PRAYAS

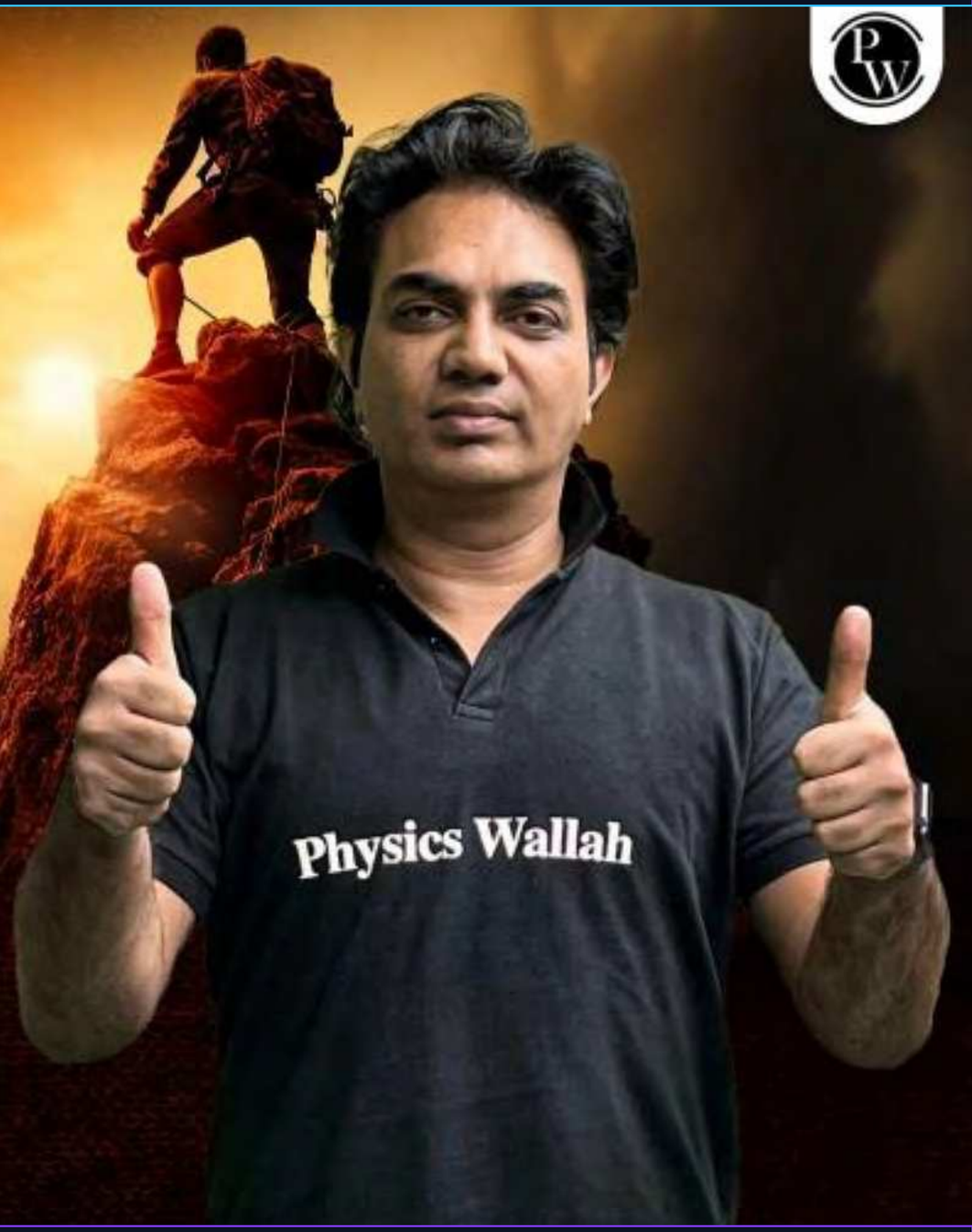
JEE 2026

PHYSICAL CHEMISTRY

SOLUTIONS

Lecture – 09

FAISAL RAZAQ



Topics to be covered

A Colligative Properties

Question 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 $H_2O = 0.52\ K\ Kg\ mol^{-1}$

$$\Delta T_b = 0.52 = K_b \cdot m = 0.52 \times \frac{(2/M)}{(20/1000)}$$

[JEE-Mains-2023]

$$M = 100\ g/mol$$

(100 g/mol)

Question 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]

$$\Delta T_b = K_b \cdot m$$

$$(373.535 - 373.15) = 0.52 \times \left(\frac{2.5/M}{75 \times 10^{-3}}\right)$$

$$M = 45 \text{ g/mol}$$

(45 g/mol)

NCERT

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 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)**

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)**

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)

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 ___8___. (Nearest Integer).

8

$$\Delta T_b = (K_b)_A \left(\frac{2/M}{200/1000} \right)$$

$$\frac{\Delta T_b}{\Delta T_b} = \frac{(K_b)_A}{(K_b)_B} \left(\frac{2/M}{200/1000} \right)$$

$$\frac{x}{y} = \frac{1}{8}$$

Question

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

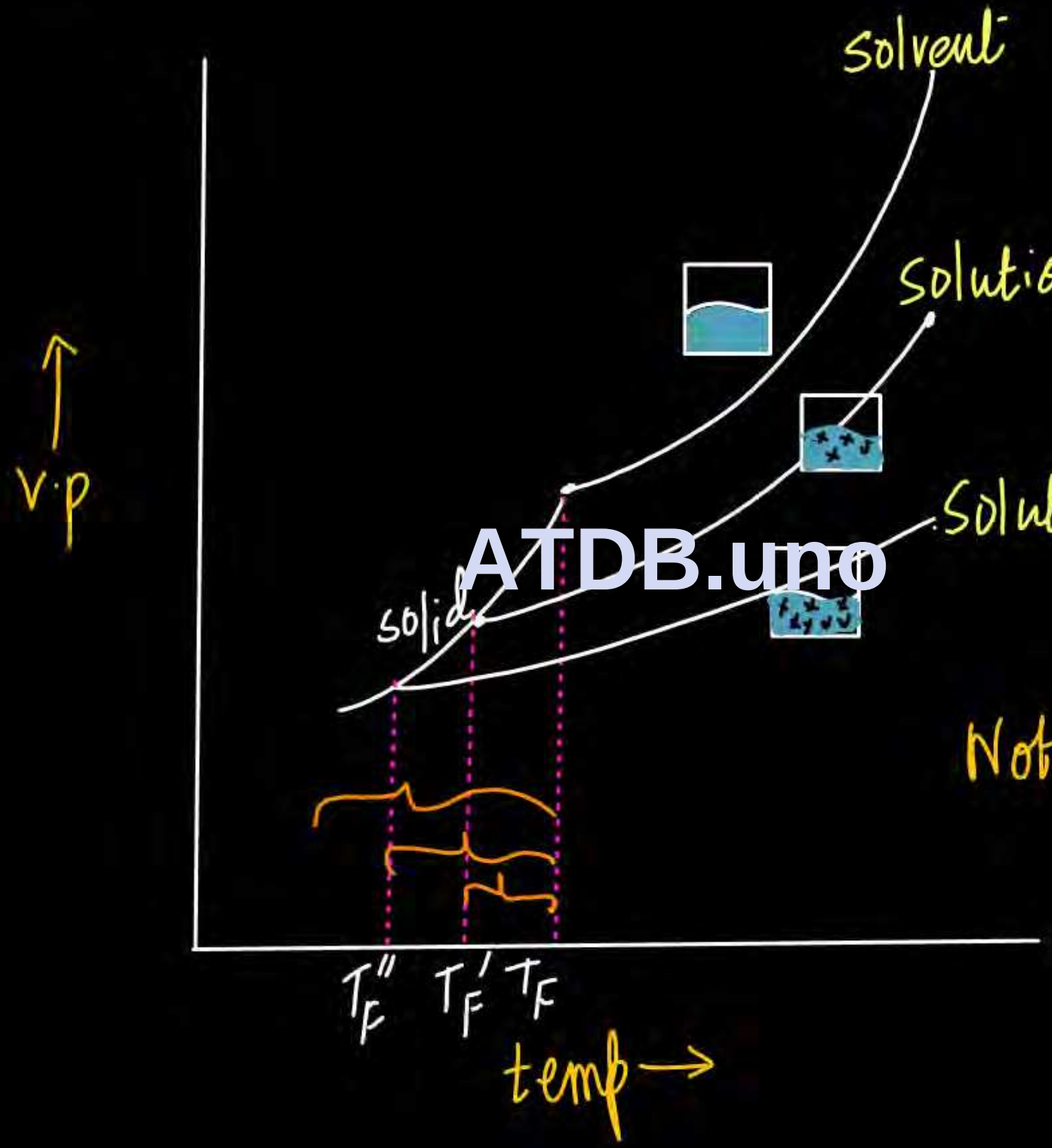
At 100°C the vapour pressure of a solution of 6.5g of a solute in 100g water is 732 mm. If $K_b = 0.52°C\ m^{-1}$, the boiling point of this solution will be

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

(3) Depression in Freezing Point

* Freezing point is the point where first crystal of ice separates.
* At freezing point of the substance, solid phase is in dynamic equilibrium with liquid phase.
* Freezing of solvent occurs only.
* Freezing point is the point where Vapour pressure of liquid phase is equal to the vapour pressure of solid phase.

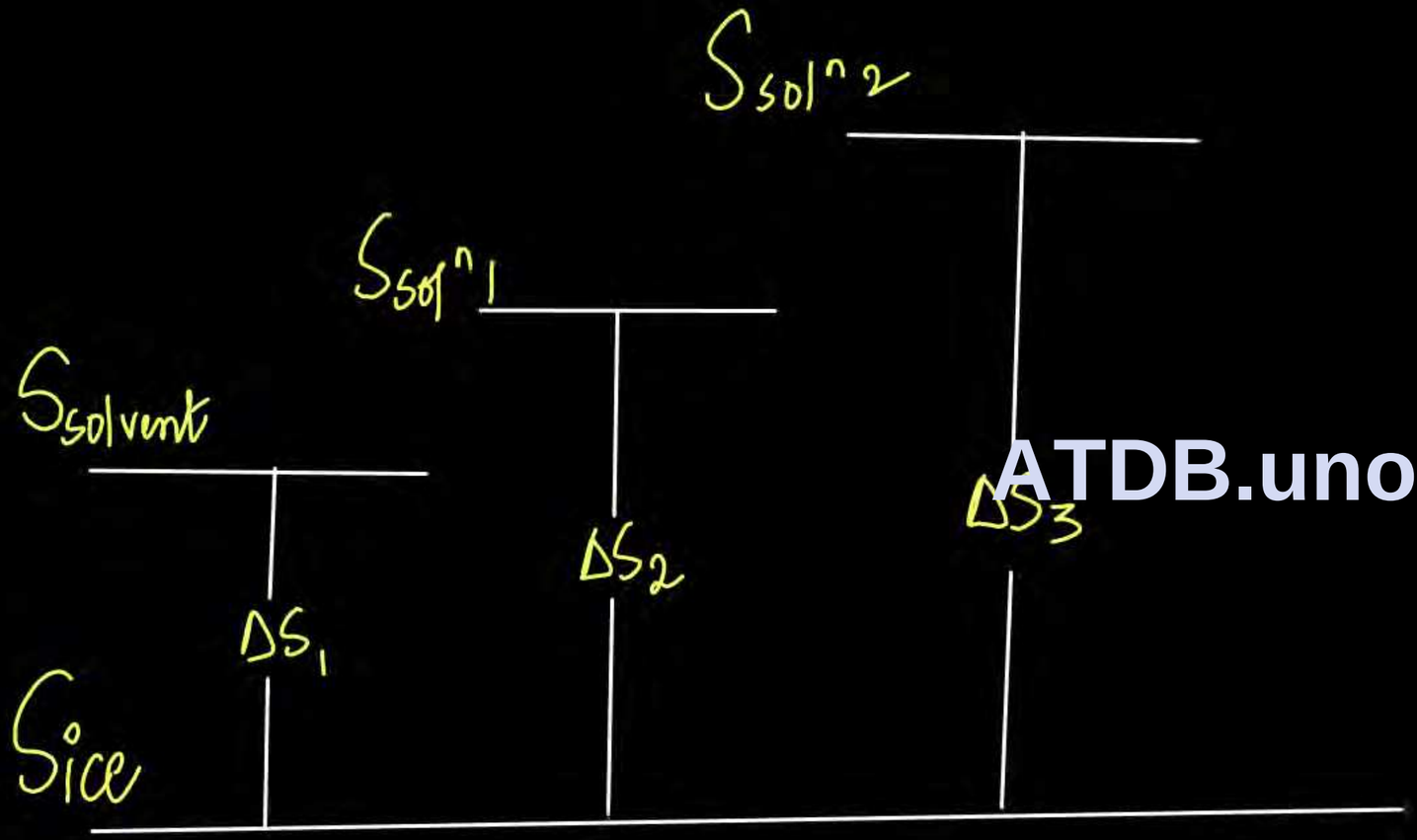
Explanation 1

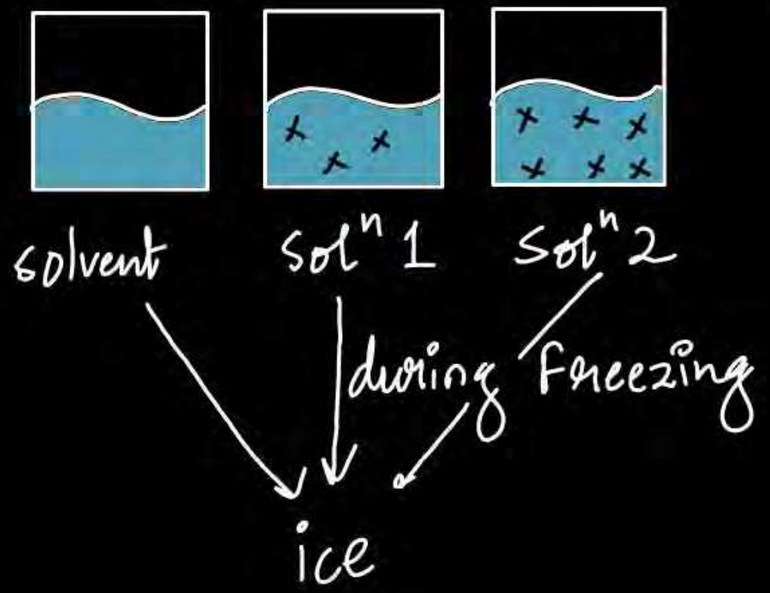


On increasing the number of solute particles Solution 1 depression in f.p increases, so this depression is a colligative property.

Note: F.P is not a coll. property.

Explaination - 2





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

At Freezing point $\Delta G = 0$ (eqbm)

$$\Delta H_{fus} - T_F \Delta S = 0$$

$$T_f = \frac{\Delta H_{Fus}}{\Delta S}$$

$\Delta S \uparrow \quad T_f \downarrow$

$\Delta S_3 > \Delta S_2 > \Delta S_1$

$T_F'' < T_F' < T_F$

$\Delta T_F \propto m$

$\Delta T_f = K_F \cdot m$

K_f = cryoscopic constant

(molar depress. of F.P)

(depends only on solvent)

$$K_f = \frac{M R T_F^2}{\Delta H_{fus} \times 1000}$$

(R = 1.98 cal/1G mol.)

M : Mol. wt of solvent

T_f : F.P of solvent

ΔH_{fus} = Heat of fusion of solvent.

Question The amount of urea to be dissolved in 500 cc of water ($K_f = 1.86\ K\,Kg\,mol^{-1}$) to produce a depression of $0.186^\circ C$ in the freezing point.

(d = 1.0 g/cc)

$$\Delta T_F = K_f \cdot m = K_f \cdot \frac{\text{mol. of solute}}{\text{wt of solvent in kg}}$$

$$0.186 = 1.86 \times \frac{\text{wt of urea}}{500/1000}$$

$$\text{mol of urea} = \frac{1}{20}\ \text{mol.}$$

$$\text{wt. of urea} = \frac{1}{20} \times 60 = 3\ g.$$

Q. 26 July, 2022 (Shift-II)

The elevation on boiling point for 1 molal solution of non-volatile solute A is 3K. The depression in freezing point for 2 molal solution of A in the same solvent is 6 K. The ratio of K_b and K_f i.e. K_b/K_f is 1 : X. The value of X is ___1___. [Nearest Integer]

$\Delta T_b = 3$

$m = 1$

$\Delta T_f = 6$

$m = 2$

$3 \leftarrow \Delta T_b = K_b \cdot \times 1$

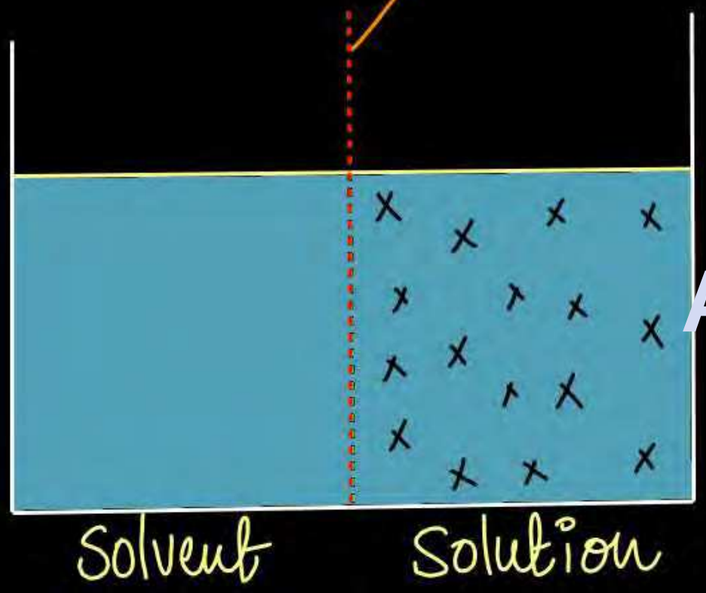
1

$6 \leftarrow \Delta T_f = K_f \times 2$

$K_b : K_f = 1 : 1$

(4) Osmotic Pressure

semi permeable membrane
- artificial $[Cu_2Fe(CN)_6]$
- Natural (animal bladder)

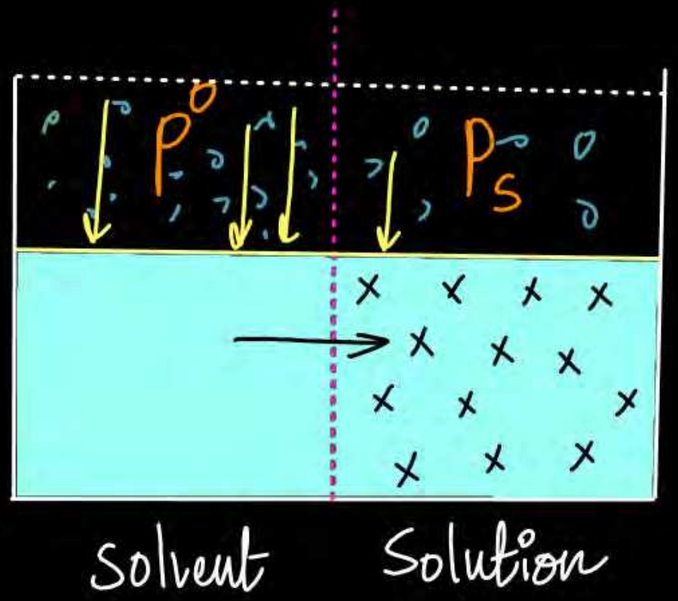


High Conc Solvent → (Flow of Solvent) → Low Conc. solvent

Low Conc Solution → (Flow of Solvent) → High Conc. Solution

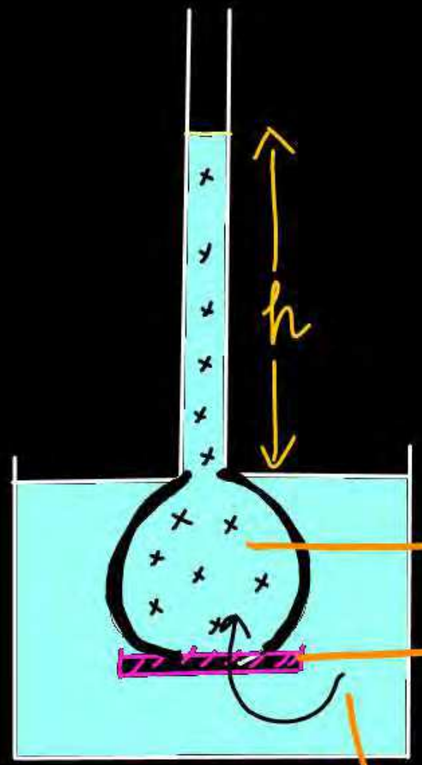
Osmotic pressure (π)

1) $P^0 > P_s$ so flow of solvent particles is more from Left to right.



2) Entropy of solvent increases when it moves from solvent side to solution side.

Osmotic pressure = $h\rho g$



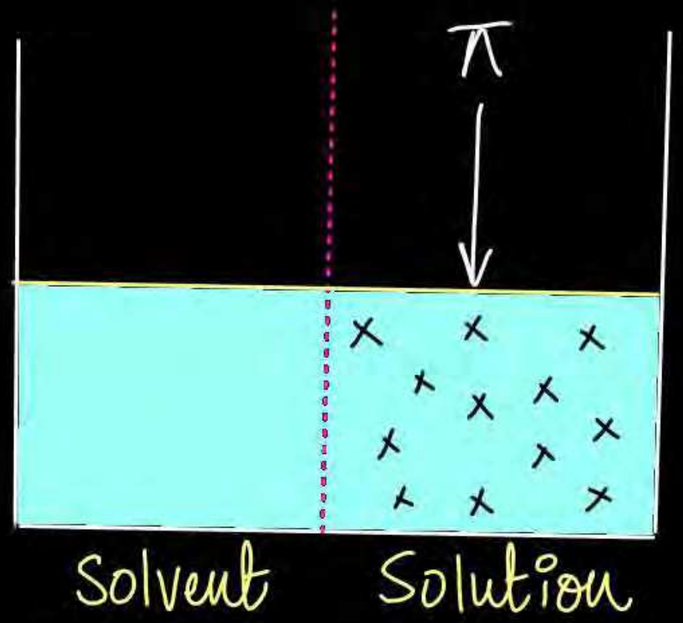
sugar solution

SPM

water

π = Osmotic Pressure

= The pressure applied on solution side so that osmosis does not start.



$$\pi = CRT$$

C = conc. of soln (molarity)

R = consl.

T = temp (K)

JEE AdV
2025

$$CRT = h\rho g$$

ATDB.uno

Question What will the concentration of sucrose solution which develops an osmotic pressure of 1·5 atm.

Question Calculate the osmotic pressure of these sol^{n} –

i) 5% w/v glucose solution at 27°C.

ii) 0·1 M urea solution at 300 K.

Question What should be the F.P. of aqueous solution containing 17 g. of C_2H_5OH in 100 gm of water?

($K_f = 1.86$ K molal^{-1})

($-6.87\ ^\circ C$)

Question

The relationship between osmotic pressure at 273 K when 10 g glucose (P_1), 10 g urea (P_2) and 10 g sucrose (P_3) are dissolved in 250 ml water is

A) $P_1 > P_2 > P_3$

B) $P_3 > P_1 > P_2$

C) $P_2 > P_1 > P_3$

D) $P_2 > P_3 > P_1$

Ans: (C)

Question

A solution of urea in water has boiling point of 100.15°C. Calculate the freezing point of the same solution. K_f and K_b for water are 1.87 K Kg mol^{-1} and 0.52 K Kg mol^{-1} respectively.

$(-0.54°C)$

Question A solution contains 62 gm ethylene glycol ($CH_2OH - CH_2OH$) in 250 gm H_2O is cooled upto $-10^\circ C$. If $K_f = 1.86\ K\ Kg\ mol^{-1}$, then amount of water (in gm) separated as ice is –

[JEE-Mains 2019]

A) 32

B) 48

C) 64

D) 16

Question

Calculate the amount of ice that will separate out on cooling a solution containing 50 g of ethylene glycol in 200 g of water to -9.3^0C .
(K_f of water is 1.86 K mol^{-1} Kg)

Question

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

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

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)**

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}]

Q. **JEE Adv. 2019**

$\Delta T_f = K_f \cdot m = K_f \times \left(\frac{\quad}{39/1000} \right)$

On dissolving 0.5 g of a non-volatile non-ionic solute to 39g of benzene, vapour pressure decreases from 650 mm Hg to 640 mm Hg. The depression of freezing point of benzene (in K) upon addition of the solute is _____.
(Given data : Molar maas and the molal freezing point depression constant of benzene are 78g mol^{-1} and 5.12 K kg mol^{-1}, respectively)

1.0256 K

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

$$\frac{650 - 640}{640} = \frac{0.5/M}{39/78} \Rightarrow M$$

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

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)

Question 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

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Aus: 1.02 K

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(A) A > C > B

(B) C > B > A

(C) A > B > C

(D) B > C > A

Ans : (C)

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($K_f = 1.86$ K molal^{-1})

($-6.87\ ^\circ C$)

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The elevation on boiling point for 1 molal solution of non-volatile solute A is 3K. The depression in freezing point for 2 molal solution of A in the same solvent is 6 K. The ratio of K_b and K_f i.e. K_b/K_f is 1 : X. The value of X is _____. [Nearest Integer]

1

Q. **27 Aug, 2021 (Shift-I)**

1 kg of 0.75 molal aqueous solution of sucrose can be cooled up to −4°C before freezing. The amount of ice (in g) that will be separated out is _____. (Nearest Integer)
[Given : $K_f\ (H_2O) = 1.86\ K\ kg\ mol^{-1}$]

(518 g)

Question

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.

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[JEE-Mains-2022]

(45 g/mol)

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(121.6 g)

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