PRAYAS

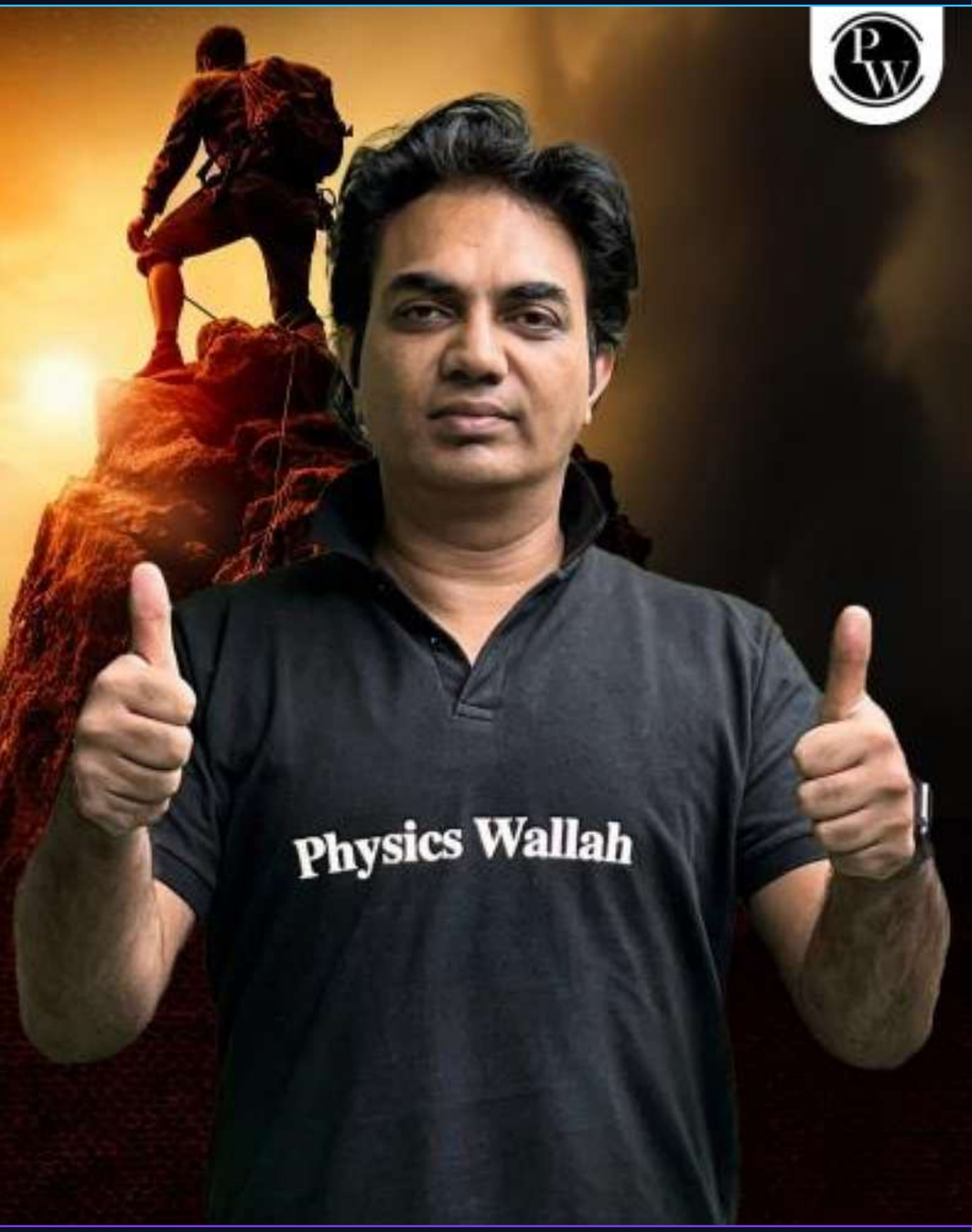
JEE 2026

PHYSICAL CHEMISTRY

SOLUTIONS

Lecture – 08

FAISAL RAZAQ



Topics to be covered

Colligative Properties

Colligative Properties

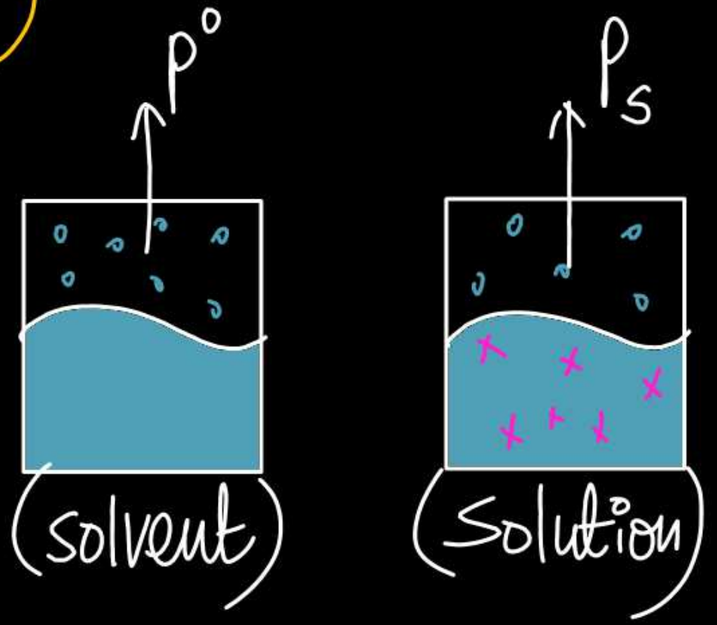
"Properties which only depend on the number of solute particles not on the nature of solute particles are colligative properties."

Conditions

1) Solute should be non-volatile
2) Solution should be dilute solution

Relative Lowering of Vapour Pressure (RLVP)

1



$P_s = P^0 X_{solvent}$

Vapour Pressure of solvent = P^0

Vapour Pressure of solution = P_s

Lowering in Vapour Pressure = $P^0 - P_s$

Relative Lowering of Vapour Pressure = $\frac{P^0 - P_s}{P^0}$

K_3 Iso

(*) $$RLVP = \frac{p^\circ - p_s}{p^\circ} = x_{solute} = \frac{n_{solute}}{n_{solute} + n_{solvent}} \simeq \frac{n_{solute}}{n_{solvent}} \quad (n_{solute} << n_{solvent})$$

K.Bo

$$\frac{p^\circ - p_s}{p_s} = \frac{x_{solute}}{x_{solvent}} = \frac{n_{solute}}{n_{solvent}}$$

Question

$p^0 = 750$ $\}\ p_s = 740$

The vapour pressure of benzene at 80°C is lowered by 10mm by dissolving 2g of a non-volatile substance in 78g of benzene. The vapour pressure of pure benzene at 80°C is 750 mm. The molecular weight of the substance will be :

(a) 15 (b) 150 (c) 1500 (d) 148

$$\frac{p^0 - p_s}{p^0} = \frac{n_{solute}}{n_{solute} + n_{solvent}} \simeq \frac{n_{solute}}{n_{solvent}}$$

$$\frac{10}{750} = \frac{2/M}{78/78}$$

$M = 150$ g/mol.

$$\frac{10}{740} = \frac{2/M}{78/78} \leftarrow$$

$M = 148$ g/mol.

(1) $$\frac{p^0 - p_s}{p^0} = \frac{n_{solute}}{n_{solute} + n_{solvent}}$$

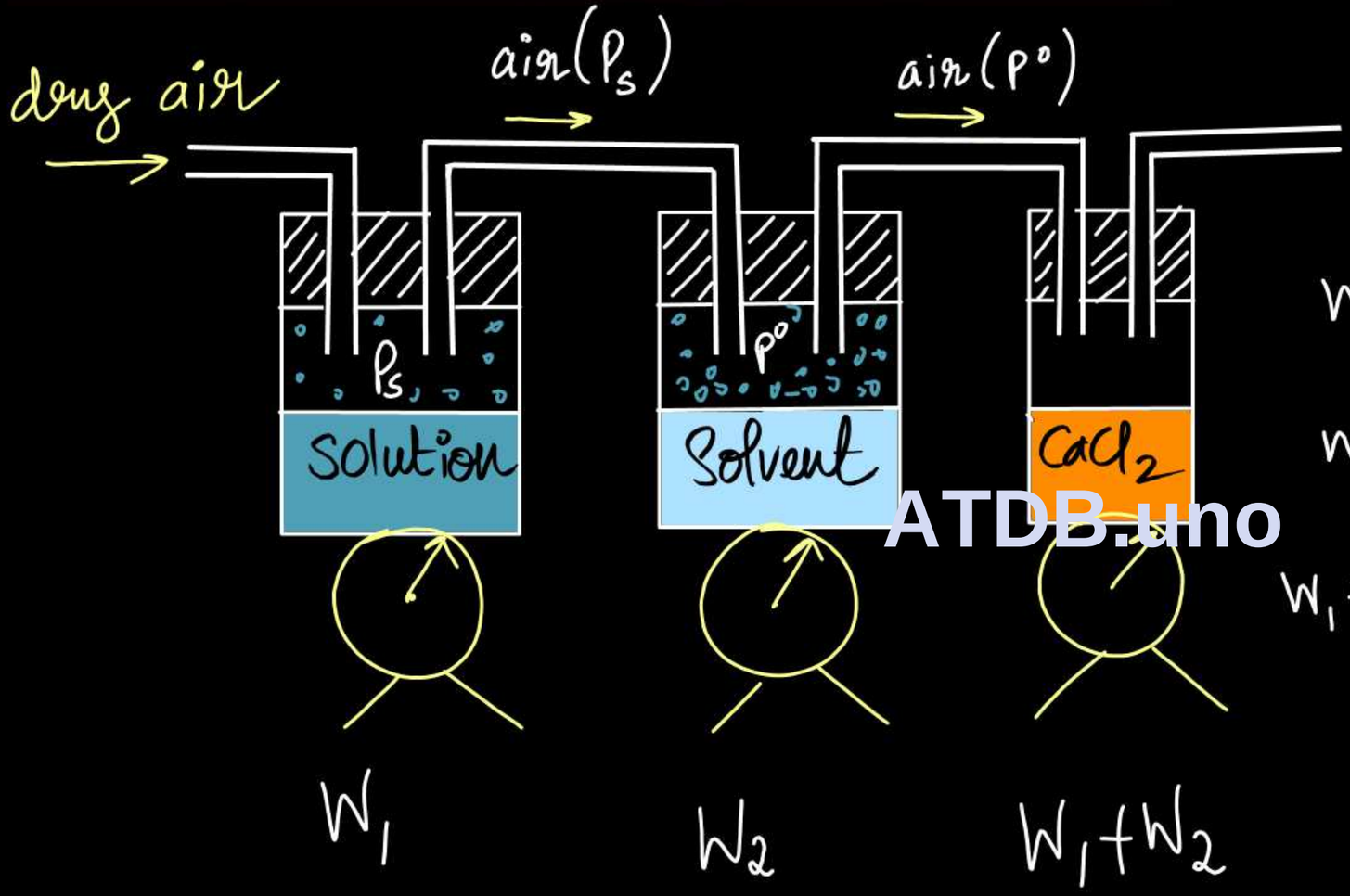
$$\frac{10}{750} = \frac{2/M}{2/M + 78/78}$$

$M = 148$ g/mol.

(2) $$\frac{p^0 - p_s}{p_s} = \frac{n_{solute}}{n_{solvent}}$$

Oswalt-Walker Experiment

anhyd. $CaCl_2$ = absorbs water



W_1 = weight loss in solution container

W_2 = weight loss in solvent container

W_1+W_2 = Total weight loss or weight gain in anhyd. $CaCl_2$ container.

$$PV = nRT$$

$$PV = \frac{w}{M}RT$$

$$w = \frac{PVM}{RT}$$

$$W_1 = \frac{P_s VM}{RT} \quad -(1)$$

$$W_2 = \frac{(P^0 - P_s)VM}{RT} \quad -(2)$$

$$W_1 + W_2 = \frac{P^0 VM}{RT} \quad -(3)$$

$$RLVP = \frac{P^0 - P_s}{P^0} = \frac{(2)}{(3)} = \frac{W_2}{W_1 + W_2}$$

$$\boxed{RLVP = \frac{W_2}{W_1 + W_2}}$$

Ko Bo

$$RLVP = \frac{\text{Weight loss in solvent container}}{\text{Weight loss in solution container} + \text{weight loss in solvent container.}}$$

(2) Elevation in Boiling Point

P_s { T_b' = BP of solution. } $T_b' > T_b$

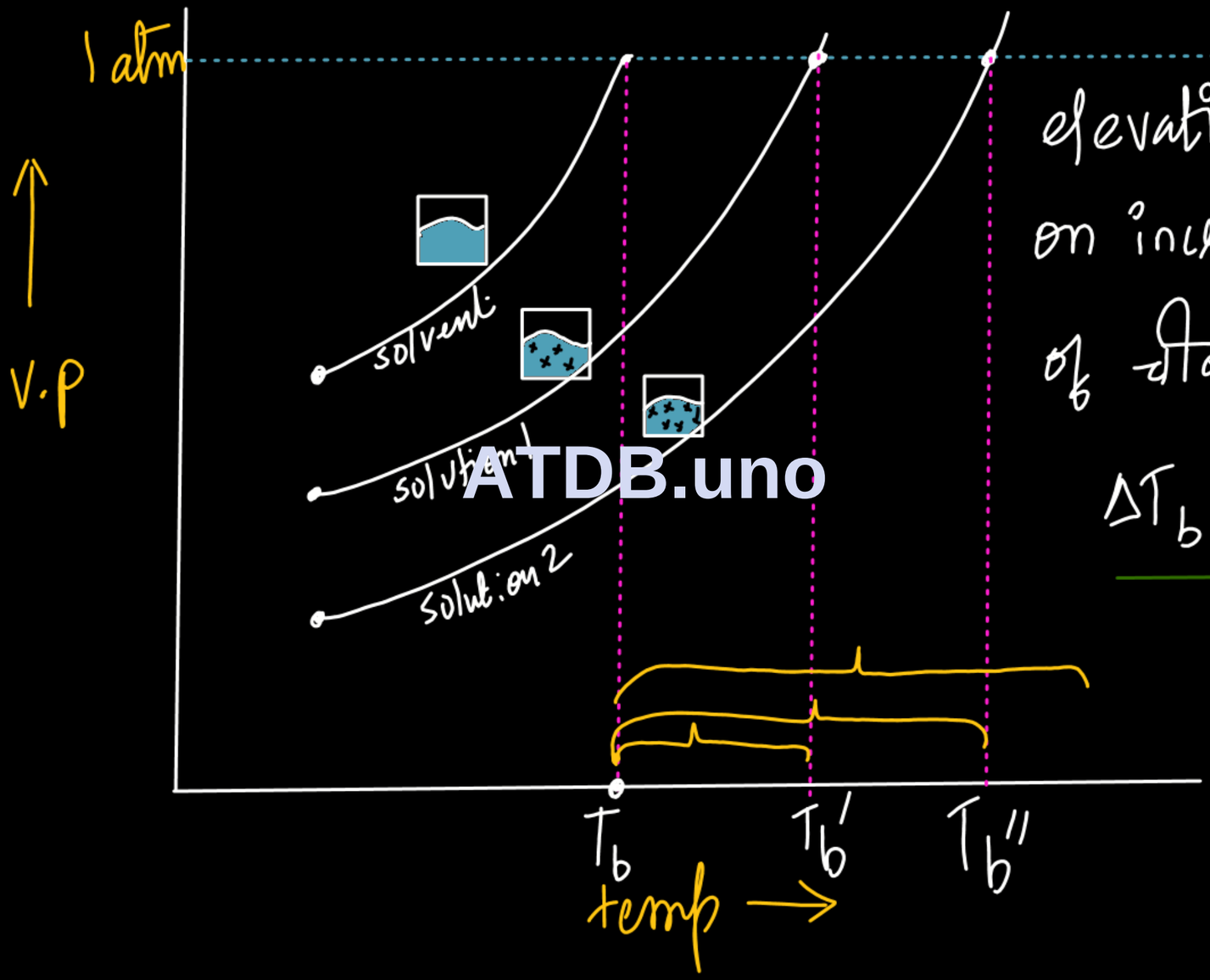
Explaination 1

The vapour pressure of a solution having non volatile solute in volatile solvent, is less than the V.P of pure solvent. → P°

Boiling occurs when V.P is equal to atmospheric pressure.

Due to decrease in the vapour pressure of solution, we need to heat the solution at higher temperature to maintain the V.P of solution equals to atmospheric pressure. So boiling point elevates.

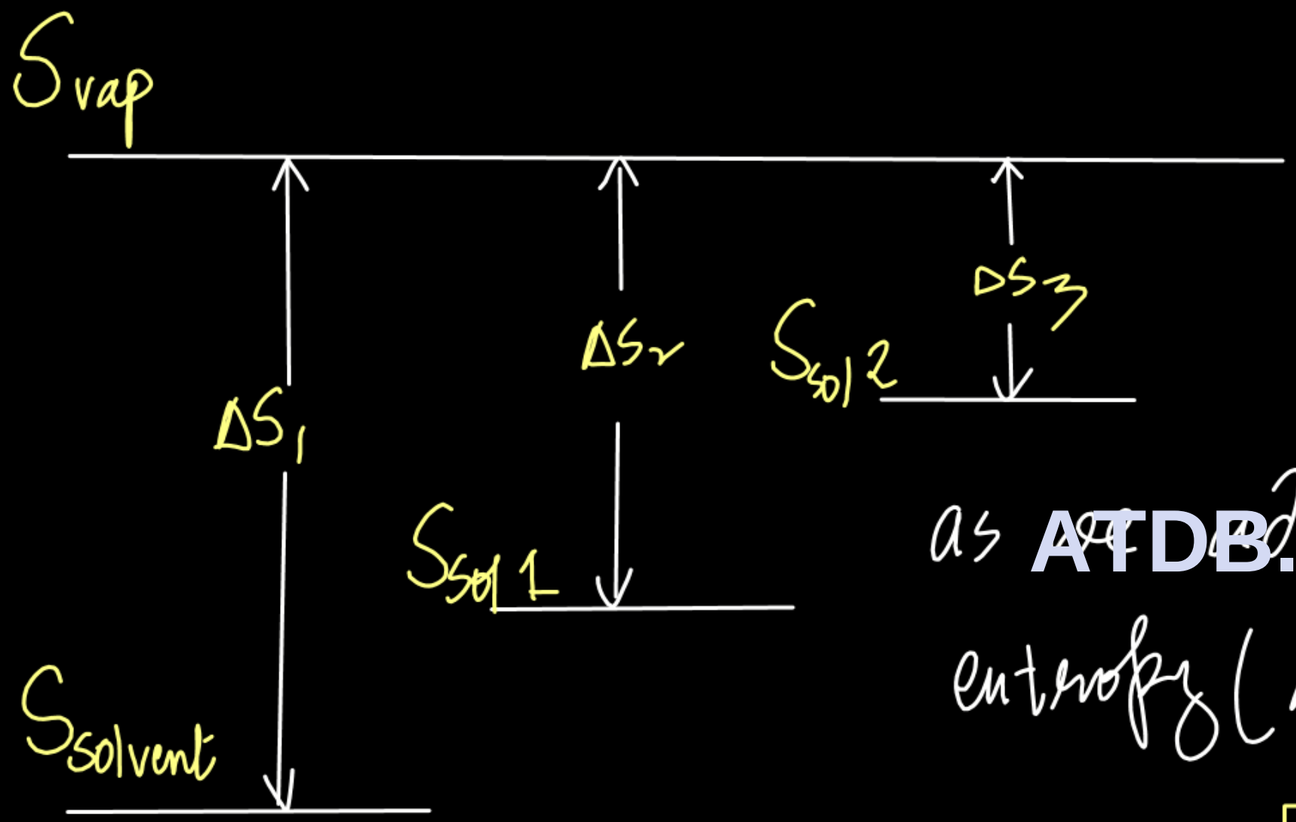
Explaination 2

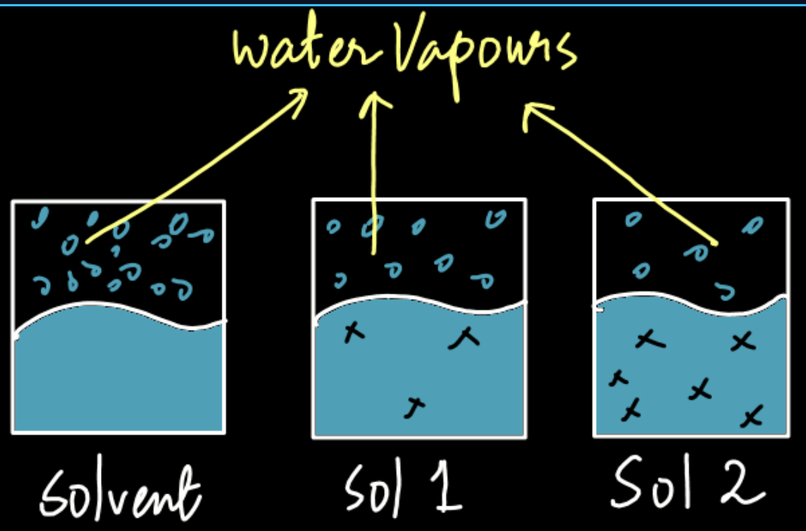


elevation in B.P increases on increasing the conc. of conc. (solute).

ΔT_b is a colligative Prop.

Explaination - 3





as ATDB.uno solute the change in entropy (ΔS) decreases.

$$\Delta S_3 < \Delta S_2 \Delta S_1$$

$$\Delta G = \Delta H - T\Delta S$$

Free energy change Enthalpy change Entropy change

At Eq^{bm} $\Delta G = 0$

$$T_b = \frac{\Delta H_{vap}}{\Delta S}$$

$\Delta S \downarrow$ $T_b \uparrow$

$\Delta S_3 < \Delta S_2 \; \Delta S_1$

$T_b > T_b > T_b$

How to Calculate ΔT_b

$\Delta T_b \propto$ molality of solution

$\Delta T_b \propto m$

$$\boxed{\Delta T_b = K_b \cdot m}$$

$$\Delta T_b = K_b \left(\frac{w/M}{W}\right)$$

K_b = ebullioscopic Constant (which is a property of solvent, does not depend on nature of solute or name of solute)

w = wt of solute
M = mol. wt of solute
W = wt of solvent in Kg.

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

M = mol. wt of solvent

T_b = B.P of solvent

ΔH_{vap} = Heat of vap. of solvent

Question

Adv.

1

Dry air is passed through a solution containing 20 g. of an organic non-volatile solute in 250 ml of water. Then the air was passed through pure water and then through a U-tube containing anhydrous $CaCl_2$. The mass lost in solution is 26 g and the mass gained in the U-tube is 26.48 g. Calculate the molecular mass of the organic solute.

Question

Adv.

(2) Dry air was passed through a solution of 5 gm of a solute in 80 gm of water and then it passed through pure water, loss in weight of solution was 2.50 gm and that of pure solvent was 0.04 gm. Calculate Molecular weight of solute.

(i) 40
(ii) 50
(iii) 60
(iv) 70

Question

(3) The vapour pressure of pure benzene at a certain temperature is 640 mm of Hg. A non-volatile and non-electrolyte solid weighing 2·175 g is added to 39 g benzene. The vapour pressure of solution is 600 mm Hg. What is the molecular weight of solid substance?

Ans : 65.25 g/mol

Question

(4)

A solution containing 2 g of a non-volatile solute in 20 g of water boils at 373.52 K.

The molecular mass of solute is ____ g/mole.

Given: T_b of water 373 K and K_b of $H_2O = 0.52\ K\ Kg\ mol^{-1}$

[JEE-Mains-2023]

(100 g/mol)

Question

(5) A solution containing 2.5×10^{-3} Kg of solute dissolved in 75×10^{-3} kg of water, boils at 373.535 K. The molar mass of solute is ____ g/mol.

Given: T_b of water = 373.15 K, K_b of H_2O = 0.52 K Kg mol^{-1}

[JEE-Mains-2022]

(45 g/mol)

NCERT

(6) The boiling point of benzene is 353.23 K. When 1.8 g of a non-volatile solute was dissolved in 90 g of benzene, the boiling point is raised to 354.11 K. Calculate the molar mass of solute. ($K_b = 2.53\ K\ Kg\ mol^{-1}$)

Question

(7) Boiling point of water at 750 mm Hg is 99.63°C. How much sucrose should be added to 500 g of water such that it boils at 100°C?

(121.6 g)

Q. **06 Sept, 2020 (Shift-II)**

8

A set of solutions is prepared using 180 g of water as a solvent and 10 g of different non-volatile solutes A, B and C. The relative lowering of vapour pressure in the presence of the solutes are in the order [Given, molar mass of A = 100 g mol^{-1}; B = 200 g mol^{-1} ; C = 10,000 g mol^{-1}]

(C)

(A) $A > C > B$

(B) $C > B > A$

(C) $A > B > C$

(D) $B > C > A$

Q. **27 July, 2022 (Shift-I)** 9

Boiling point of a 2% aqueous solution of a non-volatile solute A is equal to the boiling point of 8% aqueous of a non-volatile solute B. The relation between molecular weights of A and B is

A $M_A = 4M_B$

B $M_B = 4M_A$

C $M_A = 8M_B$

D $M_B = 8M_A$

Q. **27 June, 2022 (Shift-I)**

10

2g of a non-volatile non-electrolyte solute is dissolved in 200 g of two different solvents A and B whose ebullioscopic constants are in the ratio of 1 : 8. The elevation in boiling points A and B are in the ratio of x/y (x : y). The value of y is _____. (Nearest Integer).

8

Question

(11)

Elevation in boiling point was 0.52°C when 6g of a compound X was dissolved in 100g of water. Molecular weight of X is : (K_b for water = 0.52 K mol^{-1})

(a) 120 (b) 60 (c) 100 (d) 342

Question

12

At 100°C the vapour pressure of a solution of 6.5g of a solute in 100g water is 732 mm. If $K_b = 0.52°C\ m^{-1}$, the boiling point of this solution will be

(a) 101°C (b) 100°C (c) 102°C (d) 103°C

Question 13

The vapour pressure of a solution of a non volatile electrolyte B in a solvent A is 95% of the vapour pressure of the solvent at the same temperature . If the molecular weight of the solvent is 0.3 times the molecular weight of solute, the weight ratio of the solvent and solute is

(a) 0.15 (b) 5.7 (c) 0.2 (d) 4.0

Q. **27 July, 2022 (Shift-II)**

When a certain amount of solid A is dissolved in 100 g of water at 25°C to make a dilute solution, the vapour pressure of the solution is reduced to one-half of that of pure water. The vapour pressure of pure water is 23.76 mmHg. The number of moles of solute A added is _____. (Nearest Integer)

6 moles

Q. **06 Sept, 2020 (Shift-II)** 15

When 3.0 g of a substance 'X' is dissolved in 100g of CCl_4, it raises the boiling point by 0.60 K. The molar mass of the substance 'X' is _____ g mol^{-1}. (Nearest Integer)
[Given : K_b for CCl_4 is 5.0 K kg mol^{-1}]

Question

16

A solution containing 2 g of a non-volatile solute in 20 g of water boils at 373.52 K.

The molecular mass of solute is ____ g/mole.

Given: T_b of water 373 K and K_b of H_2O = 0.52 K Kg mol^{-1}

[JEE-Mains-2023]

Ans : 100 g/mol

Q. **08 April, 2023 (Shift-II)**

16

If the boiling points of two solvents X and Y (having same molecular weights) are in the ratio 2 : 1 and their enthalpy of vaporization are in the ratio 1 : 2, then the boiling point elevation constant of X is 'm' times the boiling point elevation constant of Y. The value of m is _____ (Nearest Integer)

Q. **10 April, 2019 (Shift-II)** 17

1g of non-volatile non-electrolyte solute is dissolved in 100g of two different solvents A and B whose ebulliopscopic constant are in the ratio of 1 : 5. The ratio of the elevation in their boiling points, $\frac{\Delta T_b(A)}{\Delta T_b(B)}$ is :

A 5 : 1

B 10 : 1

C 1 : 5

D 1 : 0.2