Dr S.K. Gupta
Dept of Chemistry
Ramjas College

Deg-I(H) - Solution
Topics - Colligative Properties (CP)

Colligative - Property in the properties of dilute solution of non-volatile solute whose value depends upon number of solute particle (concentration of solute particle) but not upon the individual identity of solute (nature of solute) are called colligative properties

Various Colligative Properties:-
1. Relative lowering of Vapour pressure
2. Elevation of boiling point
3. Depression of freezing point
4. Osmotic Pressure.

Relative lowering of V.P.

As we know when a non-volatile solute solid is added to the solvent its vapour pressure of solution decreases

Let x_A be the mole fraction of solvent & x_B the mole fraction of solute

Solute is non-volatile it has no contribution of solute particle towards vapour Pressure

of solution: The vapour pressure of solution (P_s) will be equal to the V.P of solvent (P_0) over the solution.

V.P of Solution = P_s

V.P of Solvent = P_0

Thus lowering in V.P = $P_0 - P_s$

Relative lowering of V.P = $\frac{P_0 - P_s}{P_0}$

X_A = mole fraction of solvent

X_B = ---- solute

$= \frac{\Delta P}{P_0}$

Raoult's law of relative lowering of Vapours Pressure:

According to Raoult's law

The relative lowering of V.P is directly proportional to the mole fraction of solute for a solution containing non volatile solute at constant temp.

Thus $\frac{\Delta P}{P_0} = X_B$

or, $\frac{P_0 - P_s}{P_0} = \frac{n_B}{n_A + n_B}$

$\because n_A >>> n_B$

Thus $\frac{P_0 - P_s}{P_0} = \frac{n_B}{n_A}$

$\frac{P_0 - P_s}{P_0} = \frac{W_B/M_B}{W_A/M_A}$

$\frac{P_0 - P_s}{P_0} = \frac{W_B \times M_A}{W_A \times M_B}$

We know that

$X_A + X_B = 1$

$X_A = \frac{n_A}{M_A}$, $X_B = \frac{n_B}{M_B}$

W_A = wt of solvent

W_B = ---- solute

M_A = mol wt of solvent

M_B = ---- solute

n_A = mole of solvent

n_B = ---- solute

Scanned with CamScanner

Determination of Molar Mass of a solute from Relative lowering of vapour Pressure.

molar mass of solute (M_B) can be Calculated by using Relative lowering of Vapour Pressure.

We see that, $\frac{P_0 - P_s}{P_0} = \frac{W_B \times M_A}{W_A \times M_B}$

$\therefore$ $$M_B = \frac{W_B \times M_A}{W_A \times \left(\frac{P_0 - P_s}{P_0}\right)}$$

Alternative derivation of Relative lowering of V.P from Raoult's law.

$$\frac{P_0 - P_s}{P_0} = \frac{n_B}{n_A + n_B}$$

After Rearranging

$$\frac{P_0}{P_0 - P_s} = \frac{n_A + n_B}{n_B}$$

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

$$\frac{P_0}{P_0 - P_s} - 1 = \frac{n_A}{n_B}$$

$$\frac{P_0 - P_0 + P_s}{P_0 - P_s} = \frac{n_B}{n_A}$$

$$\frac{P_s}{P_0 - P_s} = \frac{W_B}{M_B}$$

Scanned with CamScanner

If By Rearranging

$$\frac{P_0 - P_s}{P_s} = \frac{n_B}{n_A}$$

If $$\boxed{\frac{P_0 - P_s}{P_s} = \frac{W_B}{W_A} \times \frac{M_A}{M_B}}$$

Numerical Problem :-

① A solution is made by mixing 32 gm Methanol & 23 gm ethanol at 300K Calculate the partial vapour of both the constituents & Total vapour pressure of the solution.

given $P^0_{CH_3OH} = 90$ mm, $P_{C_2H_5OH} =$

Solution :-

Moles of Methanol $= \frac{32}{32} = 1$ $\left(\frac{\text{Wt}}{\text{Mol. Mass}}\right)$

moles of ethanol $= \frac{23}{46} = 0.5$

Total moles of solution $= 1.5$

$$P_{CH_3OH} = P^0_{CH_3OH} \times X_{CH_3OH}$$

$$= 90 \times \frac{1}{1.5}$$

$$= 60 \text{ mm}$$

$$P_{C_2H_5OH} = P^0_{C_2H_5OH} \times X_{C_2H_5OH}$$

$$= 51 \times \frac{0.5}{1.5} = 17 \text{ mm}$$

Thus, $P_{Total} = 60 + 17 = 77$ mm

Scanned with CamScanner