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CHAPTER 01

# Solution

**Solution** :- A homogeneous mixture of two or more chemical substances is called Solution.

**Solvent** :- The substance that dissolves another substance (solute) into itself to from a solution is called a solvent.

**Solute** :- A solute is the substance that dissolves in a liquid or a solvent.

**Example** :- In a mixture of salt and water :-

- Salt is the solute.
- Water is the solvent.
- The resulting mixture is the solution.

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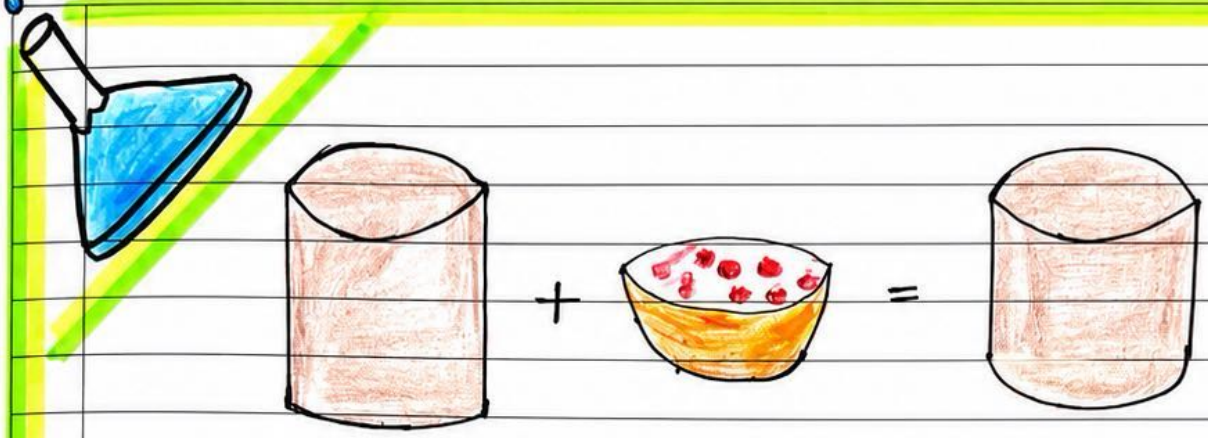

Solvent + Solute = Solution

**Types of Solutions :-** Solutions are generally classified into three Types based on the Physical State of the Solvent.

- **Solid Solution :-** A Solution in which the Solvent is in a Solid State is called a Solid Solution. there are three Subtypes :-

| TYPE | SOLUTE | SOLVENT | EXAMPLE |
|---|---|---|---|
| Solid-Solid | Solid | Solid | Mixture of copper in Gold |
| Gas-Solid | Gas | Solid | Solution of Hydrogen in Palladium |
| Liquid-Solid | Liquid | Solid | Amalgam of mercury with Sodium. |

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**Note :-** A Simple mixture of two Solids is typically not refferred to as a Solution.

- **Liquid Solution :-** A Solution in which the Solvent is in a liquid State is called a liquid Solution.

there are three Subtypes :-

| TYPE | SOLUTE | SOLVENT | EXAMPAL |
|---|---|---|---|
| Solid-Liquid | Soild | Liquid | Glucose dissolved In water. |
| Liquid - Liquid | Liquid | Liquid | Ethanol dissolved In water. |
| Gas - Liquid | Gas | Liquid | Oxygen dissolved In water. |

- **Gaseous Solutions :-** A gaseous Solution is one in which the Solvent is in a Gaseous State, and the Solute may be a Solid, liquid, or gas.

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there are three types :-

| TYPE | SOLUTE | SOLVENT | EXAMPLE |
|---|---|---|---|
| Solid-Gas | Solid | Gas | camphor in nitrogen gas. |
| Liquid-Gas | Liquid | Gas | Chloroform mixed with nitrogen gas. |
| Gas-Gas | Gas | Gas | mixture of oxygen and nitrogen gas. |

**Expressing Concentration of Solutions :-** the concentration of a solution is defined as the amount of solute dissolved in a specific volume of solvent in a solution. the composition of any solution can be expressed by its concentration.

(The quantitative description of the concentration of a solution can be done in the following ways):-

**(i) Mass percentage (w/w) :-** Mass percentage is defined as the mass of solute in grams dissolved in 100 grams of a solution.

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Mass Percentage = $\frac{\text{Mass of Solute in the Solution}}{\text{total mass of the Solution}} \times 100$

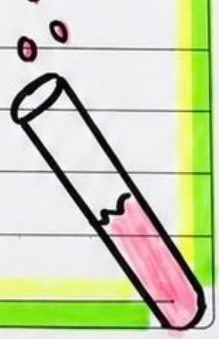
(ii) Volume percentage (v/v) :- Volume percentage is defined as the volume of Solute in ml dissolved in 100 (ml) of a Solution.

Volume Percentage = $\frac{\text{Volume of Solute in the Solution}}{\text{Total volume of the Solution}} \times 100$

(iii) Mass - Volume Percentage (w/v) :- The amount of Solute in grams dissolved in 100ml of Solution is called mass - volume percentage.

Mass - Volume percentage = $\frac{\text{Mass of Solute in Solution}}{\text{total volume of Solution}} \times 100$

(iv) Parts per million (PPM) :- the amount of Solute in grams present in $10^6$ g of a Solution is called parts per million.



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$$\text{parts/million} = \frac{\text{Number of parts of the Component}}{\text{total number of parts of all Components in Solution}} \times 10^6$$

(v) **Mole Fraction** :- The ratio of the number of moles of a particular Component to the total number of moles of all Components present in the Solution is called the mole fraction of that Component.

$$\text{mole fraction} = \frac{\text{No. of moles of Solute}}{\text{total no. of moles (Solute + Solvent)}}$$

(vi) **Molarity** :- Molarity (M) is defined as the number of moles of Solute dissolved per one liter (1L) of Solution.

$$\text{Molarity (M)} = \frac{\text{Moles of Solute}}{\text{Volume of Solution in liters}}$$

(vii) **Molality** :- Molality (m) is defined as the number of moles of Solute present in one kg (1kg) of Solvent.

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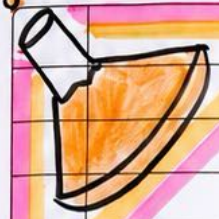

Molality (m) = $\frac{\text{Moles of Solute}}{\text{mass of Solvent in kilograms}}$

**Solubility** :- "At a Certain temperature, the maximum amount of a Solid Substance dissolved in a definite quantity of a Solvent to make the Solution Saturated is called the Solubility of that Solid Substance."

Solubility depends on the following factors :-

- Pressure.
- Temperature.
- Nature of the Solute and Solvent.

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**Solubility of Solids in liquid** :- At a Specific temperature and pressure, the maximum amount of Solid Solute that can be dissolved in a fixed quantity of Solvent is known as the Solubility of Solids in liquids.

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**Solubility of Gases in Liquids :-** At a specific temperature and pressure, the solubility of gasses in liquids occurs only up to a certain limit.
When a liquid absorbs a gas, it forms a gaseous solution; this process is referred to as gas absorption.

**Sturated Solution :-** At a constant temperature, the maximum amount of a solute that can be completely dissolved in a specific amount of solvent is called a saturated solution.

**Unsaturated Solution :-** An unsaturated solution is a solution in which the amount of solute is less than the amount required to make it a saturated solution.

* **Henry's Law :-** According to Henry's law: At a constant temperature, the solubility of a gas in a liquid is directly proportional to the partial pressure of the gas.

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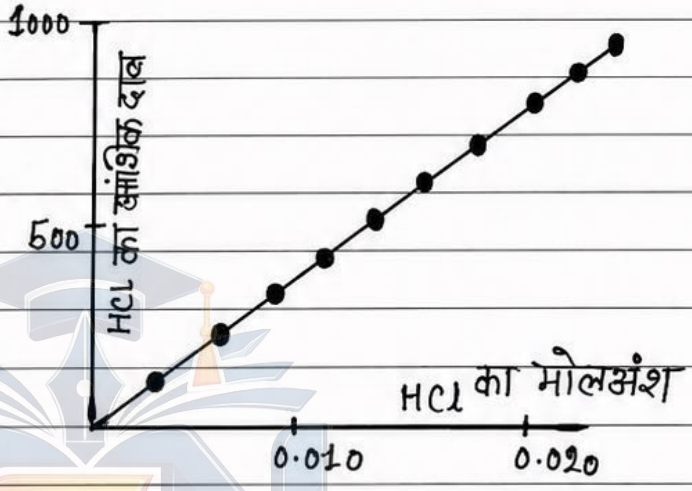
if the partial pressure of a gas is p and the solubility or mole fraction of the gas in the liquid is $x$, then:

$$P = K_H X$$

जहाँ $K_H$ = हेनरी स्थिरांक
(Henry Constant)




**Vapor pressure of Liquid Solutions :-** At a Constant Pressure exerted on the surface of a solution at equilibrium at a specific temperature is called the vapor pressure of liquid solutions.

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It is of two types:

* Liquid in liquid solution.
* Solid in liquid solution.

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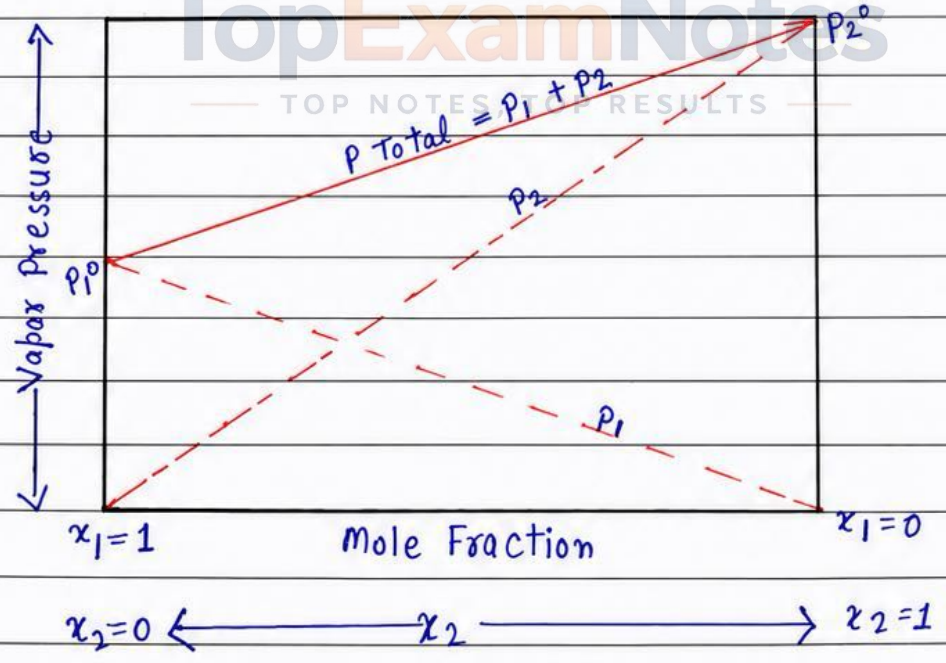
* **Liquid in liquid Solution :-** A liquid in liquid Solution is a homogeneous mixture and a binary Solution in which one liquid (Solute) is dissolved in another liquid (Solvent).

Example :- Ethanol in water.

* **Raoult's Law :-** According to Raoult's law : "At a Specific temperature, the partial Vapor pressure of each component in a Solution of Volatile liquids is directly proportional to its mole fraction in the Solution."

$P \propto x$

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Suppose $P_1$ and $P_2$ are the partial vapor pressures of two components in a solution, and $x_A$ and $x_B$ are their respective mole fractions.

According to Raoult's law:

for Component 1:- the partial Vapor pressure is directly proportional to its mole fraction:-

$$P_1 \propto x_A$$

$$P_1 = P_1^{\circ} x_A \quad \text{— (1) equation.}$$

for Component 2:- Similarly, for the second Component.

$$P_2 = P_2^{\circ} \cdot x_B \quad \text{— (2) equation.}$$

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Where:- $P_1^{\circ}$ and $P_2^{\circ}$ represent the vapor pressures of the pure components.

the total Vapor pressure of the solution = P

$$P = P_1 + P_2 \quad \text{— (3) equation.}$$

$$\therefore X_A + X_B = 1$$

$$X_A = 1 - X_B \quad \text{— (4) equation.}$$

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Substituting the value of $X_A$ from equation (4) into equation (1):-

$$P_1 = P_1^\circ (1 - X_B)$$

$$P_1 = P_1^\circ - P_1^\circ X_B$$

$$P_1^\circ - P_1 = P_1^\circ X_B$$

$$x_B = \frac{P_1^\circ - P_1}{P_1^\circ}$$

Where $(P_1^\circ - P_1)$ = Lowering of vapor pressure.

$\frac{P_1^\circ - P_1}{P_1^\circ}$ = Relative lowering of vapor pressure.

$P_1$ = Partial vapor pressure of the Solution

$P_1^\circ$ = Vapor pressure of the pure component (Solvent)

$x_B$ = Mole fraction of the Solute.

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