VAPOUR PRESSURE OF LIQUID SOLUTIONS

Vapour Pressure

Under constant temperature conditions, the pressure exerted by a liquid's vapors on its surface, when the liquid and its vapors are in a state of equilibrium, is referred to as vapor pressure.

Raoult's Law

In accordance with this principle, the partial pressure of any volatile components within a solution at a consistent temperature equals the vapor pressure of the pure components multiplied by the mole fraction of that particular component present in the solution.

(i) For liquid – liquid solution

Consider a mixture (solution) formed by combining n_A moles of liquid A and n_B moles of liquid B. Let P'_A and P'_B represent the partial pressures of the two constituents, A and B, within the solution, while P_A^0 and P_B^0 denote their respective vapor pressures in their pure states.

Thus, according Raoul's law

$$P'_A = \frac{n_A}{n_A+n_B} P_A^0 \qquad \text{....(i)}$$

Partial pressure of A = mole fraction of A × $P_A^0 = X_A P_A^0$

$$\text{and } P'_B = \frac{n_B}{n_A+n_B} P_B^0 \qquad \text{....(ii)}$$

Partial pressure of B = mole fraction of B × $P^0 = X_B P_D^0$

If total pressure be P_s , then

$$P_s = P'_A + P'_B$$

$$= \frac{n_A}{n_A+n_B} P_A^0 + \frac{n_B}{n_A+n_B} P_B^0$$

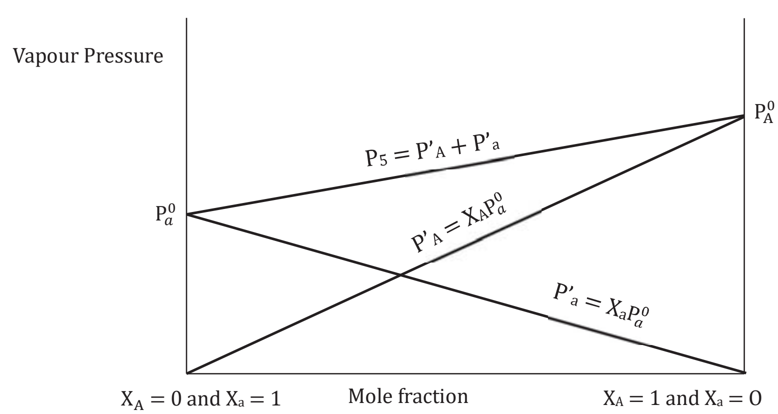
$$= X_A P_A^0 + X_B P_D^0 \qquad \text{.... (iii)}$$

$$P_S = X_A P_A^0 + (1 - X_A) P_D^0 \quad [\because X_A + X_B = 1].$$

$$P_S = X_A P_A^0 - X_A P_B^0 + P_B^0 .$$

$$P_S = X_A [P_A^0 - P_B^0] + P_B^0 \qquad \text{.... (iv)}$$

Equation 1, 2 and 3 are the straight-line equation so we can draw it as follows.



(ii) For Solid – liquid solution

A = non-volatile solids

B = volatile liquid

According to Raoul's law –

∵ $$P_m = X_A P_A^0 + X_B P_B^0$$

For $$A, P_A^0 = 0$$

∴ $$P_m = X_B P_B^0$$

Let $P_B^0 = P^0$ Vapour pressure of pure state of solvent. here X_B is mole fraction of solvent

$$P_s = \frac{n_B}{n_A + n_B} P^0$$

$$P_s \propto \frac{n_B}{n_A + n_B}$$

i.e., vapour pressure of solution ∝ mole fraction of solvent

⇒ $$P_s = X_B P_B^0$$

⇒ $$P_s = (1 - X_A) P_B^0$$

⇒ $$P_s = P_B^0 - X_A P_B^0$$

$$\frac{P_B^0 - P_s}{P_B^0} = X_A$$

$$\frac{P^0 - P_s}{P^0} = X_A$$

$$\frac{P^0 - P_S}{P^0} - \frac{n_A}{n_A + n_B}$$

$$\frac{P^0}{P^0 - P_s} = \frac{n_A + n_B}{n_A}$$

$$\text{or } \frac{P^0}{P^0 - P_s} - 1 + \frac{n_B}{n_A}$$

$$\text{or } \frac{P^0}{P^0 - P_s} - 1 = \frac{n_B}{n_A}$$

$$\text{or } \frac{P_s}{P^0 - P_s} = \frac{n_B}{n_A}$$

$$\frac{P^0 - P_S}{P_S} = \frac{n_A}{n_B}$$

$$\text{or } \frac{P^0 - P_S}{P_S} = \frac{w_A \cdot m_B}{m_A \cdot w_B}$$

$$\text{or } \frac{wM}{mW}$$