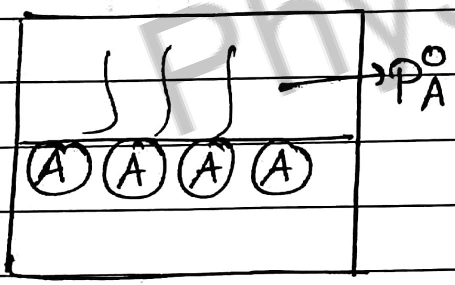
Class 12 chapter 01: Solutions Lecture-03

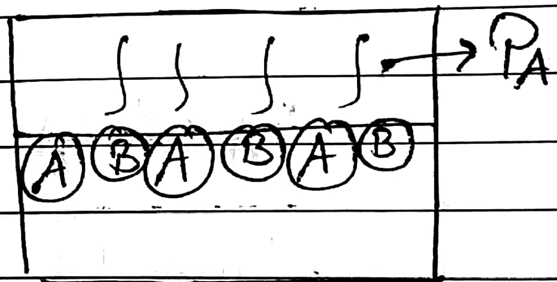
Vapour Pressure of Solution Containing Non Volatile Solute.

	Solute (B)	Solvent (A)
nature →	non volatile	volatile
physical state →	Solid	Liquid
vapour Pressure →	0	P_A^0
Mole fraction →	χ_B	χ_A



Pure A

P_A^0 (VP of pure A)



Solution (A+B)

Due to some non-volatile solute molecules, evaporation of A is also decreased

⇓

less vapours in solutions $\Rightarrow P_A < P_A^0$

$\Rightarrow$ Lowering In VP on addition of Non volatile Solute

RAULT'S LAW

"for any solution, the partial VP of each volatile component in the solution is directly proportional to its mole fraction"

— NCERT

So In solution

$$P_T = P_A + P_B$$

$P_B \to 0$ (non volatile)

$$P_T = P_A$$ (Here VP of solution is only due to Solvent A)

$$P_A \propto \chi_A$$

$$\boxed{P_A = P_A^0 \chi_A}$$

$$P_A = P_A^0 (1 - \chi_B)$$

$$P_A = P_A^0 - P_A^0 \chi_B$$

$$P_A^0 \chi_B = (P_A^0 - P_A) \rightarrow \text{lowering in VP}$$

$$\boxed{\chi_B = \frac{P_A^0 - P_A}{P_0}}$$

$P_A^0 \rightarrow$ VP of Pure Solvent

$P_A \rightarrow$ VP of Solution

χ_B → Mole fraction of solute

$\frac{P_A^0 - P_A}{P_0}$ → Relative lowering in VP

Quality of solute does not matter ⟸ **Colligative property** ⟹ Quantity of solute matters

Colligative property:

Those properties of solutions which depends only on number of solute particles (moles/molecules/ions/mole fraction) of solute particles & do not depend upon nature of solute particles.

Relative Lowering in VP $= \chi_{solute} = \dfrac{n_{solute}}{n_{solute} + n_{solvent}}$

↓

$$\boxed{\frac{P_A^0 - P_A}{P_A^0} = \chi_{\substack{solute \\ (B)}}}$$

Q1) The VP of pure water is 60 mm Hg. If 30 gm of urea (NH_2CONH_2 - solid non volatile) is added to 72 g of water. Find VP of solution.

Solution Method 1:

$$\frac{P_A^0 - P_A}{P_A^0} = \chi_B$$

B → Solute → urea
A → Solvent → water

$$\frac{60 - P_A}{60} = \frac{n_B}{n_B + n_A}$$

$n_B = \frac{30}{60} = 0.5$

$n_A = \frac{72}{18} = 4$

$$\frac{60 - P_A}{60} = \frac{0.5}{4.5}$$

$$\frac{60 - P_A}{\cancel{60}\,20} = \frac{1}{\cancel{9}\,3} \Rightarrow 180 - 3P_A = 20$$

$P_A = \frac{160}{3} = 53.33$ mm Hg

Method 2:

$$P_{solution} = P_A = P_A^o X_A$$
$(\because B \text{ is non volatile})$

$$P_{solution} = 60 \times \frac{4}{4.5}$$

$$= \frac{\overset{20}{\cancel{60}} \times \cancel{40}\ 8}{\cancel{45}\ \cancel{9}\ 3}$$

$$= \frac{160}{3} = 53.33 \text{ mm Hg}$$

Q2) Calculate the mass of a non-volatile (non electrolyte) solute (Molar Mass 40 g/mol) which should be dissolved in 114 g octane to reduce its VP to 80 %.

Solution:

Let $P_A^o = 100$

$P_A = 80$

octane C_8H_{18} $M = 114g$

$$n_A = \frac{114}{114} = 1$$

$$n_B = ?$$

$$\frac{P_A^o - P_A}{P_A^o} = X_B$$

$$\frac{100-80}{100} = \frac{n_B}{n_B + n_A}$$

$$\frac{20}{100} = \frac{n_B}{n_B + 1}$$

$$\frac{1}{5} = \frac{n_B}{n_B + 1}$$

$$5 = \frac{n_B + 1}{n_B}$$

$$5 = 1 + \frac{1}{n_B}$$

$$n_B = \frac{1}{4}$$

$$n_B = \frac{\text{mass}}{\text{Molar Mass}}$$

$$\frac{1}{4} = \frac{x}{40}$$

$x = 10g$ Ans

Q3) The VP of water is 12.3kPa at 300K. Calculate VP of 1molal solution of a non volatile solute in it.

Solution:

1 molal = 1 mole solute in 1kg solvent (water) (A)

$$P_{solution} = P_A^\circ \chi_A$$

$$= 12.3 \times \frac{n_A}{n_A + n_B}$$

$$= 12.3 \times \frac{\frac{1000}{18}}{\frac{1000}{18} + 1}$$

$$\simeq 12.08 \text{kPa}$$