Class 12 Chapter 01: Solutions Lecture 05

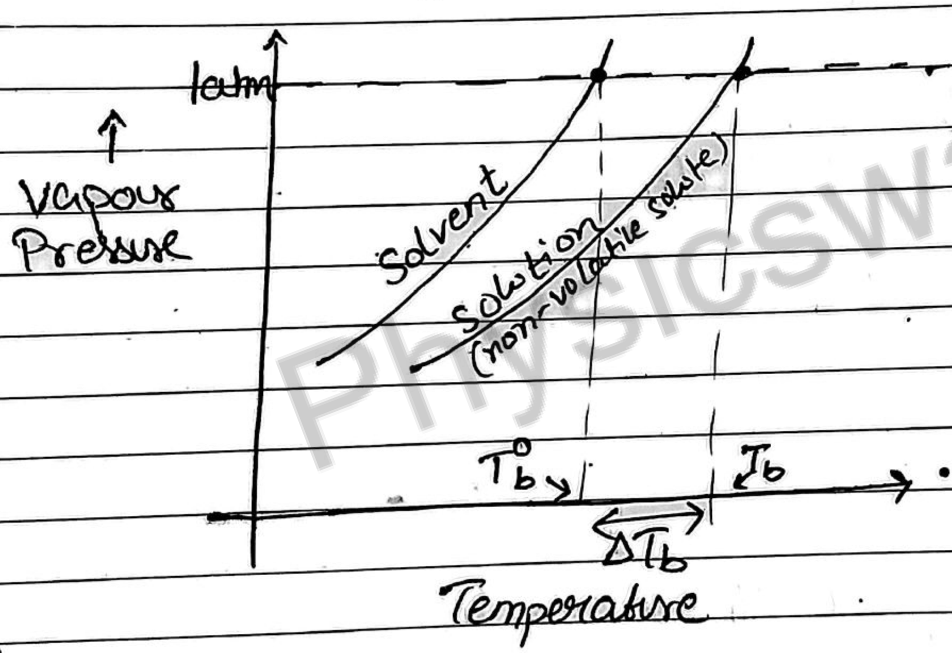
Colligative Properties.

Elevation in Boiling Point. (ΔT_b)

(B.P.)

Boiling Point is the temperature at which vapour pressure of a liquid becomes equal to atmospheric pressure

⇒ We Also Know, On adding non-volatile solute (solids like Urea, sugar, sucrose, etc) the vapour pressure of solution decreases.



** Note: The curve for solution of non volatile solute is lower than the curve of pure solvent.

from the graph, we can see

i) Vapour Pressure of solution containing non-volatile solute is lesser than Vapour Pressure of Pure solvent

ii) B.P. of pure solvent is T_b° (where V.P. = atmospheric Pressure)

iii) B.P. of solution (non-volatile solute) is T_b (where V.P. = atmospheric Pressure)

$$T_b > T_b^\circ$$

$\Delta T_b = T_b - T_b^\circ$

elevation in B.P.

*** $\Delta T_b \rightarrow$ Colligative property as it depends upon no of solute particles and not on type of solute particles

experimentally, we find

$\Delta T_b \propto m$ (molality of non volatile solute)

$\boxed{\Delta T_b = K_b m}$ *** (Colligative Property)

$\downarrow$

molal elevation constant

or

ebullioscopic constant

$K_b \rightarrow$ depends upon solvent

$K_b \rightarrow$ unit is K kg/mol

ex: K_b for water is 0.52 K kg/mol

$m \text{ (molality)} = \dfrac{\text{no. of moles of solute}}{\text{Mass of solvent (in kg)}}$

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Q1) 18g of glucose ($C_6H_{12}O_6$) is dissolved in 1kg water. Find the B.P. of solution if B.P. of Pure water is 100°C. K_b for water 0.52 K kg/mol

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

$$= 0.52 \times \frac{\frac{18}{180}}{1}$$

$$= 0.052$$

diff in kelvin = diff in °C

$T_b - T_b^\circ = 0.052$

$T_b = T_b^\circ + 0.052 = 100.052°C$

$X_m = T_b \;\; T_b$

Urea NH_2CONH_2 $M = 60$

glucose $C_6H_{12}O_6$ $M = 180$

Q3) Calculate B.P. of a solution containing 6g of urea and 9g of glucose in 300g of water.

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

$$= 0.52 \times \frac{\text{no. of moles of solute}}{\text{Mass of solvent (in kg)}}$$

$$\text{no of moles of solute} = \text{moles of Urea} + \text{moles of glucose}$$

$$= \frac{6}{60} + \frac{9}{180}$$

$$= 0.1 + 0.05$$

$$= 0.15$$

$$\Delta T_b = 0.52 \times \frac{0.15}{\frac{3\cancel{00}}{10\cancel{00}}}$$

$$= \frac{0.52 \times 1.5}{3}$$

$$= 0.26$$

$$\Delta T_b = T_b - T_b^\circ = 0.26$$

$$T_b = T_b^\circ + 0.26$$

$$= 100.26^\circ C$$

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Q4) A solution containing 3.3g of a non volatile solute in 125g benzen (B.P of pure benzene = 80°C) boils at 80.66°C. K_b for benzene is 3.28 K kg/mol. Find the Molecular Mass of non volatile solute.

<u>Solution:</u> $\Delta T_b = T_b - T_b^{\circ} = 80.66 - 80 = 0.66$

$$\Delta T_b = K_b \times m$$
$$0.66 = 3.28 \times \frac{\text{no of moles of solute}}{\text{Mass of solvent (kg)}}$$

$$0.66 = 3.28 \times \frac{\frac{3.3}{M}}{\frac{125}{1000}}$$

$$\boxed{M = 131.20 \text{ g/mol}}$$

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if K_b is not given, (rare chance)

$$K_b = \frac{R(T_b^\circ)^2 \times M}{1000 \times \Delta H_{vap}}$$

$R \rightarrow$ Gas Constant ($8.314 J/mol K$ or $2 calorie/mol K$)
$T_b^\circ \rightarrow$ B.P. of Solvent (kelvin)
$M \rightarrow$ Molar Mass of Solvent
$\Delta H_{vap} \rightarrow$ Molar Enthalpy of Vapourisation
ΔH_{vap} = (Molar Mass $\times$ Latent Heat of vap)
value ~~unit~~ of R according to unit of ΔH_{vap}

Q2) Calculate K_b of water if Latent Heat of Vapourisation is 540 calories/g.

Solution:
$T_b^\circ = 373 K$
$M = 18 g$
$R = 2 calorie/mol K$
$\Delta H_{vap} = 540 calorie/g \times 18 g$
$\downarrow$
for 1 mole

$$K_b = \frac{2 \times (373)^2 \times 18}{1000 \times 540 \times 18}$$

$$\approx 0.52 K\, kg/mol$$