

⇒ Types of Solution

S.No.	Solute	Solvent	Examples
1	Gas	Gas	Air
2	Gas	Liquid	CO ₂ and O ₂ in H ₂ O
3	Gas	Solid	Fog H ₂ in Pt/Pd
4	Liquid	Gas	Fog, Humidity in Air
5	Liquid	Liquid	C ₂ H ₅ OH in H ₂ O, Milk in H ₂ O
6	Liquid	Solid	Hg in Zn, Amalgam of Hg in Na
7	Solid	Gas	Smog, camphor in N ₂
8	Solid	Liquid	Sugar & Salt in H ₂ O
9	Solid	Solid	Alloys

⇒ Concentration of Solution

① Mass percentage (w/w) %

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

② Volume percentage (V/V) %

$$= \frac{\text{Volume of Component}}{\text{Total Volume of Sol}^n} \times 100$$

③ Mass by Volume (M/V) %

$$= \frac{\text{Mass of Solute}}{\text{Total Vol. of Sol}^n} \times 100$$

④ Parts per millions (PPM)

$$= \frac{\text{Mass of Solute} \times 10^6}{\text{Total mass of Sol}^n}$$

⑤ Mole fraction (x)

Let, solute = A, Solution = B

$$X_{\text{solute}} = X_A = \frac{n_A}{n_A + n_B}$$

$$X_{\text{solvent}} = X_B = \frac{n_B}{n_A + n_B}$$

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

⑥ Molarity (M)

$$M = \frac{n}{V(L)} = \frac{W}{M} \times \frac{1}{V(L)}$$

⑦ Molality (m)

$$m = \frac{n}{W(\text{kg})} = \frac{W}{M} \times \frac{1}{W(\text{kg}_m)}$$

⑧ Normality (N)

$$N = \frac{\text{No. of gram Equivalent Mass of Solute}}{\text{Vol. of Sol}^n (\text{in L})}$$

$$\text{Equivalent Mass} = \frac{MM}{\text{Valency factor}}$$

⇒ Henry's law: It states that the solubility of a gas in liquid is directly proportion to pressure of a gas.

$$m \propto P$$

$$\boxed{m = k_H \cdot P}$$

Henry constant

mass of gas Pressure of gas

it also state that

$$p \propto X$$

$$\boxed{p = k_H \cdot X}$$

Henry constant

Partial Pressure of gas Mole fraction of gas

- Application - ① To increase the solubility of CO_2 in Softdrink, bottle is ceiled under High pressure.

② To avoid the solubility of Nitrogen in blood, the oxygen cylinder taken by a Scuba diver oxygen is diluted with helium.

[11.7% He, 56.2% N_2 + 32.1% O_2]

③ At Higher altitude the partial pressure of O_2 is Higher than the ground level, so the thinking Ability is reduced this process is known

Anoxia.

⇒ Vapour Pressure: The pressure exerted by Vapours in equilibrium with liq. is known as Vapour pressure

Factors: ① Pure solvent exert higher Vapour pressure.

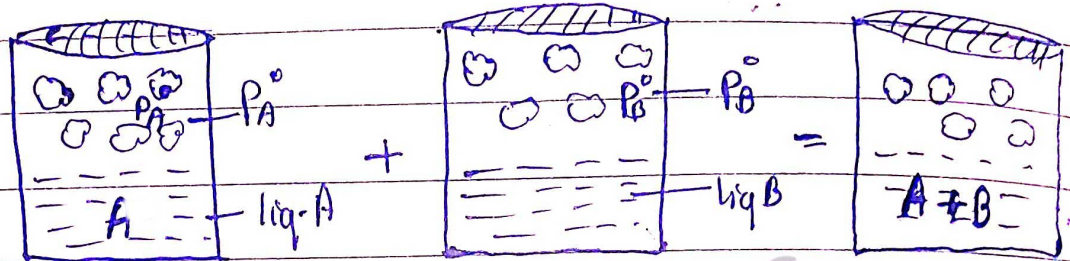
② Volatile liquid exert higher Vapour pressure.

③ Vapour pressure increase with increase the Temperature.

⇒ Vapour pressure of liquid-liquid solutions.

⇒ Rault's law:- It states that at constant temp.

The vapour pressure of liquid is directly proportional to mole fraction of liquid in solution.



$$P_A \propto X_A$$

$$P_B \propto X_B$$

$$P_T = P_A + P_B$$

$$P_A = P_A^0 X_A$$

$$P_B = P_B^0 X_B$$

— (1)

— (2)

Apply Dalton's law of partial pressure

$$P_T = P_A + P_B$$

$$P_T = P_A^0 X_A + P_B^0 X_B$$

we know that, $X_A + X_B = 1$

$$X_A = 1 - X_B$$

P_T

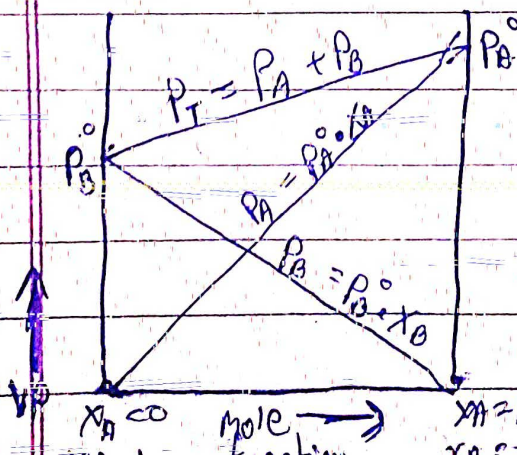
$$P_T = P_A^0 (1 - X_B) + P_B^0 X_B$$

$$P_T = P_A^0 - P_A^0 X_B + P_B^0 X_B$$

$$P_T = P_A^0 + (P_B^0 - P_A^0) X_B \quad \text{--- (3)}$$

OR

$$P_T = P_B^0 + (P_A^0 - P_B^0) X_A \quad \text{--- (4)}$$



⇒ Vapour pressure of liquid - solid Solution:

$$A = \text{Volatile liquid} = P_A = P_A^\circ \cdot X_A$$

$$B = \text{Non-Volatile Solute} = P_B = 0$$

$$P_T = P_A$$

$$= P_A^\circ \cdot X_A$$

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

$$P_T = P_A^\circ - P_A^\circ \cdot X_B$$

$$P_A \cdot X_B = P_A^\circ - P_T \longrightarrow \text{lowering of V.P.}$$

$$X_B = \frac{P_A^\circ - P_T}{P_A^\circ} \longrightarrow \text{Relative lowering of V.P.}$$

⇒ Ideal and Non-Ideal Solution:

⇒ Ideal Solution: Those Solution which obey Raoult's law at all concentration & at all Temperature.

$$P_T = P_A^\circ \cdot X_A + P_B^\circ \cdot X_B$$

For ideal solution.

$$\Delta V_{\text{mix}} = 0$$

$$\Delta H_{\text{mix}} = 0$$

$$F_{A-B} = F_{A-A} + F_{B-B}$$

Examples - ① Benzene + Toluene.

② chlorobenzene + bromobenzene

③ Ethanol + Methanol

④ CCl_4 + SiCl_4

$$P_T \neq P_A^\circ \cdot X_A + P_B^\circ \cdot X_B$$

For non ideal solution-

① $\Delta V_{mix} \neq 0$

② $\Delta H_{mix} \neq 0$

③ $F_{A-B} \neq F_{A-A} + F_{B-B}$

Types of Non-ideal Solution

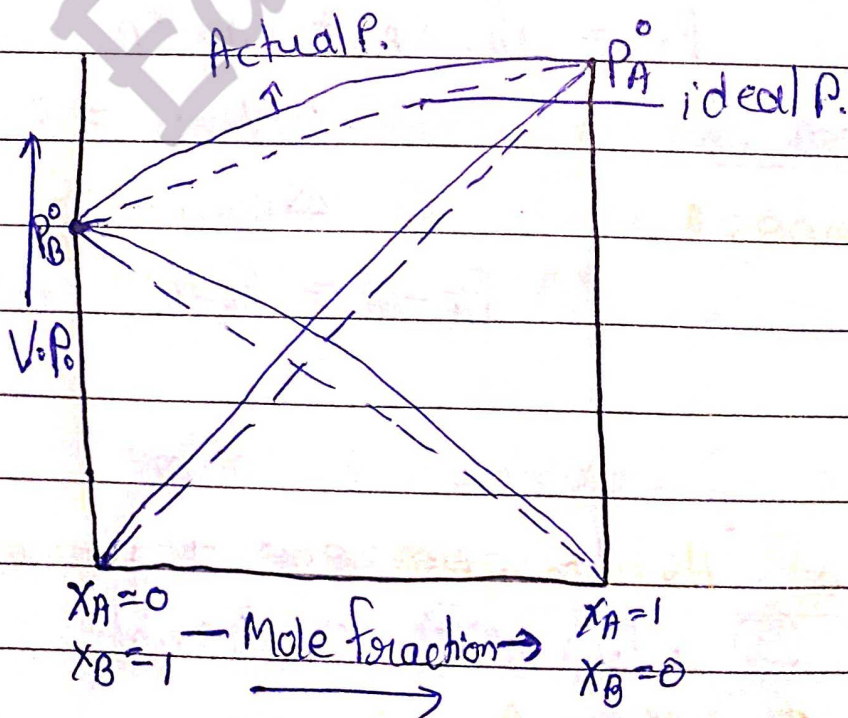
- a. Positive deviation - $\rightarrow F_{A-B} < F_{A-A} + F_{B-B}$
 $\rightarrow P_T > P_A^\circ X_A + P_B^\circ X_B$
 $\rightarrow \Delta V > 0$
 $\rightarrow \Delta H > 0$

Example - ① Ethanol + H₂O

② Methanol + H₂O

③ Benzene + Ethanol

④ Benzene + Acetone



b. Negative deviation - $\rightarrow F_{A-B} > F_{A-A} + F_{B-B}$

$$\rightarrow P_T < P_A^{\circ} X_A + P_B^{\circ} X_B$$

$$\rightarrow \Delta V < 0$$

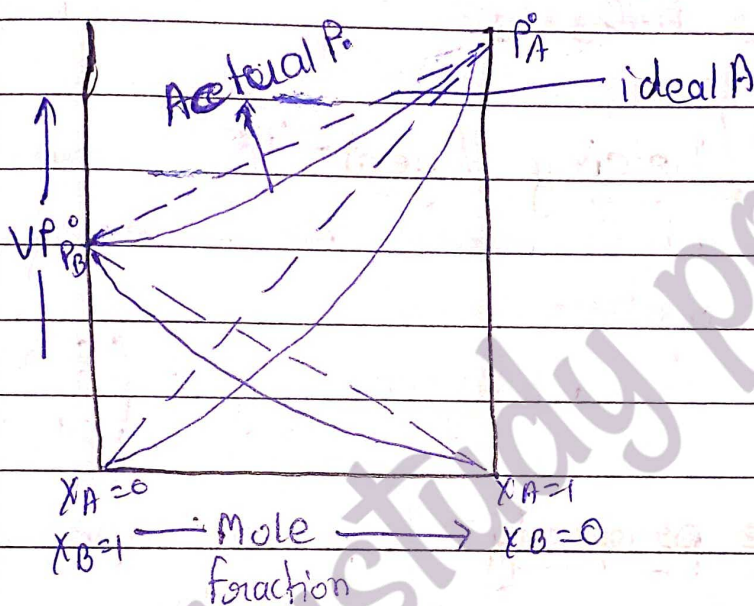
$$\rightarrow \Delta H < 0$$

Example - ① $\text{HNO}_3 + \text{H}_2\text{O}$

② $\text{HCl} + \text{H}_2\text{O}$

③ $\text{CHCl}_3 + \text{Acetone}$

④ $\text{CHCl}_3 + \text{Benzene}$



imp

\Rightarrow Azeotropes: These are the Binary Mixture having same composition and Boil at constant Temperature.

Types of Azeotropes:

① Minimum Boiling Azeotropes

\rightarrow They are formed by non-ideal Solution of positive deviation.

\rightarrow B.P. of Azeotropes is lower than either of their pure Component.

Example:- Ethanol (95.5%) + H₂O (4.5%)
[Rectified Spirit]

② Maximum Boiling Azeotropes

- They are formed by non-ideal solution of negative deviation
- B.P. of Azeotropes is Higher than either of their pure components.

Example:- HNO₃ (68%) + H₂O (32%)

③ Antifreeze / Deicing Agent - Those substance which lower the freezing point of water.

Example:- Salt, ethylene glycol $\begin{pmatrix} \text{CH}_2 - \text{OH} \\ | \\ \text{CH}_2 - \text{OH} \end{pmatrix}$

⇒ Colligative property → Depends upon quantity of particles.

- ① Relative lowering of Vapour pressure
- ② Elevation of Boiling point
- ③ Depression of freezing point
- ④ Osmotic pressure

① Relative lowering of Vapour pressure

$$\frac{P_A^\circ - P_t}{P_A^\circ} = X_B$$

$$\frac{P_A^\circ - P_t}{P_A^\circ} = \frac{n_B}{n_A + n_B}$$

for dilute solution, $n_A \gg \gg n_B$

$$\frac{P_A^\circ - P_t}{P_A^\circ}$$

$$\boxed{\frac{P_A^\circ - P_t}{P_A^\circ} = \frac{w_B \times M_A}{w_A \times M_B}}$$

② Elevation of Boiling point - (Ebulliscopy)

The difference in B.P. of solution to that of pure solvent is known as Elevation of Boiling point.

$$\Delta T_b = T_b - T_b^\circ$$

$$\Delta T_b \propto m$$

$$\Delta T_b = k_b \cdot m \quad \text{--- (1)}$$

where k_b = molal elevation constant or Ebulliscopy const.

$$k_b = 0.52 \text{ K kg mol}^{-1}$$

if $m = 1$

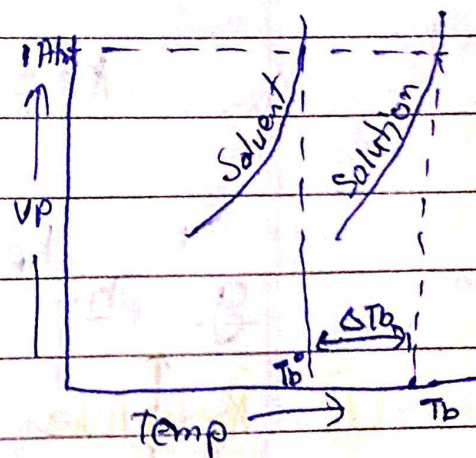
$$\Delta T_b = k_b$$

we know that

$$m = \frac{w_B}{M_B} \times \frac{1000}{w_A}$$

from eqⁿ (1)

$$\boxed{\Delta T_b = \frac{k_b \cdot w_B \times 1000}{M_B \times w_A}}$$



③ Depression of freezing point (Cryoscopy)

The difference in freezing point of solvent to that of the solution is known as depression of freezing point.

$$\Delta T_f = T_f^\circ - T_f$$

$$\Delta T_f \propto m$$

$$\Delta T_f = k_f \cdot m \quad \text{--- (1)}$$

if $m = 1$

then $\Delta T_f = k_f$

we know that

$$m = \frac{W_B}{M_B} \times \frac{1000}{W_A}$$

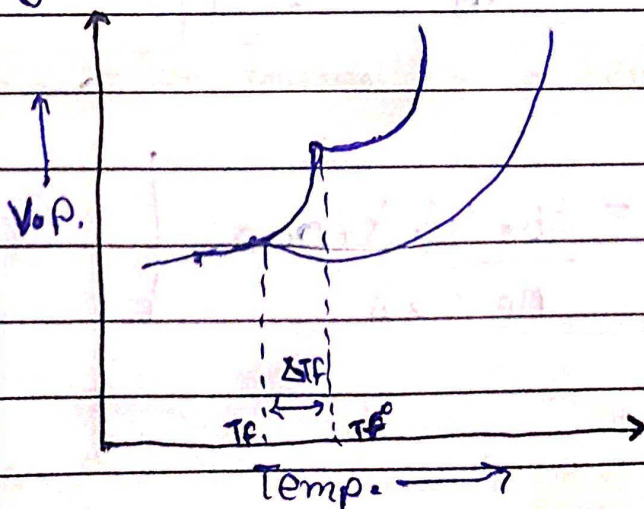
from eqⁿ (1)

$$\Delta T_f = \frac{k_f \cdot W_B \times 1000}{M_B \times W_A}$$

k_f = Molal depression constant or
Cryoscopy constant.

$$k_f = 0.52 \text{ K kg/mol}$$

graph -



④ Osmosis & Osmotic pressure: The Spontaneous

A.e. Flow of Solvent into solution through a Semipermeable Membrane (S.P.M)

SPM:-

- ① Natural SPM:- Parchment paper, living cell wall
- ② Artificial SPM:- Copper ferrocyanide, calcium phosphate, freshly prepared silicates of Fe, Co, Ni.

⇒ Osmotic pressure (π): The external pressure which must be applied on solution in order to stop flow of solvent into solution through SPM.

Mathematically: $\pi \propto CRT$

$$\pi = CRT, \text{ where-}$$

R = Solution constant.

$$= 0.0821 \text{ atm L/mol}$$

⇒ Reverse Osmosis: The external pressure is higher than osmotic pressure which applied to solution in order to flow of solvent from solution into pure solvent through SPM.
Ex - Desalination of water

⇒ Isotonic Solution:-

$$\pi_1 = \pi_2$$

i/c

$$C_1 = C_2$$

⇒ Isosmotic Solution when two isotonic solution can be separated by semi permeable membrane (SPM)

⇒ Hypotonic & Hypertonic Solution :- A solution having low osmotic pressure than other solution is known as hypotonic solution.

Ex - RBC cell will swell when it placed in Hypotonic Solⁿ

→ A solution having higher osmotic pressure than other solution is known as hypertonic Solⁿ

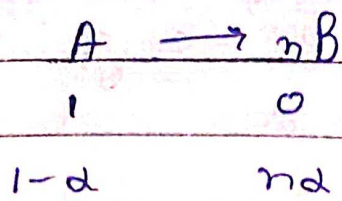
Ex - RBC cell will shrink when it placed in Hypertonic solution.

np ⇒ Van't Hoff factor (i):-

$$i = \frac{\text{observed colligative property}}{\text{Calculated colligative property}}$$

(a) Degree of dissociation

$$\alpha = \frac{\text{no. of moles dissociated}}{\text{Total no. of moles taken}}$$



$$\text{Total moles} = 1 - \alpha + n\alpha = 1 + (n-1)\alpha$$

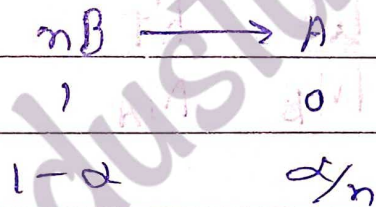
$$i = \frac{\text{observed colligative property}}{\text{Calculated colligative property}}$$

$$i = \frac{1 + (n-1)\alpha}{1} \Rightarrow i = 1 + (n-1)\alpha$$

$$\alpha = \frac{n \cdot i - 1}{n - 1}$$

(b) Degree of Association:

$$\alpha = \frac{\text{no. of Moles Associated}}{\text{Total no. of Moles taken}}$$



$$\text{Total moles} = 1 - \alpha + \alpha/n = 1 + (\frac{1}{n} - 1)\alpha$$

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

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

Case-I - Molecules neither Associate or dissociate
 $i = 1$

Case-II - Dissociation - $i > 1$

Case-III - Associates - $i < 1$

Modified expression of colligative properties for substance undergo Association & dissociation

① Relative lowering of Vapour pressure.

$$\frac{P_A^\circ - P_T}{P_A^\circ} = i X_B$$

② Elevation of Boiling point

$$\Delta T_b = i k_b \cdot m$$

③ Depression of freezing point

$$\Delta T_f = i k_f \cdot m$$

④ Osmotic pressure

$$\pi = i \frac{W_B}{M_B} \cdot \frac{RT}{M_A}$$