Solution

- **Solution** is a homogenous mixture of two or more substances on molecular level.
- **Solute:** The chemical substances of the solution present in a smaller amount is called the solute.
- **Solvent:** The chemical substance of the solution present in a larg amount is called the solvent
- **Concentration of solution** The amount of solute present in a given amount of solution, is called concentration of solution.

concentration is generally expressed as the quantity of solute a unit volume of solution.

$$\text{concentration} = \frac{\text{quantity of solute}}{\text{Volume of solution}}$$

- A solution containing a relatively low concentration of solute is called **dilute solution**. A solution of high concentration is called **concentrated solution**

Solution

Homogeneous / True solution

Characteristics

(I) Particle size = < 5mM

(II) Particles are not visible even not in microscope

(III) Particles can not be separated by simple mechanical method

Heterogeneous / coarse suspension

characteristics

(I) Particle size > 200mM

(II) Particles are visible to the naked eye

(III) Particles can be separated by simple mechanical method.

I [Classification] of solution based on phase of [solute] and [solvent]

Types and Examples of Solutions

State of solute	State of solvent	Example
Gas	Gas	Air.
Gas	Liquid (carbonated drinks)	Oxygen in water, CO_2 in water
Gas	Solid	Absorption of H_2 by palladium
Liquid	Liquid	Alcohol in water
Liquid	Solid	Mercury in silver
Solid	Liquid	Sugar, salt
Solid	Solid (steel)	Metal Alloys: Carbon in iron
Liquid	Gas	Vapour, fog
Solid	Gas	Smog, soot particle.

I [Ways of expressing concentration]

(I) weight ratio
(II) weight percent
(III) Volume ratio
(IV) Volume percent

} Used in preparing commercial reagent

(V) Molarity
(VI) Normality
(VII) Molality
(VIII) Formality.

} Used in preparing laboratory reagent

(IX) Mole fraction

Description:

Let AB is finding solution where A = solvent and B = solute

m_A, M_A are the mass and moles of solvent

m_B, M_B are the mass and moles of solute

E_A, V_A are the equivalent weight and volume of the solvent

E_B, V_B are the equivalent weight and volume of the solute.

(i) Weight ratio of B in AB = $\frac{\text{weight of B}}{\text{weight of A}} = \boxed{\frac{m_B}{m_A}}$

(ii) weight percent of B in AB = $\frac{\text{weight of B}}{\text{Total weight of AB}} \times 100 = \boxed{\frac{m_B}{m_A + m_B} \times 100}$

(iii) Volume ratio of B in AB = $\frac{\text{Volume of B}}{\text{Volume of A}} = \boxed{\frac{V_B}{V_A}}$

(iv) Volume percent of B in AB = $\frac{\text{Volume of B}}{\text{Total volume of AB}} \times 100$

$$= \boxed{\frac{V_B}{V_A + V_B} \times 100}$$

(v) Molarity (M) is defined as the number of moles of solute per litre of solution.

$$M = \frac{\text{No. of moles of solute B}}{\text{Volume of solution}}$$

$$= \frac{m_B\,(g)}{M_B\,(g/m)} \times \frac{1000\ cm^3/L}{V\ cm^3} = \boxed{\frac{m_B}{M_B} \times \frac{1000}{V}\ \text{Mole/litre}}$$

(VI) **Normality** of a solution is defined as number of equivalent of solute per litre of the solution.

$$\text{Normality (N)} = \frac{\text{Equivalent of solute}}{\text{Volume of solution in litre}}$$

$$= \frac{\text{No. of equivalent of solute}}{\text{No. of L of solution}}$$

$$= \boxed{\frac{m_A}{E_B} \times \frac{1000}{V}} \text{ equivalent/L}$$

Relation between Molarity and normality

We know, molarity $= \frac{m_B}{M_B} \times \frac{1000}{V}$ — (i)

and normality $= \frac{m_B}{E_B} \times \frac{1000}{V}$ (ii)

(i) ÷ (ii) $\frac{\text{molarity}}{\text{normality}} = \frac{\frac{m_B}{M_B} \times \frac{1000}{V}}{\frac{m_B}{E_B} \times \frac{1000}{V}} = \frac{E_B}{M_B}$

$$\boxed{\frac{M}{N} = \frac{E_B}{M_B}}$$

C/M
Molarity

Molality of a solution (m) is defined as the number of moles of solute per kilogram of solvent.

$$\text{Molality} = \frac{\text{Moles of solute}}{\text{Mass of solvent in kilograms}}$$

$$C_m = \frac{\text{No of moles of solute}}{\text{No. of Kg of solute}} = \boxed{\frac{m_B\,(g)}{M_B\,(g/M)} \times \frac{1000}{w}}$$

Mole fraction is defined as the ratio of no of moles of solute to the total number of moles of solution.

$$X_{solute} = \frac{\text{Moles of solute}}{\text{Moles of solute} + \text{Moles of solvent}}$$

$$\boxed{X_B = \frac{n_B}{n_A + n_B}}$$

$$\boxed{X_A = \frac{n_A}{n_A + n_B}}$$

$$\boxed{X_A + X_B = 1}$$

X_A = mole fraction of A
X_B = mole fraction of B
n_A = no of moles in solvent
n_B = no of moles in solute.

Classification of solution of solid in liquid

(a) **Saturated solution**: The amount of solution in a particular volume of solvent at a particular temperature as much as it can be hold.

(b) **Unsaturated solution**: The amount of solution in a particular volume of solvent at a particular temperature less than it can hold.

(c) **Super saturated solution**: The amount of solution in a particular volume of solvent at a particular temperature more than it can hold. precipitation

Classification of solution of liquid in liquid:

(a) completely miscible solution — e.g. alcohol and water

(b) Partially miscible solution - e.g ether and water

(c) Immiscible solution - e.g. benzene and water

Solubility:

The solubility is defined as the concentration of the solute in solution when it is in equilibrium with the solid substance at a particular temperature

Factors affecting the solubility of solid in liquid

(1) **Nature of solute and solvent:**

Polar solutes dissolve easily in polar solvents while they remain insoluble in non-polar solvents. For example, NaCl is fairly soluble in water which is highly polar solvent, while it is insoluble in a non-polar solvent like chloroform. On the other hand, a non-polar solute does not dissolve in a polar solvent e.g benzene which is non polar is insoluble in water. The electrical attraction between the oppositely charged solute and the solvent molecules results to form a solution.

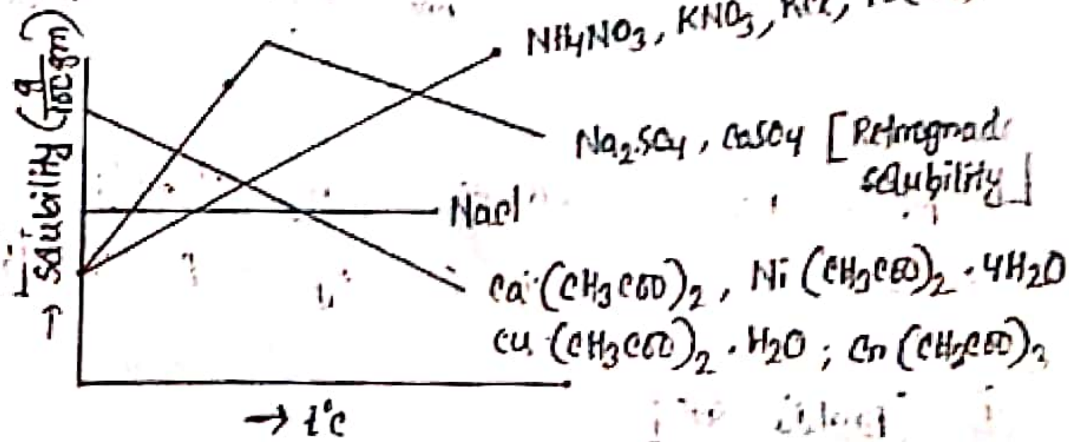
Example

$NH_4NO_3 \xrightarrow{H_2O} NH_4^+{}_{(aq)} + NO_3^-{}_{(aq)}$

$HgCl_2 \rightarrow Hg^{2+} + Cl^{2-}$

		Water	ethanol
NH_4NO_3	→	$\frac{192\ gm}{100\ gm}$	$\frac{3.8\ gm}{100\ gm}$
$HgCl_2$	→	$\frac{6.58\ gm}{100\ gm}$	$\frac{43.6\ gm}{100\ gm}$

② **Effect of temperature**



Generally, for most of the substances in solid-liquid system when the temperature is increase, their solubility also increases. But there are some substances whose characteristics are differ, from other. For NaCl, when its temperature is increase, its is still unchanged. That is the solubility of NaCl is constant. Again for Na_2SO_4 by its increasing temperature for a certain value, its solubility increases but after that value if the temperature increases the solubility decreases. We can relate the solubility and temperature as follows.

$$\frac{d}{dT}\ln K = \frac{\Delta H}{RT}$$

That is $$\ln\frac{K_2}{K_1} = -\frac{\Delta H}{RT}\left(\frac{1}{T_2}-\frac{1}{T_1}\right)$$

③ **Effect of pressure:**

Those which dissolves with the reduction in volume, solubility increases with the rise of pressure and vice-versa.

NaCl → 18°C when pressure 1 atm solubility = $\frac{26g}{100g\ H_2O}$

when pressure 500 atm solubility = $\frac{27g}{100g\ H_2O}$

NH_4Cl → 18°C, pressure 1 atm, solubility is more than 1 atm than solubility in pressure 500 atm

④ **Particle size:**

The smaller particle size, the higher solubility and the higher particle size the smaller solubility.

Example: $CaSO_4$ → Particle size = 2μ (origin size)

$$\text{Solubility} = \frac{2.067\,gm}{100g\ H_2O}$$

when particle size = 0.1μ

$$\text{Solubility} = \frac{2.987\,g}{100g\ H_2O}$$

3. **Henry's law**

For a gas in contact with a solvent at constant temperature, concentration of the gas that dissolves in the solvent is directly proportional to the pressure of the gas.

Mathematically Henry's law can be expressed as,

$$C \propto P$$
$$C = KP$$

Where P = Pressure of the gas
C = concentration of the gas in solution
K = constant

4. **Limitation of Henry's law**

It applies closely to gases with nearly ideal behaviour

(a) at moderate temperature and pressure

(b) If the solubility of the gas in the solvent is low.

(c) The gas does not associate or dissociate on dissolving in the solvent.