Class - XII

Subject - Chemistry

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(b) Vapour Pressure of solutions of solids in liquids

This is a most common class of solution formed by the dissolution of solids in liquids such as sodium chloride, glucose, urea, sugar in water and iodine and sulphur in carbon disulphide.

When evaporation of this solution takes place the vapour phase again consists of vapours of solvent because the solute is non-volatile! However the vapour pressure of the solution is found to be less than that of the pure solvent.

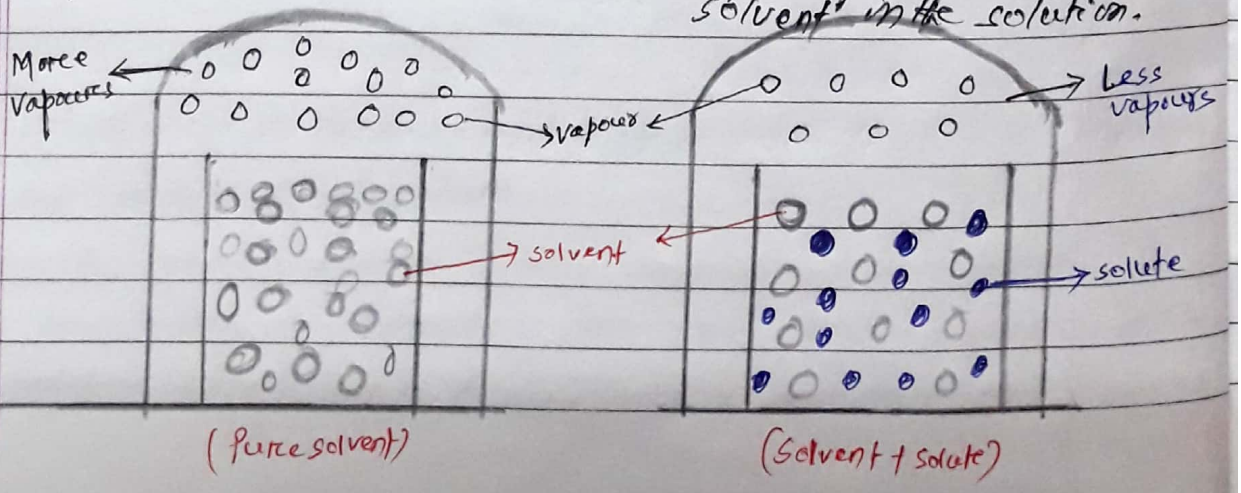
Explanation: We know that evaporation is a surface-phenomenon. The vapour pressure depends on the escape of solvent molecules from the surface of the liquid.

Raoult's Law for Liquid Solution containing non-volatile Solutes

According to Raoult's law the partial pressure of volatile component in the solution is directly proportional to the molefraction in it.

When the solute is non-volatile, only the solvent molecules are present in the vapour phase. Therefore the vapour pressure of the solution will be vapour pressure due to solvent only.

Vapour pressure of the solution = Vapour pressure of the solvent in the solution.



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If p_A = Vapour pressure of the solvent over the solution containing non-volatile solute

x_A = mole fraction,

then according to Raoult's law, the vapour pressure of the solvent in the solution,

$$p_A = p_A^\circ \cdot x_A \quad \text{---- (1)}$$

or $$p = p_A^\circ \cdot x_A \quad \text{---- (2)}$$

i.e. $p_{(solution)} = p_{(pure\ solvent)} \times$ mole fraction of the solvent

This is called Raoult's law for solution containing non-volatile solute.

Thus for solutions containing non-volatile solute, Raoult's law may be stated as: at a given temperature, the vapour pressure of the solution containing non-volatile solute is directly proportional to the mole fraction of the solvent.

Rearranging eq (2) we will get

$$\frac{p}{p_A^\circ} = x_A \quad \text{---- (3)}$$

Substracting each side of the equation from 1 we get

$$1 - \frac{p}{p_A^\circ} = 1 - x_A \quad \text{---- (4)}$$

$$\Rightarrow \frac{p_A^\circ - p}{p_A^\circ} = x_B \quad \text{---- (5)} \quad \left\{ \because x_A + x_B = 1 \text{ or } 1 - x_A = x_B \right\}$$

or

$$\frac{p^\circ_{(solvent)} - p_{(solution)}}{p^\circ_{(solvent)}} = x_{(solute)}$$

Here: $p_A^\circ - p_A$ (difference in vapour pressure of pure solvent and solution) represents lowering in vapour pressure on the formation of solution.

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$\frac{p_A^\circ - p_A}{p_A^\circ}$ = Relative lowering of vapour pressure

Hence Raoult's in modified form can be stated as: the relative lowering in vapour pressure of an ideal solution containing non-volatile solute is equal to the molefraction of the solute at a given temperature.

Raoult's law is a special case of Henry's law

According to Raoult's law, the vapour pressure of a volatile component in a given solution is expressed as:

$$p_A = p_A^\circ \cdot x_A \quad \text{---} (1)$$

where p_A° = vapour pressure of the pure component

p_A = vapour pressure of the solution having mole fraction x_A.

In the case of solution of a gas in a liquid, the gaseous component is volatile component. Its solubility is governed by Henry law which gives the relation

$$p = K_H \cdot x \quad \text{---} (2)$$

where p = pressure of the gas above the solution and

x = mole fraction

K_H = Henry's constant

The comparison of equations for Raoult's law and Henry's law shows that the partial pressure of the volatile component or gas is directly proportional to its molefraction in solution.

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