17. What type of deviation is shown by a mixture of ethanol and acetone? Give reason. [2023]

18. What type of deviation from Raoult's Law is observed by mixing chloroform and Acetone? Why is a decrease in vapour pressure observed on mixing chloroform and acetone? [2021(C)]

19. State Raoult's law for a solution containing volatile components. What is the similarity between Raoult's law and Henry's law? [2020]

20. State Raoult's law for a solution containing volatile components. Write two characteristics of the solution which obeys Raoult's law at all concentrations. [2019]

21. Why a mixture of carbon disulphide and acetone shows positive deviation from Raoult's law? What type of azeotrope is formed by this mixture? [2018]

22. Define the following terms:
(*i*) Ideal solution
(*ii*) Molarity (M) [2017]

23. What is meant by positive deviations from Raoult's law? Give an example. What is the sign of $\Delta_{mix}H$ for positive deviation? [2015]

SA Short Answer Type Questions (3 Marks)

24. The vapour pressure of pure liquids A and B at 400 K are 450 and 700 mmHg respectively. Find out the composition of liquid mixture if total vapour pressure at this temperature is 600 mmHg. [2017]

25. State Raoult's law for a solution containing non-volatile solute. What type of deviation from Raoult's law is shown by a solution of chloroform and acetone and why? [2017]

Colligative Properties: $\frac{p_A^\circ - p_A}{p_A^\circ}$, ΔT_b, ΔT_f, Osmosis and Osmotic Pressure

MCQ Multiple Choice Questions (1 Mark)

1. If molality of dilute solution is doubled, the value of K_b (molal elevation constant) will be [2023]
(*a*) halved (*b*) doubled
(*c*) tripled (*d*) unchanged

2. Which of the following colligative property is used to find molar mass of proteins? [2023]
(*a*) Osmotic pressure
(*b*) ΔT_b
(*c*) ΔT_f
(*d*) Relative lowering of vapour pressure

3. The osmotic pressure of a solution increases if: [2021]
(*a*) The volume of the solution is increased
(*b*) The number of solute molecules is increased
(*c*) Temperature is decreased
(*d*) Solution constant (*R*) is increased

4. Vapour pressure of dilute aqueous solution of glucose is 750 mm Hg at 373 K. The mole fraction of solute is: [2021]
(*a*) $\frac{1}{7.6}$ (*b*) $\frac{1}{38}$
(*c*) $\frac{1}{76}$ (*d*) $\frac{1}{10}$

5. The freezing point of a 0.2 molal solution of a non-electrolyte in water is : [2021]
(K_f for water = 1·86 K kg mol^{-1})
(*a*) − 0.372°C (*b*) −1.86°C
(*c*) +0.372°C (*d*) +1.86°C

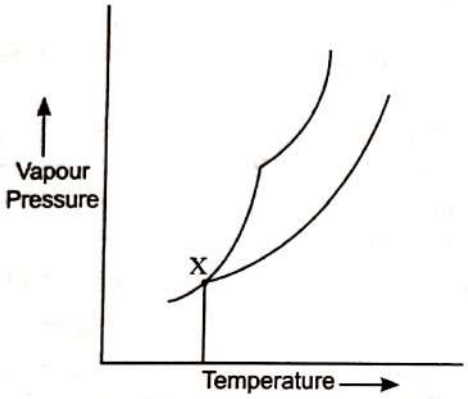
6. A 5% (by mass) solution of glucose (molar mass = 180 g mol^{-1}) is isotonic with 1% solution (by mass) of a substance 'X'. The molar mass of 'X' is [2021]
(*a*) 36 g mol^{-1} (*b*) 18 g mol^{-1}
(*c*) 72 g mol^{-1} (*d*) 900 g mol^{-1}

7. When 2.5 g of a non-volatile solute was dissolved in 50 mL of water, it gave boiling point elevation of 0.52 °C. The molar mass of the solute is (K_b for water = 0.52 Km^{-1}) [2021]
(*a*) 100 g mol^{-1} (*b*) 50 g mol^{-1}
(*c*) 25 g mol^{-1} (*d*) 75 g mol^{-1}

8. Which of the following analogies is correct ? [2021]
   (*a*) Chloroform-acetone : Positive deviation :: Ethanol-H_2O : Negative deviation.
   (*b*) $p_A = p_A^\circ \cdot x_A$: Henry's law : : $p = K_H \cdot x$: Raoult's law.
   (*c*) $P_{Total} = p_A + p_B$: Non-ideal solution : : $P_{Total} > p_A + p_B$: Ideal solution
   (*d*) $\pi = CRT$: Osmotic pressure :: $P > \pi$: Reverse osmosis.

9. The boiling point of a 0.2 m solution of a non-electrolyte in water is (K_b for water = 0.52 K kg mol^{-1}) [2021]
   (*a*) 100°C (*b*) 100.52°C
   (*c*) 100.104°C (*d*) 100.26°C

10. In the following diagram point, 'X' represents [2021]



   (*a*) Boiling point of solution
   (*b*) Freezing point of solvent
   (*c*) Boiling point of solvent
   (*d*) Freezing point of solution

11. Relative lowering in vapour pressure is a colligative property because it depends upon [2021]
   (*a*) Molar fraction of solvent
   (*b*) Mole fraction of solute
   (*c*) Temperature
   (*d*) Molarity of solution

12. The vapour pressure of dilute aqueous solution of glucose is 740 mm Hg at 373 K, The mole fraction of glucose is [2021]
   (*a*) $\frac{1}{38}$ (*b*) $\frac{1}{76}$
   (*c*) $\frac{1}{760}$ (*d*) $\frac{1}{74}$

VSA Very Short Answer Type Questions (2 Marks)

13. A solution is prepared by dissolving 10 g of non-volatile solute in 200 g of water. It has a vapour pressure of 31.84 mm Hg at 308 K. Calculate the molar mass of the solute.
   (Vapour pressure of pure water at 308 K = 32 mm Hg) [2023]

14. Vapour pressure of water at 293 K is 17·536 mm Hg. Calculate the vapour pressure of aqueous solution when 20 g of glucose (Molar mass = 180 g mol^{-1}) is dissolved in 500 g of water. [2021]

15. (*i*) What happens when (*i*) a pressure greater than osmotic pressure is applied on the solution side separated from solvent by semi permeable membrane?
   (*ii*) Acetone is added to pure ethanol? [2020]

16. Why does a solution containing non-volatile solute have higher boiling point than the pure solvent? Why is elevation of boiling point a colligative property? [2020]

17. When fruits and vegetable that have dried up placed in water, they slowly swell and return to original form. Why? Will temperature increase accelerate the process? Explain. [2020]

18. For a 5% solution of urea (Molar mass = 60 g/mol), calculate the osmotic pressure at 300 K. [R = 0.0821 L atm K^{-1} mol^{-1}] [2020]

19. Visha took two aqueous solutions — one containing 7·5 g of urea (Molar mass = 60 g/mol) and the other containing 42·75 g of substance 'Z' in 100 g of water, respectively. It was observed that both the solutions frozen at the same temperature. Calculate the molar mass of 'Z'. [2020]

20. Calculate the freezing point of a solution containing 60 g of glucose (molar mass = 180 g mol^{-1}) in 250 g of water. (K_f of water = 1.86 K kg mol^{-1}) [2018]

21. Define the following terms: [2017]
   (*i*) Colligative properties.
   (*ii*) Molality (m)

22. What is meant by elevation in boiling point? Why is it a colligative property? [2017]

23. Explain why on addition of 1 mol of glucose to 1 litre of water, the boiling point of water increases. [2017]

24. (*i*) On mixing liquid X and liquid Y, the volume of the resulting solution increases. What type of deviation from Raoult's law is shown by the resulting solution? What change in temperature would you observe after mixing liquids X and Y?

(*ii*) How can the direction of osmosis be reversed? Write one use of reverse osmosis. [2015]

25. What do you understand by depression of freezing point? Derive the relationship between depression of freezing point and molar mass of the solute. [2015]

26. Derive the relationship between relative lowering of vapour pressure and molar mass of the solute. [2015]

SA Short Answer Type Questions (3 Marks)

27. Vapour pressure of water at 298 K is 17·536 mm Hg. Calculate the vapour pressure of aqueous solution when 20 g of glucose (Molar mass = 180 g mol) is dissolved in 500 g of water. [2021 (C)]

28. A solution containing 30 g of non-volatile solute exactly in 90 g of water has a vapour pressure of 2.8 kPa at 298 K. Further 18 g of water is then added to the solution and the new vapour pressure becomes 2.9 kPa at 298 K. Calculate: (*i*) molar mass of the solute (*ii*) vapour pressure of water at 298 K. [2020 (C)]

29. An antifreeze solution is prepared by dissolving 31 g of ethylene glycol (Molar mass = 62 g mol^{-1} in 600 g of water. Calculate the freezing point of the solution. [K_f for water = 1.86 K kg mol^{-1}] [2020]

30. Calculate the mass of ascorbic acid (Vitamin C, $C_6H_8O_6$) to be dissolved in 75 g of acetic acid to lower its melting point by 1.5 °C. [2020] (K_f = 3.9 K kg mol^{-1})

31. A solution containing 8 g of substance in 100 g of diethyl ether boils at 36.86°C where as pure ether boils at 35.60°C. Determine the molar mass of solute.

[K_b for ether = 2.02 K kg mol^{-1}] [2019]

32. A 4% solution (w/w) of sucrose (M = 342 g mol^{-1}) in water has a freezing point of 271.15 K. Calculate the freezing point of 5% glucose (M = 180 g mol^{-1}) in water. (Given: Freezing point of pure water = 273.15 K) [2019]

33. A 10% solution (by mass) of sucrose in water has freezing point of 269.15 K. Calculate the freezing point of 10% glucose in water, if freezing point of pure water is 273.15 K.

Given: (Molar mass of sucrose = 342 g mol^{-1})
(Molar mass of glucose = 180 g mol^{-1}) [2017]

34. A solution is prepared by dissolving 5 g of non-volatile solute in 95 g of water. It has a vapour pressure of 23.375 mm Hg at 25 °C. Calculate the molar mass of the solute. (vapour pressure of pure water at 25 °C is 23.75 mm Hg). [2015]

35. Calculate the mass of compound (molar mass = 256 g mol^{-1}) to be dissolved in 75 g of benzene to lower its freezing point by 0.48 K.
(K_f = 5.12 K kg mol^{-1}). [2014]

36. Some ethylene glycol, $HOCH_2—CH_2OH$ is added to your car's cooling system along with 5 kg of water. If the freezing point of water glycol solution is −15 °C, what is the boiling point of the solution?
[K_b = 0.52 K kg mol^{-1}, K_f = 1.86 K kg mol^{-1}] [2014 (C)]

LA Long Answer Type Questions (5 Marks)

37. (*a*) 30 g of urea (m = 60 g mol^{-1}) is dissolved in 846 g of water. Calculate the vapour pressure of water for this solution if vapour pressure of pure water at 298 K is 23.8 mm Hg.
(*b*) Write two difference between ideal solutions and non-ideal solution. [2023]

38. (*a*) A solution contains 5.85 g NaCl (Molar mass = 58.5 g mol^{-1}) per litre of solution. It has an osmotic pressure of 4.75 atm at 27°C. Calculate the degree of dissociation of NaCl in this solution.
(Given: R = 0.082 L atm K^{-1} mol^{-1})
(*b*) State Henry's law. Why is air diluted with helium in the tanks used by scuba divers? [2020]

39. (*a*) A 5% solution (by mass of) of cane sugar in water has a freezing point of 271 K. Calculate the freezing point of 5% solution (by mass) of glucose in water. The freezing point of pure water is 273.15 K.
(*b*) Why is osmotic pressure of 1 M KCl higher than 1 M urea solution?
(*c*) What type of liquids form ideal solutions? [2019 (C)]

40. (*a*) 1.0 g of a non-electrolyte solute dissolved i n 50 g of benzene lowered the freezing point of benzene by 0.40 K. The freezing point depression constant of benzene is 5.12 K kg mol^{-1}. Find the molar mass of the solute.
(*b*) What is the significance of Henry's law constant, K_H?
(*c*) What leads to anoxia? [2019 (C)]

Abnormal Molar Masses, van't Hoff Factor, Degree of Association, Dissociation and Dissociation Constant

MCQ Multiple Choice Questions (1 Mark)

1. A compound undergoes complete dimerisation in the given solvent. The van't Hoff factor (*i*) is [2023]
(*a*) 2.0 (*b*) 0.5
(*c*) 0.25 (*d*) 1.0

2. Out of following 1.0 M aqueous solution which will show largest ΔT_f? [2023]
(*a*) NaCl (*b*) Na_2SO_4
(*c*) $C_6H_{12}O_6$ (*d*) $Al_2(SO_4)_3$

3. For an electrolyte undergo dissociation in aqueous solution the van't Hoff factor is [2023]
(*a*) is always less than one
(*b*) is always greater than one
(*c*) has zero value
(*d*) has negative value

VSA Very Short Answer Type Questions (2 Marks)

4. A 0.01 m aqueous solution of $AlCl_3$ freezes at −0.068 °C. Calculate the percentage of dissociation.
[Given: K_f for Water = 1.86 K kg mol^{-1}] [2020]

5. Predict whether van't Hoff factor, (*i*) is less than one or greater than one in the following: [2019]
(*i*) CH_3COOH dissolved in water.
(*ii*) CH_3COOH dissolved in benzene.

6. Determine the osmotic pressure of a solution prepared by dissolving 25 mg of K_2SO_4 in 2 litre of water at 25°C, assuming that it is completely dissociated. [2019]

7. Predict the state of solute in the following situation:
(*a*) Experimentally determined molar mass is more than true value.
(*b*) '*i*' value is 0.4 [2020]

8. Define the following terms:
(*i*) Abnormal molar mass
(*ii*) van't Hoff factor (*i*) [2017]

SA Short Answer Type Questions (3 Marks)

9. Give reasons for the following:
(*a*) Measurement of osmotic pressure method is preferred for the determination of molar masses of macromolecules such as proteins and polymers.
(*b*) Aquatic animals are more comfortable in cold water than in warm water.
(*c*) Elevation of boiling point of 1 M KCl solution is nearly double than that of 1 M sugar solution. [2023]

10. If benzoic acid (M = 122 g/mol) is associated into dimer when dissolved in benzene and osmotic pressure of its solution of 6.1 g of benzoic acid in 100 mL of Benzne is 6.5 atm at 27°C. What is percentage of association?
[R = 0.0821 Latm K^{-1} mol^{-1}) [2023]

11. 0.3 g of acetic acid (M = 60 g/mol) dissolved in 30 g of benzene shows a depression of freezing point is 0.45°C. Calculate the percentage association of

acid if it forms dimer in solution [Given K_f for benzene = 5.12 K kg mol^{-1}] [2023]

12. (*a*) Find the value of van't Hoff factor for acetic acid in benzene as per the given equation: $2CH_3COOH \rightleftharpoons (CH_3COOH)_2$, assuming its complete association.
(*b*) Osmotic pressure of a solution containing 3·5 g of dissolved protein in 0.05 L of a solution is 0.035 atm at 310 K. Calculate the molar mass of the protein. (R = 0.0821 L atm K^{-1} mol^{-1}) [2023(C)]

13. Calculate the amount of $CaCl_2$ (Molar mass 111 g mol^{-1}) which must be added to 500 g of water to lower its freezing point by 2K assuming $CaCl_2$ is completely dissociated [K_f = 1.86 K kg mol^{-1}] [2020]

14. A solution 0.1 M of Na_2SO_4 is dissolved to the extent of 95%. What would be its osmotic pressure at 27°C? (R = 0.0821 L atm K^{-1} mol^{-1}) [2019]

15. Calculate the freezing point of an aqueous solution containing 10.5 g of Magnesium bromide in 200 g of water, assuming complete dissociation of Magnesium bromide. (Molar mass of Magnesium bromide = 184 g mol^{-1}, K_f for water = 1.86 K kg mol^{-1}). [2018]

16. Calculate the boiling point of solution when 4 g of $MgSO_4$ (M = 120 g mol^{-1}) was dissolved in 100 g of water, assuming $MgSO_4$ undergoes complete ionization. (K_b for water = 0.52 K kg mol^{-1}) [2016]

17. Calculate the freezing point of solution when 2 g of Na_2SO_4(M = 142 g mol^{-1}) was dissolved in 50 g of water, assuming Na_2SO_4 undergoes complete ionization. (K_f for water = 1.86 K kg mol^{-1}) [2016]

18. 3.9 g of benzoic acid dissolved in 49 g of benzene shows a depression in freezing point of 1.62 K. Calculate the van't Hoff factor and predict the nature of solute (associated or dissociated).
(Given: Molar mass of benzoic acid = 122 g mol^{-1}, K_f for benzene = 4.9 K kg mol^{-1}) [2015]

LA Long Answer Type Questions (5 Marks)

19. (*i*) Why is value of van't Hoff factor for ethanoic acid in benzene closed to 0.5?
(*ii*) Determine the osmotic pressure of solution prepared by dissolving 2.32 × 10^{-2} g of K_2SO_4 in 2 L solution at 25° C assuming K_2SO_4 is completely dissociated.
[R = 0.082 Latm K^{-1} mol^{-1}, Molar mass of K_2SO_4 = 174 g mol^{-1}]
(*iii*) When 25.6 g sulphur was dissolved in 1000g of benzene, the freezing point lowered by 0.512 K. Calculate the formula of sulphur (S_x) [K_f for benzene = 5.12 K kg mol^{-1}, Atomic mass of sulphur = 32 g mol^{-1} [2023]

20. (*i*) Why is boiling point of 1M NaCl solution more than that of 1 M glucose solution.
(*ii*) A non-volatile solute 'X' (molar mass = 50 g/mol) when dissolved in 78 g of benzene reduced the vapour pressure to 90%. Calculate the mass of 'X' dissolved in the solution.
(*iii*) Calculate the boiling point elevation for a solution prepared by adding 10 g of $MgCl_2$ in 200 g of water assuming $MgCl_2$ is completely ionised.
[K_b for water = 0.512 K kg mol^{-1}. Molar mass of $MgCl_2$ = 95 g mol^{-1}] [2023]

21. (*a*) When 19.5 g of F – CH_2 – COOH (Molar mass = 78 g mol^{-1}) dissolved in 500 g of water, the depression in freezing point is observed to be 1°C. Calculate the degree of dissociation of F – CH_2 – COOH.
[Given: K_f for water = 1.86 K kg mol^{-1}]
(*b*) Give reasons:
(*i*) 0.1 M KCl has higher boiling point than 0.1 M Glucose.
(*ii*) Meat is preserved for a longer time by salting. [2020]

22. (*a*) When 2.56 g of sulphur was dissolved in 100 g of CS_2, the freezing point lowered by 0.383 K. Calculate the formula of sulphur (S_x.)
(K_f for CS_2 = 3.83 K kg mol^{-1}, Atomic mass of Sulphur = 32 g mol^{-1})
(*b*) Blood cells are isotonic with 0.9% sodium chloride solution. What happens if we placed blood cells in a solution containing
(*i*) 1.2% sodium chloride solution?
(*ii*) 0.4% sodium chloride solution? [2016]

23. (*a*) Calculate the freezing point of solution when 1.9 g of $MgCl_2$ (M = 95 g mol^{-1}) was dissolved in 50 g of water, assuming $MgCl_2$ undergoes complete ionization. (K_f for water = 1.86 K kg mol^{-1}) [2016]
(*b*) (*i*) Out of 1 M glucose and 2 M glucose, which one has a higher boiling point and why?
(*ii*) What happens when the external pressure applied becomes more than the osmotic pressure of solution?

AR Assertion and Reason Questions

In the following questions a statement of assertion followed by statement of a reason is given. Choose the correct answer out of the following choices.

(*a*) Both A and R are true and R is the correct explanation of A.

(*b*) Both A and R are true but R is not the correct explanation of A.

(*c*) A is true but R is false.

(*d*) A is false but R is true.

1. **Assertion (A):** When glucose is added to water, an elevation in boiling point is observed.
   Reason (R): The lowering of vapour pressure causes elevation in boiling point. [2023]
2. **Assertion (A):** Osmotic pressure is a colligative property.
   Reason (R): Osmotic pressure of a solution depends on the molar concentration of solute at any temperature T. [2021]
3. **Assertion (A):** Relative lowering in vapour pressure is a colligative property.
   Reason (R): Relative lowering in vapour pressure depends upon mole fraction of pure solvent. [2021]
4. **Assertion (A):** A raw mango placed in a saline solution loses water and shrivel into pickle.
   Reason (R): Through the process of reverse osmosis, raw mango shrivel into pickle. [2021]
5. **Assertion (A):** Elevation in boiling point is a colligative property.
   Reason (R): Elevation in boiling point is directly proportional to molarity. [2020]
6. **Assertion (A):** 0.1 M solution of KCl has greater osmotic pressure than 0.1 M solution of glucose at same temperature.
   Reason (R): In solution, KCl dissociates to produce more number of particles. [2020]
7. **Assertion (A):** An ideal solution obeys Henry's law.
   Reason (R): In an ideal solution, solute-solute as well as solvent-solvent interactions are similar to solute-solvent interaction. [2020]
8. **Assertion (A):** Osmotic pressure is a colligative property.
   Reason (R): Osmotic pressure is directly proportional to molarity. [2020]
9. **Assertion (A):** Non-ideal solutions form azeotropic mixture.
   Reason (R): Maximum boiling azeotropes are formed by solution showing negative deviation. [2020]
10. **Assertion (A):** Molality of solution in a liquid state changes with temperature.
    Reason (R): The volume of solution changes with change in temperature. [2020]

CBQ Case-Based Questions

1. **Read the following passage and answer the questions that follow:**

   Raoult's law for volatile liquids states that the partial vapour pressure of each component in the solution is directly proportional to its mole fraction, whereas for a non-volatile solute, it states that the vapour pressure of a solution of a non-volatile solute is equal to the vapour pressure of the pure solvent at that temperature multiplied by its mole fraction. Two liquids A and B are mixed with each other to form a solution. Once the components in the solution have reached equilibrium, the total vapour pressure of the solution can be determined by combining Raoult's law with Dalton's law of partial pressures. If a non-volatile solute B is dissolved into a solvent A to form a solution, the vapour pressure of the solution will be lower than that of the pure solvent. The solutions which obey Raoult's law over the entire range of concentration are ideal solutions, whereas the soltutios for which vapour pressure is either higher or lower than that predicted by Raoult's law are called non-ideal solutions. Non-ideal solutions are identified by determining the strength of the intermolecular forces between the different molecules in that particular solution. They can either show positive or negative deviation from Raoult's law depending on whether the A – B interactions in solution are stronger or weaker than A – A and B – B interactions. [2023(C)]

   (*a*) 20 mL of a liquid A was mixed with 20 mL of liquid B. The volume of resulting solution was found to be less than 40 mL. What do you conclude from the above data?

   (*b*) Which of the following show positive deviation from Raoult's law?

   Carbon disulphide and Acetone; Phenol and Aniline; Ethanol and Acetone.

(c) The vapour pressure of a solution of glucose in water is 750 mm Hg at 100°C. Calculate the mole fraction of solute. (Vapour pressure of water at 373 K = 760 mm Hg)

Or

(c) The boiling point of solution increases when 1 mol of NaCl is added to 1 litre of water while addition of 1 mol of methanol to one litre of water decreases its boiling point. Explain the above observations.

2. **Read the following passage and answer the questions that follow:**

There are many phenomena which we observe in nature or at home. For example, raw mangoes shrink when pickled in brine, wilted flowers revive in fresh water, etc. The substances are bound by membranes. Small molecules like water can pass through these membranes. This process of flow of solvents is called osmosis. The pressure that just stops the flow of solvents is called osmotic pressure of solution. Osmotic pressure is directly proportional to molarity of the solution at a given temperature. [2020(C)]

(i) Out of 1 M urea and 1 M NaCl, which one has higher osmotic pressure of the solution ?

(ii) Name one natural and one synthetic membrane that can be used in osmosis.

(iii) A doctor advised a person suffering from high blood pressure to take less quantity of salt. Why?

(iv) How can we convert sea water into potable water?

(v) The Red Blood Corpuscles (RBC) in animal cells are isotonic with 0.9% NaCl solution. What will happen when RBCs are placed in 1% NaCl solution?