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Class \Rightarrow B.Sc. (Part-I) Subsidiary

Subject \Rightarrow Chemistry

Chapter \Rightarrow Colligative properties

Topic \Rightarrow Relation between osmotic pressure and lowering of vapour pressure.

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Relation between osmotic pressure and vapour pressure

Since, at equilibrium, the osmotic pressure of solution (π) is exactly balanced by hydrostatic pressure due to h cm. height of solution of density d , we can write

$$\pi = h \times d \quad \text{--- (1)}$$

If P is the vapour pressure of the solvent at the given temperature and P_s is the vapour pressure of the solution at height h . Thus

$$P - P_s = hD \quad \text{--- (2)}$$

Where D = density of solvent vapour at pressure P

Dividing eqn (1) by (2) we get

$$\frac{\pi}{P - P_s} = \frac{hd}{hD}$$

$$\text{or } \frac{\pi}{P - P_s} = \frac{d}{D} \quad \text{--- (3)}$$

At a given temperature, d and D are constant.

i.e.

$$\frac{\pi}{P - P_s} = \text{Constant}$$

$$\text{or } \pi = \text{constant} \times (P - P_s)$$

$$\therefore \pi \propto (P - P_s)$$

This shows that osmotic pressure is directly proportional

(2)

to the lowering of vapour pressure.

Relation between osmotic pressure and Relative lowering of vapour pressure.

When the osmotic equilibrium is established

$$\pi = h \times d \quad \text{for dilute solution} \quad \text{--- (1)}$$

$$P - P_s = h \times D \quad \text{for solvent vapour} \quad \text{--- (2)}$$

Dividing (2) by (1) and simplifying

$$\frac{P - P_s}{\pi} = \frac{D}{d} \quad \text{--- (3)}$$

Where D is the density of the solvent vapour and d is the density of the solution.

from the gas equation for one mole of the solvent vapour ($PV = RT$)

$$P = \frac{RT}{V} \quad \text{--- (4)}$$

If M is the molar mass of the solvent vapour, its density

$$D = \frac{M}{V}$$

$$\text{or } V = \frac{M}{D}$$

Substituting the value of V in eqn (4), we get

$$P = \frac{RTD}{M} \quad \text{--- (5)}$$

Dividing eqn (3) by (5), we get

$$\frac{P - P_s}{P} = \frac{\pi \times D \times M}{d \times RTD}$$

$$\text{or } \frac{P - P_s}{P} = \frac{\pi \times M}{dRT} \quad \text{--- (6)}$$

At a fixed temperature, d is constant and hence the factor $\frac{M}{dRT}$ has a constant value. Therefore,

we can write

(3)

$$\frac{P - P_s}{P} \propto \pi$$

i.e. Relative lowering of vapour pressure is directly proportional to the osmotic pressure.

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