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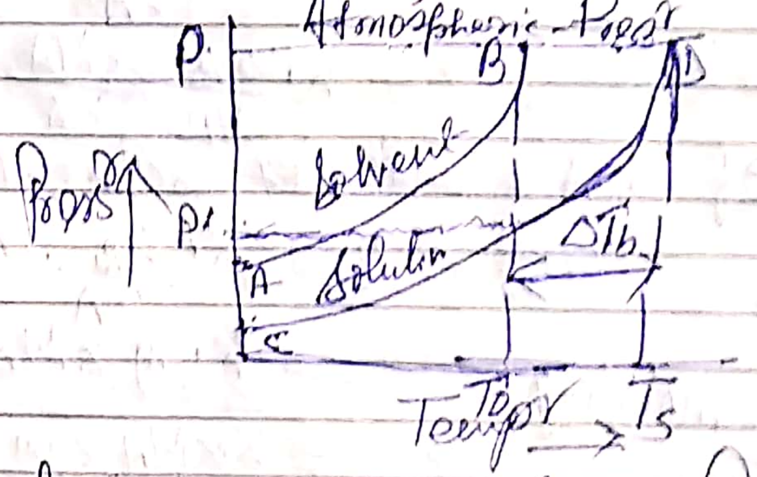
Deg-I (H) - Solution

Topics - Elevation of B.pt + Depression in F.pt

Boiling Point (T_b) Boiling point of a liquid may be defined as the temp at which its vapour pressr becomes equal to atmospheric pressr.

We know earlier that the vapour pressr of solution is always less than its solvent.

But Boiling point of solution containg non volatile solute



is always greater than pure solvent.

If B.pt of solution $= T_s$
B.pt of Solvent $= T_0$
Thus Elevation of B.pt, $\Delta T_b = T_s - T_0$

Magnitude of ΔT_b depend upon lowering of vap. pressure (Δp).

Thus $\Delta T_b \propto \Delta p$

But from Raoult's law, $\Delta p \propto X_B$

Then $\Delta T_b \propto X_B$

$$\Delta T_b = K \cdot X_B$$

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

But $n_A >>> n_B$

then $\Delta T_b = K \cdot \frac{n_B}{n_A}$

$$= K \cdot \frac{w_B}{M_B} \times \frac{M_A}{w_A}$$

If w_A = mass of solvent in kg

Then $\Delta T_b = K \cdot \frac{n_B}{w_A} \cdot M_A$

$$= K \cdot m \times M_A$$

m = molality

$$= K \times M_A \times m$$

$$\Delta T_b = K_b \times m$$

K_b = molal elevation of Boiling point or ebullioscopic Constant

If $m = 1$, then $\Delta T_b = K_b$

The K_b is defined as the elevation in boiling point for one molal solution.

K_b can also calculated thermodynamically as

$$\boxed{K_b = \frac{M_A R T_b^2}{\Delta H_{vap} \times 1000}} = \frac{R T_b^2}{1000 \times L_v}$$

M_A = molar mass of solvent
R = gas constant
T_b = b.pt of solvent
ΔH_{vap} = latent heat of the vaporisation
L_v = latent heat of vap. of solvent in J/gm

Molal elevation constant (for some solvent)

Solvent	b.pt (K)	K_b/(K kg mol^{-1})
Water	373	0.52
Benzene	353.3	2.53
ethanol	351.5	1.20

Determination of molar mass of unknown non volatile compound from elevation of boiling point

$$\Delta T_b = K_b \times m \quad \text{--- (1)}$$

$$\text{molality} = \frac{w_B \times 1000}{M_B \times w_A}$$

Substituting the value of m in above relation (1)

We get $\Delta T_b = \frac{1000 \times K_b \times W_B}{M_B \times W_A}$

$$\therefore \boxed{M_B = \frac{1000 \times K_b \times W_B}{\Delta T_b \times W_A}}$$

Numerical Problem:-

The b.pt of benzene is 353.23 K. When 1.80 gm of non-volatile solute was dissolving in 90 gm of benzene, the b.pt is raised to 354.11 K. Calculate the molar mass of solute.

K_b for benzene = 2.53 K kg mol

$T_0 = 353.23\ K$

$T_s = 354.11\ K$

$\Delta T_b = 354.11 - 353.23$

$= 0.88$

$W_A = 90$

$W_B = 1.80\ gm$

$$M_B = \frac{1000 \times K_b \times W_B}{\Delta T_b \times W_A}$$

$$= \frac{1000 \times 2.53 \times 1.80}{0.88 \times 90}$$

Molar mass of solute = 57.5 gm mol