# Revision Notes on Solution:

A solution is a homogeneous mixture of two (or more) substances, the composition of which may vary between certain limits. A solution consisting of two components is called **binary solution**. The component which is present in large quantity is called **solvent** and the component which is small in quantity is called **solute**. If both components are in same physical state.
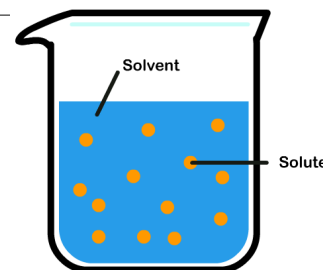
Type of Solutions

All the three states of matter (gas, liquid or solid) may behave either as solvent or solute. Depending on the state of solute or solvent, mainly there may be the following seven types of binary solutions.

S.No.	Solute	Solvent	Example
1	Gas	Gas	Air
2	Gas	Liquid	Aerated water (CO_2 + H_2O)
3	Gas	Solid	Hydrogen in palladium
4	Liquid	Liquid	Alcohol in water, benzene in toluene
5	Liquid	Solid	Mercury in zinc amalgam
6	Liquid	Gas	CO_2 dissolved in water
7	Solid	Liquid	Sugar in water, common salt in water
8	Solid	Gas	Smoke
9	Solid	Solid	Various alloys

Vapour Pressure:

- The pressure exerted by vapours over the liquid surface at equilibrium is called **vapour pressure** of the liquid.

- If solute is non volatile solid or liquid the vapour pressure of solution is equal to partial vapour pressure of solvent in the solution.

- If the solute is volatile solid or liquid, then vapour pressure will be equal to the sum of partial vapour pressure of solute and that of solvent.

Raoult's Law:

"The partial vapour pressure of any component in the solution is directly proportional to its mole fraction".

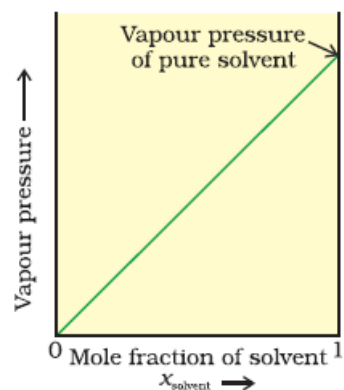For a binary solution of two components A and B,

$P_A = X_A$

$P_B = X_B$

Where

P^0_A = vapour pressure of component A in pure state.

P_A = vapour pressure of component A in the solution.

P^0_B = vapour pressure of component B in pure state.

P_B = vapour pressure of component B in the solution

Limitations of Raoult's Law

- Raoult's law is applicable only to very dilute solutions.

- It is applicable to solutions containing non-volatile solute only.

- It is not applicable to solutes which dissociate or associate in a particular solution

Raoult's Law in Combination with Dalton's Law of Partial Pressure:

$$P_T = X_A P^0_A + X_B P^0_B = P^0_B + (P^0_A - P^0_B) X_A$$

Where

P_T = Total Vapour Pressure of the Solution.

Ideal and Non-Ideal Solutions:

- **Ideal Solution:**

?These solutions obey Raoult's law at all compositions of solute in solvent at all temperature

Two liquids A and B form and ideal solution when A –A and B–B molecular attractions will be same and hence A–B molecular attraction will be almost same as A–A and B–B molecular attraction.

For Ideal Solution:

1. $dH_{mixing} = 0$, i.e. no heat should be absorbed or evolved during mixing

2. $dV_{mixing} = 0$, i.e. no expansion or contraction on mixing

Examples , Ethyl chloride and ethyl bromide, n–hexane and n–heptane , CCl_4 and $SiCl_4$

- **Non-Ideal Solution:**

?These solutions deviate from ideal behaviour and do not obey Raoult's law over entire range of composition.

For non ideal solutions,

1. $dH_{mixing} \neq 0$
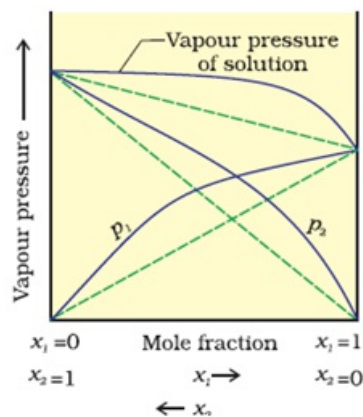
2. $dH_{mixing} \neq 0$

Here we may have two cases

A) Positive Deviation:

1. $P_A > X_A$ **&** $P_B > X_B$

2. $dH_{mix} > 0$

3. $dV_{mix} > 0$

Example: Cyclohexane and Ethanol

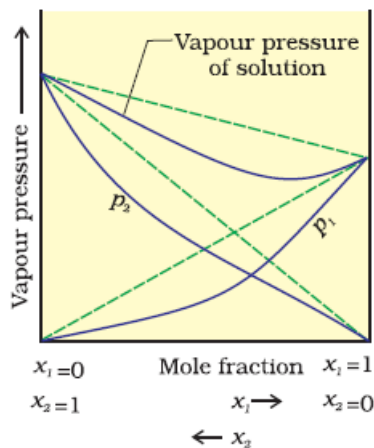**B) Negative Deviation:**
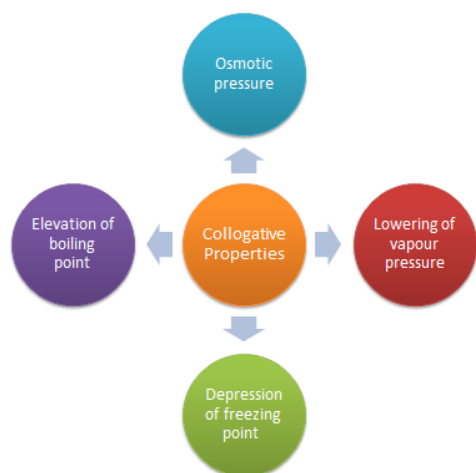
1. $P_A > X_A$ **&** $P_B > X_B$

2. $dH_{mix} < 0$

3. $dV_{mix} < 0$

Colligative Properties

The properties of dilute solutions which depend only on number particles of solute present in the

solution and not on their identity are called ***colligative properties*** (denoting depending upon collection).


Lowering of Vapour Pressure by a Non-Volatile Solute

The relative lowering of vapour pressure of a solution containing a non-volatile solute is equal to the mole fraction of the solute present in the solution.

$$\frac{p_1^0 - p_1}{p_1^0} = \frac{w_2 \times M_1}{M_2 \times w_1}$$

## Elevation of Boiling Point by a Non-Volatile Solute :

Since the addition of a non-volatile solute lowers the vapour pressure of the solvent, the vapour pressure of a solution is always lower than that of the pure solvent, and hence it must be heated to a higher temperature to make its vapour pressure equal to atmospheric pressure.
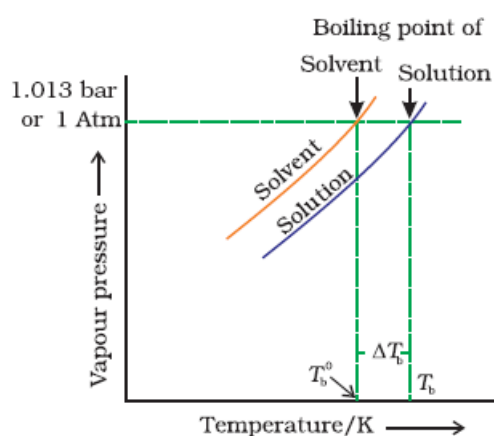
$$\Delta T_b = \frac{K_b \times 1000 \times w_2}{M_2 \times w_1}$$

where M_1 = molecular weight of solute and w_2 and w_1 are weights of solute and solvent

Depression of Freezing Point by a Non-Volatile Solute:
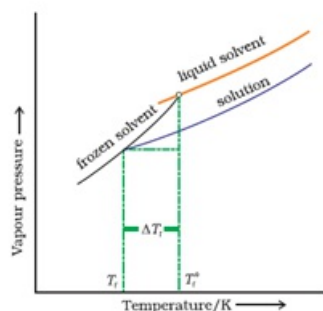
$$\Delta T_f = \frac{K_f \times w_2 \times 1000}{M_2 \times w_1}$$

where M_1 = molecular weight of solute and w_2 and w_1 are weights of solute and solvent

Osmosis and Osmotic Pressure:

- **Osmosis:** The phenomenon of the passage of pure solvent from a region of lower concentration (of the solution) to a region of its higher concentration through a semi-permeable membrane.

- **Osmotic Pressure:** Excess pressure which must be applied to a solution in order to prevent flow of solvent into the solution through the semi-permeable membrane.

$\pi V = nRT$

where

π = Osmotic pressure

V = volume of solution

n = no. of moles of solute that is dissolved

R = Gas constant

T = Absolute temperature

sotonic Solutions: A pair of solutions having same osomotic pressure is called isotonic solutions.

## Abnormal Molecular Weight and Van't Hoff Factor:

Van't Hoff Factor:

Van't Hoff, in order to account for all abnormal cases introduced a factor **i** known as the Van't Hoff factor, such that

$$i = \frac{\text{Observed colligative property (actual)}}{\text{Theoretical colligative property (expected)}}$$

$$= \frac{\text{No. of molecules actually present}}{\text{No. of molecules expected to be present}}$$

Degree of Association:

The fraction of the total number of molecules which combine to form bigger molecule

$$nA \rightleftharpoons (A)_n$$
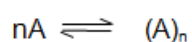
Let a be the degree of association, then,

The number of unassociated moles = $1-\alpha$

The number of associated moles = α/n
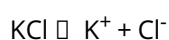
Total number of effective moles = $1-\alpha+\alpha/n$

$$i = \frac{1-\alpha+\alpha/n}{1}$$

$$i = 1 - \alpha\,(1-1/n)$$

Obviously, $i < 1$

Degree of Dissociation

The fraction of the total number of molecules which dissociates in the solution, that is, breaks into simpler molecules or ions.

$KCl \rightleftharpoons K^+ + Cl^-$

$1-\alpha \quad \alpha \quad \alpha$

Thus, the total number of moles after dissociation $= 1-\alpha+\alpha+\alpha = 1+\alpha$

Hence, $i = (1+\alpha)/1$

$i = 1 + \alpha = 1 + (2-1)\alpha$

In general, **i = 1+ (n–1) α,**

Where, n = number of particles (ions) formed after dissociation

From the above formula, it is clear that **i > 1**