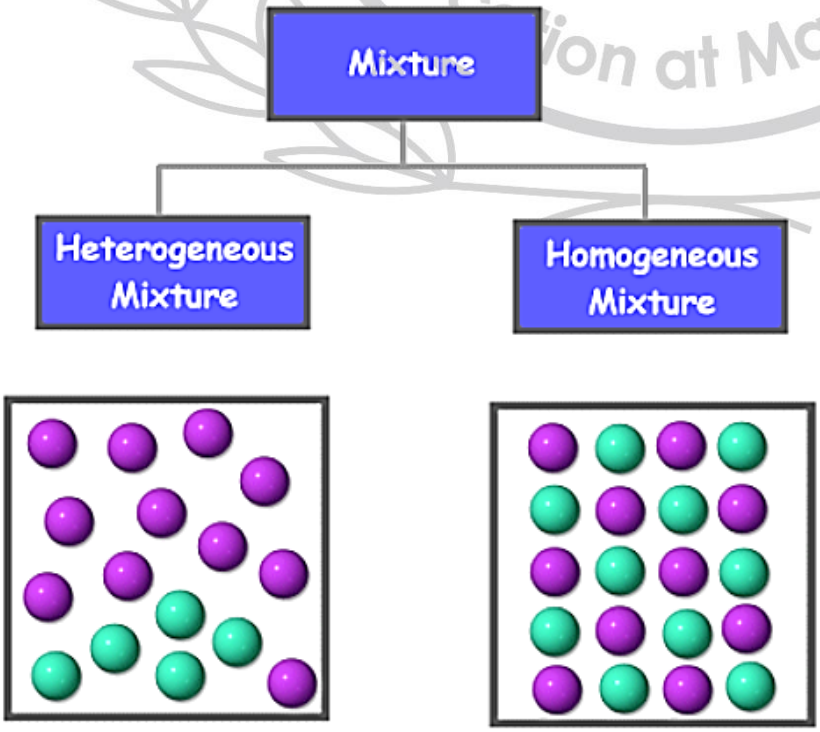
A substance that consists of only one type of particle is called a **Pure Substance**. **For Example**, Diamond, Salt, Sulphur, Tin.

What is a mixture?

- When we combine different substances into each other a mixture is formed. **For Example**, Lemonade is a mixture of three substances, Lemon Juice, Sugar and Water.

Types of Mixtures

There are two categories of mixtures: Homogeneous Mixtures and Heterogeneous Mixtures



Homogenous Mixtures

- When we add sugar, water and lemon juice together they all uniformly mix with each other. Now it is no possible to separate these substances from the mixture. Such mixtures in which the components mix with each other uniformly are called **Homogenous Mixtures**.
- The ratio of compositions of homogeneous mixtures can be different. **For Example**, one may add two spoons of sugar in lemonade while someone else may add only one spoon of sugar in their lemonade. Still, lemonade is a homogeneous mixture.

Heterogeneous Mixtures

- The components in a heterogeneous mixture do not completely dissolve in each other and we can separate them by physical means. In other words, the composition of such mixtures is not uniform.
- **For Example**, If we mix sand in water the sand settles down in water after some time and we can separate it by filtration.

Here are a few differences between homogeneous and heterogeneous mixtures –

Homogenous Mixtures	**Heterogeneous Mixtures**
They have a uniform composition throughout	They have a non-uniform composition
We cannot separate the components of the mixture through physical processes	We can separate the components through physical processes
Components cannot be seen through naked eyes	Components can easily be seen through naked eyes
The mixture is in single phase throughout	The substances can be of two different phases and we may see separate layers of the substances
Example: A mixture of water and milk	**Example**: A mixture of oil in water

What is a solution?

A solution is nothing but a uniform mixture of two or more substances. Homogenous Mixtures are solutions.

Solution of -

- **Liquid into liquid:** Water and Ink
- **Solid into solid:** Alloys
- **Gas into gas:** Air
- **Solid into liquid:** Sugar and Water
- **Solid into gas:** Hydrogen and Metals
- **Liquid into gas:** Carbon Dioxide and Water

What is an alloy?

An alloy is a mixture of different metals or non-metals and metals that cannot be separated from each other using physical methods. **For Example:**

Brass – Copper with up to 50% zinc

Bronze – Copper with up to 12% tin

Solution constitutes of two types of substances, a solute and a solvent.

Solution = Solute + Solvent

Solvent – The substance in which another substance is mixed is called the **Solvent**. **For Example**, Water is a solvent in which we can mix different substances such as salt or sugar.

Solute – The substance that is added to the solvent to form a solution is called a **Solute**. **For Example**, Salt, when mixed in water, acts as a solute for the mixture.

Properties of a Solution:

- A solution is a homogenous mixture.
- We cannot see the particles of a solution through naked eyes as they as are small as 1 nanometer in diameter.
- The path of light is not visible through the solution. The particles of a solution do not scatter light through them as they are extremely small.
- We cannot separate the particles of a solution by methods of filtration.

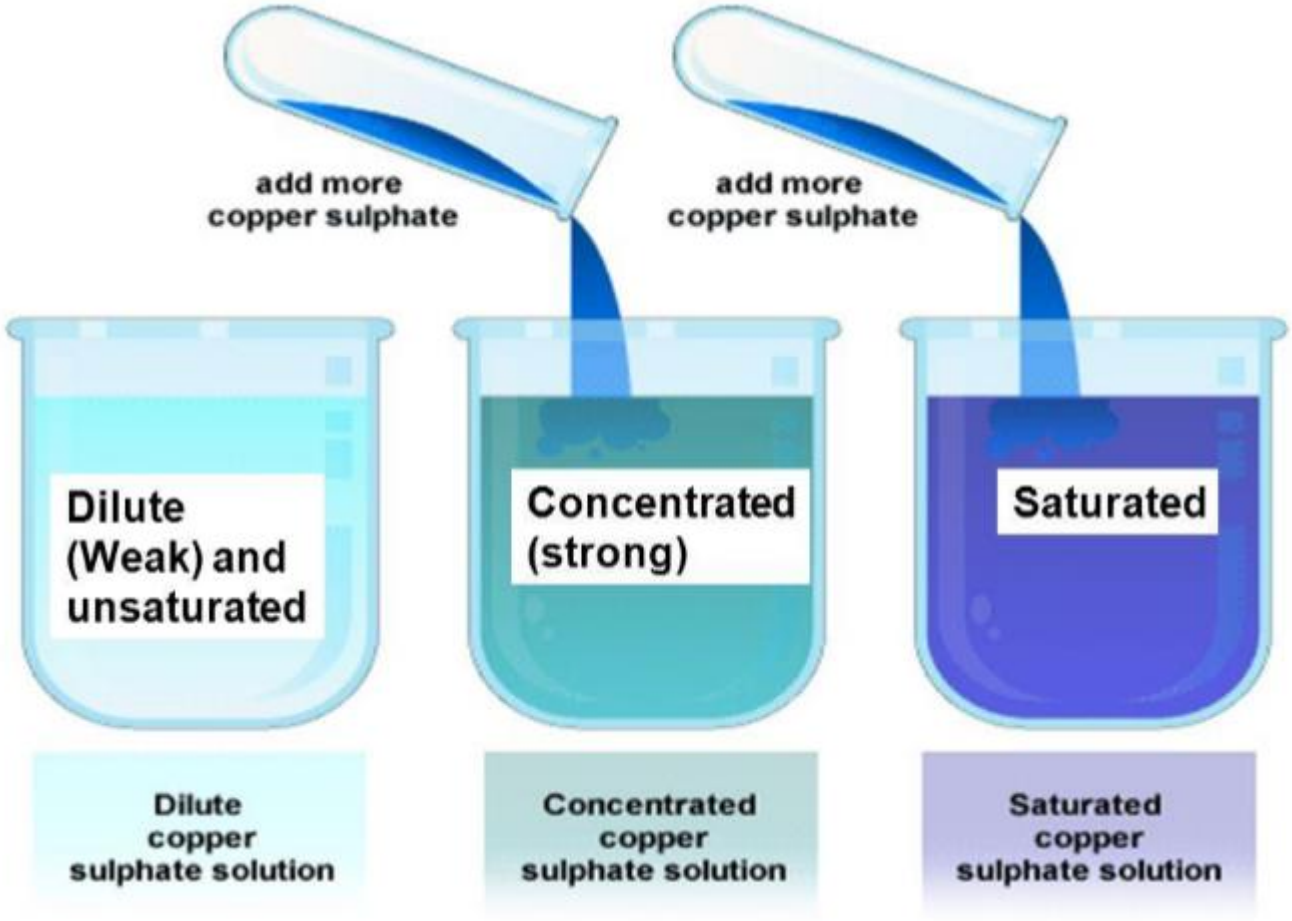
What is a stable solution?

A stable solution is a solution in whose particles do not settle down if we leave the solution undisturbed for some time. This is because the particles of a stable solution are homogeneously spread.

Different Types of Solutions

- **Dilute –** A solution in which the concentration of the solute is much less than that of the solvent. **For Example**, If we mix 1gm of salt in 500 ml of water, the salt solution thus obtained will be diluted. If we keep on adding the solute in a solution there comes a point when no more solute dissolves in the solution. This is called the **Saturation Point of a Solution**.

- **Unsaturated Solution –** A solution, in which we can add more amount of solute as it has not achieved its saturation level yet, is called an Unsaturated Solution. A dilute solution can be called as an **Unsaturated Solution**.
- **Concentrated Solution –** A solution with a large amount of solvent is called a **Concentrated Solution**.
- **Saturated Solution –** A solution in which no more solute can be added since it has already dissolved the maximum amount of solute it can is called a **Saturated Solution**.



What is concentration?

C**oncentration** refers to the amount of a substance per defined space or can be defined as the ratio of solute in a solution to either solvent or total solution.

To calculate the concentration consider the formulae below:

- **Percent by Mass** = (Mass of solute / Mass of solution) X 100
- **Percent by Volume** = (Volume of solute / Volume of solution) X 100
- **Molarity (M)** = Number of moles of solute / Volume of Solution in litres

Where, Moles of solute = Given mass / molar mass

- **Molality (m)** = Moles of solute / weight of solvent in kg
- **Normality (N)** = Number of mole equivalents/ volume of solution in litres

= Mass of solute / (equivalent mass * volume of solution in Litres)

- **ppm (Parts Per Million)** = (Mass of Solute / Mass of Solvent) * 10^6

- **Mole Fraction**$_{SOLUTE}$ = Moles of Solute / Total Moles of Solution
- **Mole Fraction**$_{SOLVENT}$ = Moles of Solvent / Total Moles of Solution
- **Mole Fraction**$_{SOLUTE}$ + Mole Fraction$_{SOLVENT}$ = 1

What is a suspension?

A suspension is formed when two or more substances are mix in a non-uniform manner. Heterogeneous mixtures are suspensions. The solute does not mix with the solvent and can be viewed through naked eyes.

Properties of Suspensions:

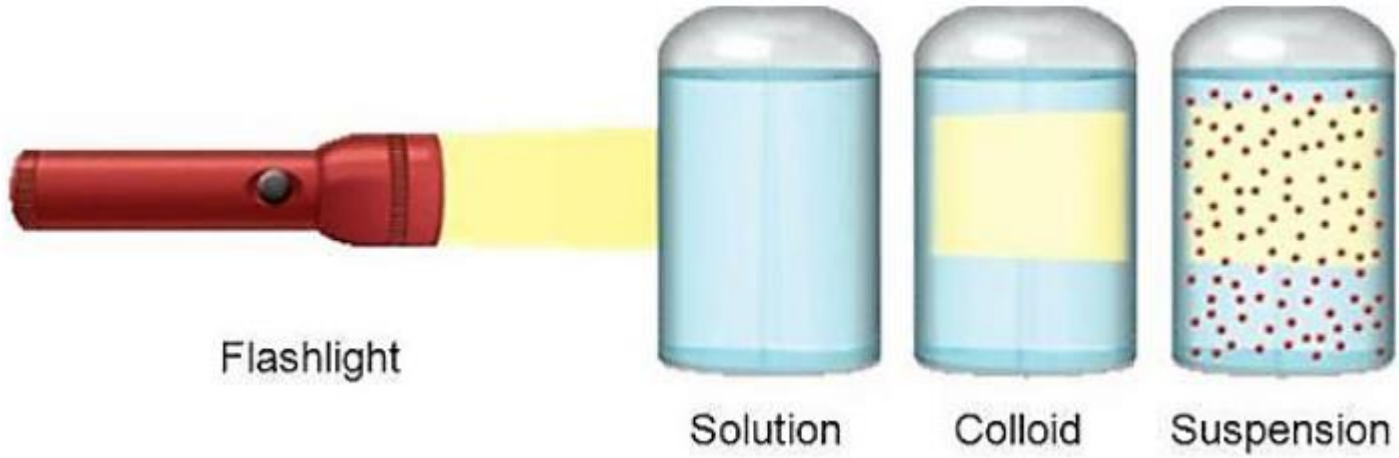
- A suspension is a heterogeneous mixture.
- We can see the particles of suspensions through naked eyes.
- We can see the path of light through the particles of a suspension.
- The particles of suspension tend to settle down when left undisturbed. Then, they can be separated using filtration.

What are colloids or colloidal solutions?

A colloidal solution or a colloid is a uniform solution of two or more substances. The particles are relatively very small that the solution appears as a homogeneous mixture but it is not.

Properties of colloids:

- Colloids are heterogeneous in nature.
- The particles of a colloid cannot be seen through naked eyes.
- The particles scatter a beam of light passed through a colloid and produce Tyndall effect.
- Colloids are stable in nature. The particles of colloids do not settle down if left uninterrupted.
- We cannot separate the particles of a colloid through filtration. We use a method called **Centrifugation** to separate the particles of a colloid.



What is the Tyndall Effect?

When a beam of light is passed through a colloid the particles of the colloid scatter the beam of light and we can see the path of light in the solution. **For Example**, when a ray of light enters a dark room it is scattered by the dust particles present in the air and we can see the path of light clearly.


Classification of Colloids

Dispersed Phase – The dispersed particles or the solute-like components in a colloid

Dispersing Medium – The substance in which these solute-like particles are added

Based on the state of the dispersing medium colloids are classified as:

Types of Colloids

Example	Dispersed Substance	Dispersing Medium	Colloid Type
Fog, Aerosol sprays	Liquid	Gas	Aerosol
Smoke, Airborne bacteria	Liquid	Gas	Aerosol
Whipped cream, Soap suds	Gas	Liquid	Foam
Milk, Mayonnaise	Liquid	Liquid	Emulsion
Paints, Clays, Gelatin	Solid	Liquid	Sol
Marshmallow, Styrofoam	Gas	Solid	Solid foam
Butter, cheese	Liquid	Solid	Gel/ Solid emulsion
Ruby glass	Solid	Solid	Solid sol

How to separate components of a mixture?

We can separate the heterogeneous mixtures into their constituents by means of physical methods like:

- Filtration
- Hand-picking
- Sieving

The components of a mixture can be separated from each other using several other techniques like:

- Evaporation
- Centrifugation

- Sublimation
- Chromatography
- Distillation

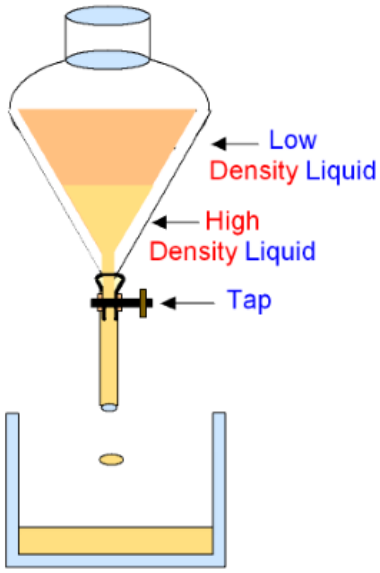
1. Evaporation – For separating a mixture of a non-volatile and a volatile substance

- **Applications:**
  - Separating coloured component from the ink
  - Salt from water
  - Sugar from Water
- **Method:**
  - Mix some ink into water and heat it. After some time the water will evaporate leaving behind the coloured substance.

2. Centrifugation – Separating dense particles from lighter particles

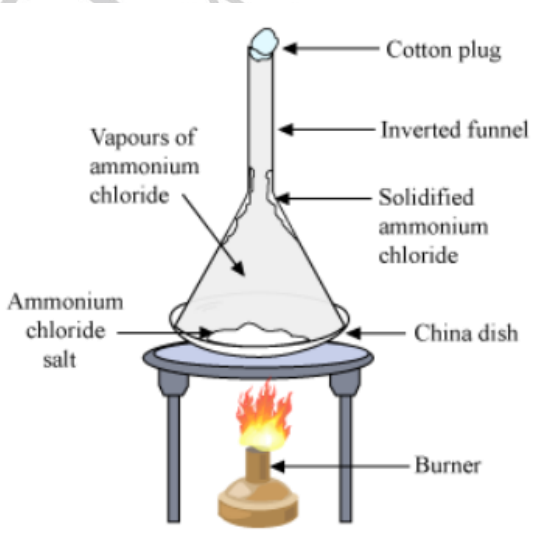
- **Applications:**
  - Separating milk from cream
  - Separating butter from cream
  - Squeezing out water from wet clothes
- **Method:**
  - Milk is put in a centrifuging machine or milk churner and the cream thus separates from milk.

3. Using a Separating funnel – To separate two immiscible liquids



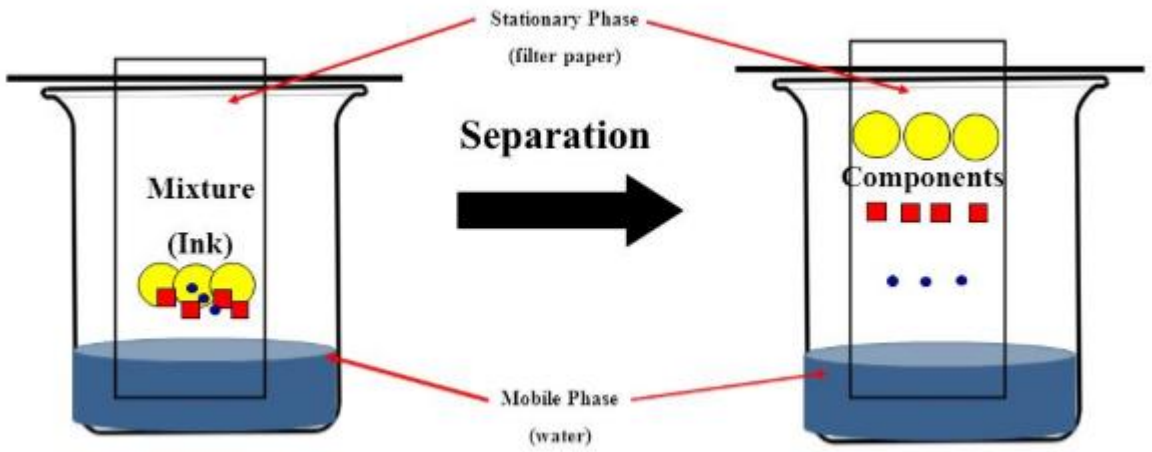
- **Applications:**
  - Oil from water
  - Iron and iron ore
- **Method:**
  - The immiscible liquids are allowed to settle in the funnel. They soon form separate layers due to varying densities. The first liquid is allowed to flow out of the funnel and as soon as it is completely poured out, the stopcock is closed thereby separating the two liquids from each other.

4. Sublimation – To separate a sublimable component from a non-sublimable component



- **Applications:**
  - Ammonium chloride / camphor / naphthalene and salt
- **Method:**
  - Heat the mixture in an inverted funnel so that the sublimable component sublimes in the air and settles over the walls of the funnel and the non-sublimable component, on the other hand, is left behind.

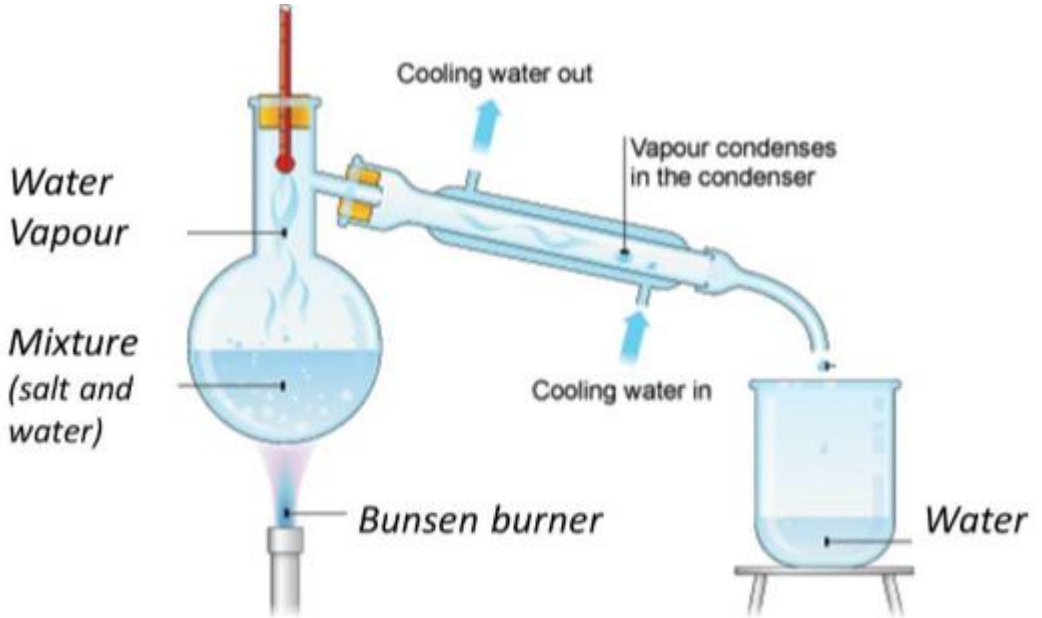
5. Chromatography – To separate solutes that can dissolve in the same solvent



- **Applications:**
  - Separating colour components of a dye
  - Drugs from blood

- **Method:**
  - Take a filter paper or a blotting paper and place a drop of ink at the rear end. Dip the end in water. Since ink is a mixture of two or more colors, the component of ink which is soluble in water mixes into it and then separates quickly from the other components that are less soluble in water.

6. Distillation – To separate miscible liquids (the boiling points of the liquids must be sufficiently different)



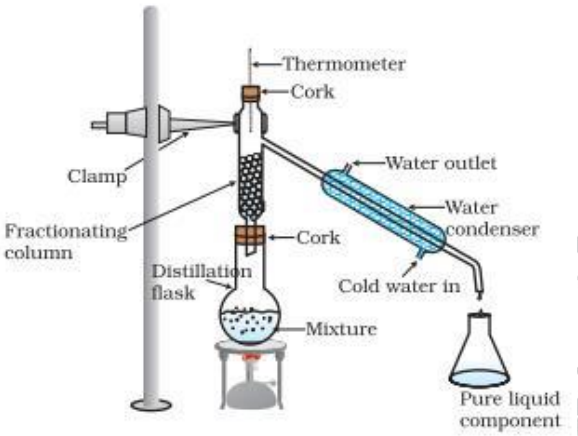
- **Applications:**
  - Acetone and water
- **Method:**
  - The mixture is heated in a distillation apparatus. The one substance with lower boiling point evaporates first, condenses and gets separated from the one with a higher boiling point.
  - **Simple Distillation –** when the miscible liquids have a satisfactory difference in their boiling points
  - **Fractional Distillation –** when the difference between the boiling points of the liquids is less than 25 K

<u>Fractional Distillation</u>

- Fractional distillation is a process of separating two (or more) miscible liquids by distillation, the distillate being collected in fractions boiling at different temperatures.
- The more volatile liquid (having lower boiling point) distils over first, and the less volatile liquid (having higher boiling point) distils over later.
- A simple fractionating column is a tube packed with glass beads. The beads provide surface for the vapours to cool and condense repeatedly.
- For example: - Mixture of acetone and water can be separated by fractional distillation.

Applications of Fractional Distillation

1. Fractional distillation is used to separate mixtures of miscible liquids.
2. It is used to separate crude oil "petroleum" into useful fractions such as kerosene, petrol or diesel etc.
3. It is used to separate gases of the air.



Separating different Gases from the Air

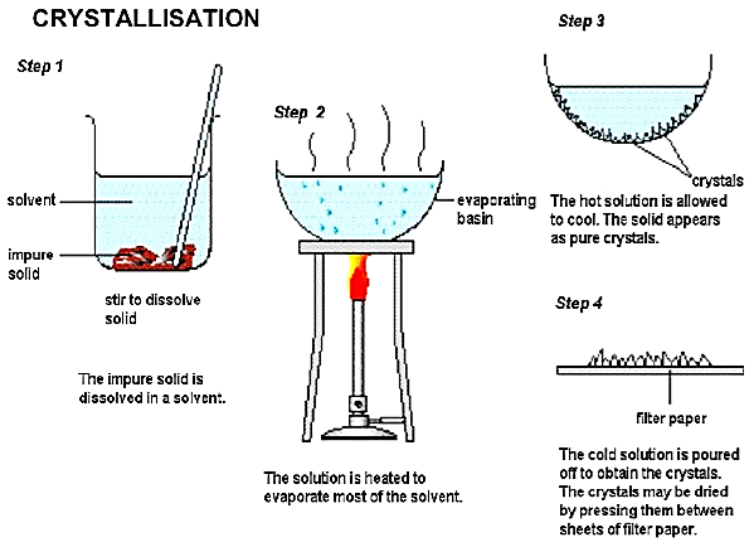
Method – Fractional Distillation

- Compress and cool the air by increasing the temperature and decreasing the pressure. The air turns to liquid air.
- Liquid air is warmed up slowly in a fractional distillation apparatus
- The several components of air get separated and are collected at various heights on the basis of their boiling points

Purifying Solids

Method used – Crystallization

In the crystallization method, we can obtain a pure solid in the form of crystals from its solution



- **Applications:**
  - Salt from sea water
  - Purification of copper sulphate
- **Method:**
  - The impurities of a substance are filtered out.
  - Water is evaporated to obtain a saturated solution.
  - The solution is covered with filter paper and left as it is.
  - After some time, the crystals of pure solid are formed.
- **Is evaporation better than crystallization?**

Simple evaporation is not better than crystallization because:

1. Some solid substances decompose because of excess heat. **For Example**, Sugar gets charred on extra heating.

2. If after filtration some impurities remain in the solution they can contaminate the solid and therefore we would not obtain a pure substance.

Physical Change and Chemical Change

Physical Property of a Substance:

Properties of a substance such as rigidity, colour, fluidity, boiling point, melting point, density and hardness which we can observe are called as **Physical Properties**.

Physical Change:

When physical properties of a substance change it is known as a **Physical Change**. When we convert a substance from one state to another, such as a solid into a liquid or vice-versa, it is also a physical change as only the physical nature of the substance changes without affecting its chemical nature.

For Example, Change of ice into water. The chemical properties of water remain the same.

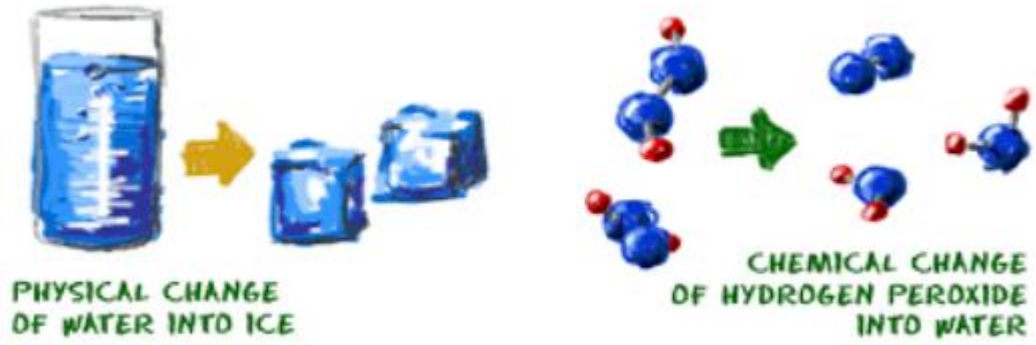
Chemical Property of a Substance:

The chemical nature of a substance is known as its **Chemical Property** such as its odour or its chemical composition.

Chemical Change:

When the chemical properties or chemical composition of a substance gets altered it is called a chemical change. It is also called as a **Chemical Reaction**.

For Example, Burning of paper



Types of Pure Substances

Pure substances are classified as elements and compounds

Elements

An element is the simplest form of matter. Elements cannot be broken down into further elements by chemical reactions. Elements are further characterized as Metals, Non-Metals and Metalloids

Metals – Silver, Mercury, Copper, Gold

1. Metals are lustrous (shiny)

2. Metals conduct heat and electricity

3. Metals have a silver-grey or gold-yellow colour

4. We can hammer metals and form thin sheets (Malleability)

5. We can convert metals into wires (Ductility)

6. Metals always produce a ringing sound if they are hit (Sonorous)

Non-Metals – Carbon, Iodine, Chlorine, Oxygen, Hydrogen

1. Non-Metals do not conduct heat and electricity

2. Non-Metals are not sonorous, lustrous or ductile

3. Non-Metals have varied colours

Metalloids – Silicon, Germanium

They show some properties of metals and some of the non-metals.

Quick Facts –

1. There are 100 elements known to us

2. 92 elements out of them occur naturally

3. Rest, 8 are man-made elements

4. Most of the elements are solid in nature

5. At room temperature, 11 elements exist in the gaseous state

6. At room temperature, 2 elements exist in the liquid state – bromine and mercury

7. At a temperature slightly higher than room temperature, 2 elements exist in the liquid state – calcium and gallium

Compounds

It is a substance that consists of two or more substances. These substances are combined chemically with each other in fixed proportions. The properties of a compound are different than that of its constituents. **For Example**, Ammonium Sulphate, Sulphur Chloride, Water.

Mixtures vs. Compounds

Mixtures	Compounds
Properties of a mixture Reflect the properties of the materials it contians.	Different properties from that of the elements that make up the compounds.
No uniform composition	Definite composition. Definite ratio/formula
Can be separated by physical means.	Cannot be separated by physical means.