Chapter 2

Solutions

Solutions (Set-1)

Very Short Answer Type Questions :

1. What is the physical state of solvent in $Na_2SO_4 \cdot 10H_2O(s)$?

Sol. Solid

2. Identify solvent in $Na_2SO_4 \cdot 10H_2O(s)$.

Sol. $Na_2SO_4(s)$

3. In moist air solvent is …… .

Sol. Air (Gas)

4. What is the effect of temperature on the molality of a solution?

Sol. No effect

5. If $(\text{molar mass})_{obs} = (\text{molar mass})_{calc.}$ and if the solvent is water then predict whether the solute is electrolytic or non-electrolytic.

Sol. Non-electrolyte

6. Can we say that for non-electrolytic solutes observed v.p. of solution is equal to its calculated value?

Sol. No, solute may associate.

7. For reverse osmosis how much pressure should be applied?

Sol. Greater than osmotic pressure.

8. Which type of solutes show colligative properties, volatile or non-volatile?

Sol. Non-volatile

9. What is the sign of $(\Delta G)_{sol}$ for a non-ideal solution?

Sol. Negative

10. What is the sign of (ΔS) for ideal solutions?

Sol. Positive

Short Answer Type Questions :

11. What is sign of ΔH_{mix}, ΔV_{mix} and ΔG_{mix} for ideal solution?

Sol. $\Delta H_{mix} = 0$, $\Delta V_{mix} = 0$, $\Delta G_{mix} < 0$

12. Name same concentration terms which are independent of temperature.

Sol. Molality, mole fraction, mass percentage.

13. In a solution with positive deviation v.p. of solution is greater than v.p. of pure solvent. Explain.

Sol. See text, graphical representation.

14. In a solution with negative deviation v.p. of solution is less than v.p. of pure solute. Explain.

Sol. See text.

15. R–COOH dimerises in benzene upto 50% and it ionises upto 10% in water. Determine ratio of van't Hoff factors in dimerisation versus ionisation.

Sol. $\left.\begin{aligned} i_1 &= 1-0.5+\frac{0.5}{2}=0.75 \\ i_2 &= 1-0.1+2\times 0.1=1.1 \end{aligned}\right\} \Rightarrow \frac{i_1}{i_2}=\frac{0.75}{1.1}$

16. For two solvents K_f is 2 and 8 respectively, which one will be preferred in a depression of freezing point method and why?

Sol. Second one, greater the K_f easier will be measurement.

17. From 2 L 0.1 M aq. solution of sugar 0.5 L water is evaporated, determine final concentration of solution in molarity.

Sol. $2 \times 0.1 = 1.5\ M$

$$\therefore \quad M=\frac{0.2}{1.5}=\frac{2}{15}$$

18. On dilution or on concentration of a solution what does not change?

Sol. Moles of solute

19. As per Dalton's law of partial pressure how to represent vapour pressure of a solution?

Sol. $p_{sol.} = p_A + p_B$

20. A solution with both volatile components is boiled and condensate is collected in another vessel, which component will be major and why?

Sol. Component with greater volatility.

21. If $p_A^o = 400\ mm\ Hg$, $p_B^o = 360\ mm\ Hg$, $x_A = 0.8$, determine x_B and p_{sol}.

Sol. $x_B = 0.2$

$p_{sol.} = 400 \times 0.8 + 360 \times 0.2$

$= 80(5 \times 0.8 + 0.9)$

$= 80 \times 4.9$

$= 392.0$

22. With reference to question 21, determine vapour phase composition in equilibrium with solution.

Sol. $x_A' = \frac{400\times 0.8}{392}=\frac{320}{392}=0.816$; $\quad x_B' = 0.1836$

23. Henry's law constant for CO_2 in water is 1.67×10^8 Pa. Calculate amount of CO_2 in a 500 ml soft drinks bottle packed at 2.5 atm pressure of CO_2 at 298 K.

Sol. $x_{CO_2} = \frac{p}{K_H} = \frac{2.5\times10^5}{1.67\times10^8} = \frac{2.5\times10^{-3}}{1.67}$

n_{CO_2} in 500 ml $= \frac{2.5\times500\times10^{-3}}{1.67\times18} = 0.042$

24. Determine osmotic pressure of an aqueous solution containing 25 g K_2SO_4/L at 25°C.

Sol. $\pi = 3\times\frac{\left(\frac{25}{39\times2+96}\right)}{1}\times0.0821\times298 = \frac{3\times25}{174}\times0.0821\times298 = 10.54$ atm

25. What happens when a plant cell is placed in a (i) hypertonic solution (ii) hypotonic solution?

Sol. (i) It will shrink

(ii) It will expand

26. Doctors advises patients of high blood pressure to take less quantity of common salt, why?

Sol. Osmotic pressure increases.

27. A decimolar solution of $K_4[Fe(CN)_6]$ is 75% dissociated at 27°C. Determine its osmotic pressure in atmosphere.

Sol. π = (1 – 0.75 + 5 × 0.75) × 0.1 × 0.0821 × 300

= 4 × 0.1 × 8.21 × 3 = 9.85 atm

28. Determine mass of bi-phenyl dissolved in 100 g benzene if rise in boiling point is 2.3.

K_b(benzene) = 2.57 K kg mol^{-1}.

Sol. $2.3 = 2.57\times\frac{\frac{m}{77\times2}}{\frac{100}{1000}} = 2.57\times\frac{m}{77\times2}\times\frac{1000}{100}$

$\therefore \quad m = \frac{2.3\times77\times2}{2.57\times10} = 13.78$ g

29. Henry's law constant for the solubility of N_2 in water at 25°C is 10^5 atm and air is supposed to be 1 : 4 mixture of O_2 and N_2. Determine the number of moles of air dissolved in 1 mole water at 5 atm pressure.

Sol. $p_{N_2} = 5\times\frac{4}{5} = x_{N_2}\times10^5$

$\therefore \quad x_{N_2} = 4\times10^{-5}$

30. ΔT_f for 0.002 m aq. solution of $Co(NH_3)_5(NO_2)Cl$ is 0.00732°C. Determine number of ions produced per molecule in aq. solution. (K_f = 1.86 K kg mol^{-1})

Sol. 0.00732 = i × 1.86 × 0.002

$\therefore$ i = 1.97 ≈ 2

$\therefore$ ions/molecule = 2

Long Answer Type Questions :

31. What is the need and applicability of van't Hoff factor? Explain the conditions where $\Delta T_b = K_b \cdot m$ can be used.

Sol. See text.

32. Explain the conditions where $\Delta T_b = i\, K_b m$ should be used to set correct results.

Sol. In case of association or dissociation of solutes.

33. Define and relate the terms volatility, vapour pressure and boiling point.

Sol. See text.

34. Give graphical representation for both types of non-ideal solutions.

Sol. See text.

35. Give introduction of reverse osmosis, make labelled diagram for purification of water by this method.

Sol. See text.

36. 10 g of NaOH is added to 50 mL of 0.1 M aqueous solution and volume is finally made 100 ml. Calculate the molarity of resulting solution.

Sol. 2.25 M

37. Mention characteristics of an ideal solution. What causes them to be non-ideal, discuss in detail?

Sol. See text.

38. After removing the shell of egg, one is placed in distilled water while the other is placed in saturated solution of NaCl. What will you observed and why?

Sol. Egg in water will swell while that in NaCl will shrink because of osmosis.

39. Calculate osmotic pressure of 0.1 M dibasic strong acid of pH = 4 at 27°C.

Sol. $H_2A \rightleftharpoons 2H^+ + A^{2-}$

$0.1(1-\alpha) \qquad 0.2\alpha \quad 0.1\alpha$

$pH = 4 \Rightarrow -\log[H^+] = 4 \Rightarrow [H^+] = 10^{-4} = 0.2\alpha$

$\therefore \quad \alpha = 5 \times 10^{-4}$

$\pi = (1 - 5 \times 10^{-4} + 3 \times 5 \times 10^{-4}) \times 0.1 \times 0.0821 \times 300$

$= (1 + 10^{-3}) \times 0.0821 \times 30 = 2.46$ atm

40. Calculate boiling point of solution containing 30 g urea and 38 g thiourea in 800 g chloroform. Boiling point of chloroform = 61.2°C, K_b = 3.63 K kg mole^{-1}.

Sol. $$T_b' = 61.2 + 3.63 \times \frac{\left(\frac{30}{60} + \frac{38}{76}\right)}{\left(\frac{800}{1000}\right)} = 3.63 \times \frac{1}{1} \times \frac{1000}{800}$$

$\therefore \quad T_b' = 65.73°C$

41. Mention the conditions in which a solute becomes solvent and solvent becomes solute.

Sol. Component of greater mass % is solvent.

42. What is molal elevation constant? What are its units?

Sol. Molal elevation constant is the elevation in boiling point when molality of solution is 1.

Unit of K_b = K . kg mol^{-1}

43. 1 mole A_2 is dissolved in 1 mole solvent (polar), in another case 1 mole A^+B^- is added to 1 mole same solvent. Determine mole fraction of solvent in both the cases.

Sol. $(x_{solvent})_1 = \frac{1}{2}, \; x_{(solvent)_2} = \frac{1}{3}$

44. In 10 L water 1 mole of $Ca(OH)_2$ is added with 1 mole of H_2SO_4. Determine van't Hoff factor (i) of final solution.

Sol. $Ca(OH)_2 + H_2SO_4 \rightleftharpoons CaSO_4 + 2H_2O$

van't Hoff factor for $CaSO_4$ = 2

45. 1 mole urea and 1 mole NaCl are added to water. K_f = 1.86, K_b = 0.52 (In K kg $mole^{-1}$) determine the ratio of ΔT_b vs ΔT_f for the solution (Urea : NaCl).

Sol. $\Delta T_b = \frac{3}{2} \times 0.52 \times \frac{2}{w}$ …(i)

$\Delta T_f = \frac{3}{2} \times 1.86 \times \frac{2}{w}$ …(ii)

$\therefore \quad \frac{\Delta T_b}{\Delta T_f} = \frac{0.52}{1.86} = \frac{26}{93}$

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Chapter 2

Solutions

Solutions (Set-2)

[Concentration Term and Raoult's Law]

1. What is the molarity of 4.9% H_3PO_4 solution by mass (density of H_3PO_4 = 1.22 g/ml)?

(1) 0.61 M (2) 4.9 M (3) 1.22 M (4) 1 M

Sol. Answer (1)

Given: ρ of H_3PO_4 solution = 1.22 g/ml

Let the volume of solution = 1000 ml

$\rho = \frac{m}{v} \Rightarrow m_{Solution} = 1.22 \times 1000 = 1220$ g

$W_{H_3PO_4} = \frac{4.9}{100} \times 1220$ g

$\frac{W}{M} = n = \frac{4.9 \times 1220}{100 \times 980} = \frac{4.9 \times 1220}{1000 \times 98}$

$\therefore \quad \frac{W}{M} = n = \frac{4.9}{100} \times \frac{1220}{98} = 0.61$

$\therefore$ 0.61 moles are present in 1L

$\therefore$ Molarity is 0.61 M

2. The molality of 1 M $NaNO_3$ solution is (d = 1.25 g/ml)

(1) 0.8 m (2) 0.858 m (3) 1.6 m (4) 1 m

Sol. Answer (2)

For $NaNO_3$ solution, C = 1 M

$\rho = \frac{m}{V} \Rightarrow m_{Solution} = \rho \times V$

$\Rightarrow \quad m_{Solution} = 1.25 \times 1000 = 1250$ g

$W_{NaNO_3} = 1 \times (23 + 14 + 48) = 85$

$W_{SOLVENT} = (1250 - 85) = 1165$ g

$\therefore$ Molality = $\frac{1 \times 10^3}{1165} = 0.858$ m

3. The solubility of a gas in a liquid generally increases with

(1) Increase in temperature (2) Amount of liquid taken

(3) Decrease in temperature (4) Reduction of gas pressure

Sol. Answer (3)

Dissolution process is exothermic

4. When a saturated solution of sodium chloride is heated it

(1) Remains saturated (2) Becomes unsaturated

(3) Becomes supersaturated (4) Achieves equilibrium state

Sol. Answer (2)

NaCl gets precipitated out.

5. The vapour pressure of pure liquid A is 70 torr at 27°C. It forms an ideal solution with another liquid B. The mole fraction of B is 0.2 and total vapour pressure of the solution is 84 torr at 27°C. The vapour pressure of pure liquid B at 27°C is

(1) 140 torr (2) 50 torr (3) 14 torr (4) 70 torr

Sol. Answer (1)

Given: $P^o_A = 70$ torr

$X_B = 0.2$; $P_T = 84$ torr

P^o_B = ?; $X_A = 1 - X_B = 1 - 0.2 = 0.8$

We know that

$$P_T = P^o_A X_A + P^o_B X_B$$

$$\Rightarrow (84) = (70)(0.8) + P^o_B (0.2)$$

$$\text{or } \frac{28}{0.2} = P^o_B = 140 \text{ mm Hg}$$

6. If two liquids A and B form an ideal solution, then

(1) Enthalpy of mixing is zero (2) Entropy of mixing is zero

(3) Free energy of mixing is zero (4) Both free energy and entropy of mixing is zero

Sol. Answer (1)

$\Delta H_{mix} = 0$ but ΔS_{mix} and ΔG_{mix} is not zero.

7. Raoult's law is not valid in

(1) Non-ideal solution showing positive deviation (2) Non-ideal solution showing negative deviation

(3) Mixture of two immiscible liquid (4) All of these

Sol. Answer (4)

Non-ideal solution do not obey Raoult's law, both negative and positive but it is valid for both negative and positive non-ideal solution.

Non-ideal solutions are the part of miscible liquid.

Raoult's law is valid for miscible liquid only it is not for immiscible liquid.

[Colligative Properties (Non-electrolytic solute)]

8. 20 g of non-electrolyte, non-volatile solute ($C_xH_{2x}O_x$), when dissolved in 100 gm water at 100°C, lowers the vapour pressure of solution by $\frac{1}{100}$th of the vapour pressure of pure water at this temperature. What is formula of the compound?

(1) $C_6H_{12}O_6$ (2) $C_{12}H_{24}O_{12}$ (3) $C_{44}H_{88}O_{44}$ (4) $C_3H_6O_3$

Sol. Answer (2)

W_{solute} = 20 g ; $W_{solvent}$ = 100 g

For pure water, P° is the vapour pressure.

$$P_S = P° - \frac{P°}{100} = \frac{99P°}{100}$$

We know that

$$\frac{P°}{100}\times\frac{1}{P°} = \frac{\frac{20}{M}}{\frac{20}{M}\times\frac{100}{18}}$$

$\Rightarrow$ M = 360

$\therefore$ Formula of non-electrolyte is $C_{12}H_{24}O_{12}$.

9. The vapour pressure of a solvent decreases by 5.4 torr when a non-volatile solute is added. In this solution, mole fraction of solute is 0.2. What would be mole fraction of the solvent if decrease in vapour pressure is 16.2 torr?

(1) 0.6 (2) 0.4 (3) 0.2 (4) 0.8

Sol. Answer (2)

$(\Delta P)_1 = P° - P_S$ = 5.4 torr

X_{solute} = 0.2

(ΔP_2) = 16.2 torr;

We know that

$$\frac{\frac{(P° - P_S)_1}{P°}}{\frac{(P° - P_S)_2}{P°}} = \frac{(X_{solute})_1}{(X_{solute})_2} = \frac{0.2}{x}$$

$$\frac{5.4}{16.2} = \frac{0.2}{x} \Rightarrow x = \frac{0.2\times16.2}{5.4}$$

$\therefore$ X_{solute} = 0.6 $\therefore$ $X_{solvent}$ = 1 – 0.6 = 0.4

10. When NaCl is added to aqueous solution of glucose

(1) Freezing point is raised (2) Freezing point is lowered

(3) Boiling point is lowered (4) No change in freezing point or boiling point

Sol. Answer (2)

NaCl is a solute which will cause the depression in the freezing point as it is one of the colligative property.

11. 2.56 g of sulphur in 100 g of CS_2 has depression in freezing point of 0.010°C K_f = 0.1°C (molal)$^{-1}$. Hence atomicity of sulphur in the solution is

(1) 2 (2) 4 (3) 6 (4) 8

Sol. Answer (4)

W_{SOLUTE} = 2.56 g

$W_{SOLVENT}$ (CS_2) = 100 g

ΔT_f = 0.01° C ; K_f = 0.1

We can apply the equation,

$\Delta T_f = K_f \, xm$

$$(0.01) = \frac{(0.1)\times 2.56\times 1000}{M\times 100}$$

$$M = \frac{2.56\times 1000\times 0.1}{100\times 0.01} = 256 \text{ g}$$

$\therefore$ No. of atoms of Sulphur

$$\Rightarrow \frac{256}{32} = 8$$

$\therefore$ Atomicity = 8

12. 'A' gram of non-volatile, non-electrolyte (molar mass M) is dissolved in 200 ml of unknown solvent (density = 1.25 gm/ml molal elevation constant is K_b). Elevation in boiling point of this solution can be given by

(1) $\frac{M}{K_b}$ (2) $\frac{4K_bA}{M}$ (3) $\frac{K_bA}{4M}$ (4) $\frac{K_bM}{4A}$

Sol. Answer (2)

W_{solute} = A ;

$V_{solvent}$ = 200 ml ; ρ = 1.25 g/ml

$\Delta T_b = K_b \times$ molality

$$\text{Molality} = \frac{A}{M}\times\frac{1000}{200\times 1.25} = \frac{4A}{M}$$

$$\text{So, } \Delta T_b = \frac{4K_bA}{M}$$

13. 75 g ethylene glycol is dissolved in 500 gram water. The solution is placed in a refrigerator maintained at a temperature of 263.7 K. What amount of ice will separate out at this temperature?

(K_f water = 1.86 K molality^{-1})

(1) 300 g (2) 200 g (3) 178 g (4) 258 g

Sol. Answer (4)

W ($CH_2OH.CH_2OH$) = 75 g

W (H_2O) = 500 g and ΔT_f = 9.3

$$\Rightarrow (9.3) = \frac{75\times1000\times1.86}{62\times W_{solvent}}$$

$$\Rightarrow W_{solvent} = \frac{75\times1000\times1.86}{62\times9.3} = 242 \text{ g}$$

Ice separated = 500 – 242 = 258 g

[Abnormal Colligative Properties]

14. If relative decrease in vapour pressure is 0.4 for a solution containing 1 mol NaCl in 3 mol of H_2O, then % ionization of NaCl is

(1) 60% (2) 80% (3) 40% (4) 100%

Sol. Answer (4)

$$\frac{P^\circ - P_s}{P^\circ} = \frac{i\times n}{i\times n + N}$$

$$0.4 = \frac{i\times1}{i\times1+3}$$

i = 2

For NaCl, i = 1 + α

or 2 = 1 + α

or α = 1

$\therefore$ NaCl is 100% ionized.

15. Amongst the following, the solution which shows highest osmotic pressure is

(1) 0.05 M NaCl (2) 0.10 M $BaCl_2$

(3) 0.05 M $FeCl_3$ (4) 0.05 M Na_2SO_4

Sol. Answer (2)

Osmotic Pressure $\pi = i\times C\times S\times T$

NaCl (i = 2)	$C_1 = 0.05$
$BaCl_2$ (i = 3)	$C_2 = 0.10$
$FeCl_3$ (i = 4)	$C_3 = 0.05$
Na_2SO_4 (i = 3)	$C_4 = 0.05$

$\therefore$ Product of C and i is maximum for $BaCl_2$.

$\therefore$ $BaCl_2$ solution has maximum Osmotic pressure.

16. A 0.2 molal aqueous solution of weak acid HX is 20% ionized. The freezing point of solution is (K_f = 1.86)

(1) – 0.45°C (2) – 0.9°C (3) – 0.31°C (4) – 0.53°C

Sol. Answer (1)

Weak acid HX is 20% ionized

$$\underset{1-\alpha}{HX} \rightleftharpoons \underset{\alpha}{H^+} + \underset{\alpha}{X^-}$$

$i = 1 - \alpha + \alpha + \alpha = 1 + \alpha = 1 + 0.2 = 1.2$

$\Delta T_f = (0.2) \times (1.86) \times (1.2) = 0.45°C$

$\therefore \quad T_f = 0 - 0.45°C = -0.45°C$

17. When 20 g of napthanoic acid ($C_{11}H_8O_2$) is dissolved in 50 g of benzene (K_f = 1.72 K kg/mol) a freezing point depression of 2 K is observed. The van't Hoff factor (i) is

(1) 0.5 (2) 2.0 (3) 1.0 (4) 3.0

Sol. Answer (1)

$W = 20$ g ; $W_{solvent} = 50$ g

$K_f = 1.72$; $\Delta T_f = 2K$

We can use the equation

$\Delta T_f = i \times K_f \times m$

$\Rightarrow \quad i = \dfrac{\Delta T_f}{K_f \times m} = \dfrac{2 \times 172 \times 50}{1.72 \times 20 \times 1000}$

$\Rightarrow \quad i = 0.5$

18. van't Hoff factor of aqueous acetic acid solution is

(1) < 1 (2) > 1 (3) = 1 (4) 0

Sol. Answer (2)

CH_3COOH undergoes ionization in aqueous solution therefore i > 1.

$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$

19. Acetic acid dimerises in benzene solution. The van't Hoff factor for the dimerisation of acetic acid is 0.8. The % of dimerisation of acetic acid is

(1) 20% (2) 40% (3) 60% (4) 80%

Sol. Answer (2)

For, $2\,CH_3COOH \rightleftharpoons (CH_3COOH)_2$

$i = 1 - \alpha + 0.5\,\alpha$

$0.8 = 1 - 0.5\,\alpha$

$0.5\,\alpha = 0.2$

$\alpha = 0.4$

Hence % dimerisation is 40.

20. Which has lowest osmotic pressure at same temperature?

(1) 100 ml of 1 M urea (2) 400 ml of 0.5 M KCl

(3) 200 ml of 0.5 M glucose (4) 300 ml of 0.25 M K_3PO_4

Sol. Answer (3)

For 0.5 M $C_6H_{12}O_6$ the osmotic pressure will be least because i = 1

For urea, $\pi = 1 \times 1 \times ST$

For KCl, $\pi = 2 \times 0.5 \times (S)(T) = ST$

For K_3PO_4, $\pi = 4 \times 0.25 \times ST = ST$

Hence, osmotic pressure will be least for 0.5 M $C_6H_{12}O_6$.

21. The value of observed and calculated molecular weights of silver nitrate are 92.64 and 170 respectively. The degree of dissociation of silver nitrate is

(1) 60% (2) 83.5% (3) 46.7% (4) 60.23%

Sol. Answer (2)

Colligative properties are inversely related to molecular mass of the solute. Because of which

$$i = \frac{M_{CAL}}{M_{OBS}} = \frac{170}{92.64} = 1.83$$

Since

$i = 1 + (n - 1)\,\alpha$

For $AgNO_3$, $i = 1 + \alpha$

$\therefore \alpha = (1.83 - 1) = 0.835$

$\therefore$ 83.5% ionization takes place

22. If a solute undergoes dimerisation and trimerisation, the minimum values of the van't Hoff factors are

(1) 0.5 and 1.50 (2) 1.5 and 1.33 (3) 0.5 and 0.33 (4) 0.25 and 0.67

Sol. Answer (3)

$2A \rightleftharpoons A_2$ (Dimerization)

$$i = 1 - \alpha + \frac{\alpha}{2} = 1 - \frac{\alpha}{2}$$

For minimum , $\alpha = 1 \Rightarrow$ $i = 1 - \frac{1}{2} = \frac{1}{2}$

or $i = 0.5$

For trimerization $3A \rightleftharpoons A_3$

$$i = 1 - \alpha + \frac{\alpha}{3} = 1 + \alpha\left(\frac{1}{3} - 1\right) = 1 + \alpha\left(\frac{-2}{3}\right)$$

$$\Rightarrow i = 1 - \frac{2\alpha}{3} = 1 - \frac{2}{3} = \frac{1}{3} = 0.33$$

23. 2 millimolar solution of sodium ferrocyanide is 60% dissociated at 27°C. Osmotic pressure of the solution is

(1) 2.14 atm (2) 1.02 atm (3) 0.167 atm (4) 0.0234 atm

Sol. Answer (3)

$Na_4[Fe(CN)_6]$ undergoes 60% ionization

$i = 1 + (n - 1)\,\alpha = 1 + (5 - 1)\,\alpha = 1 + 4\,\alpha = 1 + 4(0.6) = 3.4$

$C = 2 \times 10^{-3}M$

$\therefore \pi = i \times C \times S \times T$

$\Rightarrow \pi = (3.4)\,(2 \times 10^{-3})\,(0.0821)\,(300) = 0.167$ atm.

24. A water sample contains 9.5% $MgCl_2$ and 11.7% NaCl (by weight). Assuming 80% ionisation of each salt. Boiling point of water will be approximately (K_b = 0.52)

(1) 110.01°C (2) 377 K (3) 277.25 K (4) 102.5°C

Sol. Answer (2)

25. A complex is written as $M(en)_y.xBr$. Its 0.05 molar solution shows 2.46 atm osmotic pressure at 27°C. Assuming 100% ionisation and coordination number of metal (III) is six, complex may be

(1) $[M(en)_2Br_2]Br$ (2) $[M(en)_3]Br_3$ (3) $[M(en)_2Br]Br_2$ (4) $[M(en)]Br_3$

Sol. Answer (1)

The complex is $M(en)_Y . x\ Br$

C = 0.05M ; π = 2.46 atm ; T = 300 K

Osmotic pressure of the solution is given by

$\pi = i \times C \times S \times T$

$\Rightarrow i = \frac{2.46}{(0.05)(0.0821)(300)} = 2$

The van't Hoff factor is 2 and since the coordination no. is 6 and n = 2 ; Formula is $[M(en)_2 Br_2] Br$

On ionization it forms two ions

$[M(en)_2 Br_2] Br \rightleftharpoons [M(en)_2 Br_2]^+ + Br^-$

26. Consider three solutions of 3 strong electrolytes. AB, CD_2 and EF_3

AB solution at 127°C (I) | CD_2 solution at 438.11°C (II) | EF_3 solution at 27°C (III)

The osmotic pressure ratio of I, II, and III is

(1) 1 : 4 : 3 (2) 1 : 2 : 3 (3) 2 : 3 : 4 (4) 2 : 4 : 3

Sol. Answer (1)

For (I)

$AB \rightarrow A^+ + B^-$

$\pi_1 = i \times C_1 \times S \times T_1$

$= 2 \times (2) \times 400 \times S = 1600\ S$

For (II)

$CD_2 \rightarrow 2D^- + C^{2+}$

$\pi_2 = 3 \times 3 \times 711.11 \times S = 6400\ S$

For (III)

$EF_3 \rightarrow E^{3+} + 3F^-$

$\pi_3 = 4 \times 4 \times 300 \times S = 4800\ S$

$\therefore$ Ratio of Osmotic pressures is

1600 S : 6400 S : 4800 S / *i.e.*, 1 : 4 : 3

27. Degree of dissociation of three binary electrolytes AB, CD and EF are 60%, 20% and 100% in the solution having same mole fraction of water. Ratio of lowering in vapour pressure of their solution is

(1) 0.8 : 0.6 : 1 (2) 0.2 : 0.4 : 0.1 (3) 0.3 : 0.5 : 0.2 (4) 1 : 2 : 0.5

Sol. Answer (1)

i for AB = 1 + 0.6 = 1.6

for CD ; i = 1.2

and for EF ; i = 1 + 1 =2

$(\Delta P)_1 = i\ P^\circ\ .\ (X_{solute})_1$

$(\Delta P)_2 = i\ P^\circ\ .\ (X_{solute})_2$

$(\Delta P)_3 = i\ P^\circ\ .\ (X_{solute})_3$

$(1.6)P^\circ : 1.2P^\circ : 2P^\circ$

1.6 : 1.2 : 2

0.8 : 0.6 : 1

28. Osmotic pressure of a blood sample is 4.92 atm at 27°C. Which of the following is not isotonic with blood sample?

(1) 3.6% (m/m%) glucose aqueous solution (2) 1.2% (m/m%) urea aqueous solution

(3) 0.585% (m/m%) NaCl aqueous solution (4) 1.7% (m/m%) $NaNO_3$ aqueous solution

Sol. Answer (4)

1.7% $NaNO_3$ solution has the concentration as

$$\underset{(S)}{2\times\left(\frac{1.7}{85}\right)}\times 10\times \underset{(T)}{0.0821\times 300} = 9.852 \text{ atm}$$

which is not isotonic with blood sample.

29. 0.067 molar aqueous solution of a binary electrolyte A^+B^- shows 2.46 atm osmotic pressure at 27°C. What fraction of A^+B^- remains unionised?

(1) 10% (2) 15% (3) 50% (4) Zero

Sol. Answer (3)

For AB ; C = 0.067 M

π = 2.46 atm ; T = 300 K

$$i = \frac{\pi}{C\times S\times T}$$

$$i = \frac{2.46}{0.067\times 0.0821\times 300} = 1.5$$

For electrolyte AB

$i = 1 + \alpha \quad \Rightarrow \alpha = 0.5$ or 50% ionized

30. The value of observed molecular weight of silver nitrate is 132.5 gram/mole, in an aqueous solution. The degree of dissociation of silver nitrate in this solution may be

(1) 79% (2) 32% (3) 28% (4) 44%

Sol. Answer (3)

$$i = \frac{M_{CAL}}{M_{OBS}}$$

$$i = \frac{M_{AgNO_3}}{132.5} = \frac{170}{132.5} = 1.28$$

For $AgNO_3$

$i = 1 + (n - 1)\,\alpha = 1 + \alpha = 1.28$

$\alpha = 0.28$

Hence, 28% ionization takes place.

31. When mercuric iodide is added to an aqueous solution of KI the

(1) Boiling point increases (2) Boiling point decreases

(3) Freezing point decreases (4) Osmotic pressure increases

Sol. Answer (2)

When HgI_2 is added to KI it forms the complex which indicates that no. of solute particles decreases.

$$HgI_2 + KI \rightleftharpoons K_2[HgI_4]$$

$\therefore$ Boiling point decreases.

32. Which of the following aqueous solutions has the highest freezing point (assuming m = M)?

(1) 0.1 M KNO_3 (2) 0.2 M Na_3PO_4 (3) 0.25 M $FeCl_3$ (4) 0.01 M Na_2SO_4.

Sol. Answer (4)

For KNO_3

$(\Delta T_f)_1 = 2 \times 0.1 \times m = 0.2\ m$

For Na_3PO_4

$(\Delta T_f)_2 = (0.2) \times (4) \times m = 0.8\ m$

For $FeCl_3$

$(\Delta T_f)_3 = (0.25) \times 4 \times m = m$

For Na_2SO_4

$(\Delta T_f)_4 = (0.01) \times 3\ m = 0.03\ m$

Hence, maximum depression in freezing point is for Na_3PO_4, and least for Na_2SO_4

Hence, F.P. is highest for Na_2SO_4 solution.

33. Which of the following pair of aqueous solutions can be expected to be isotonic at the same temperature? (Consider each electrolyte according to its 100% dissociation)

(1) 0.1 M urea and 0.1 M NaCl (2) 0.1 M NaCl and 0.1 M Na_2SO_4

(3) 0.1 M $Ca(NO_3)_2$ and 0.1 M Na_2SO_4 (4) 0.1 M glucose and 0.2 M $MgCl_2$

Sol. Answer (3)

0.1 M $Ca(NO_3)_2$ solution has

$\pi_1 = (0.1)\ (3) \times ST = (0.3)\ ST$ ...(i)

and Na_2SO_4 solution

$\pi_2 = (0.1)\ (3) \times ST = (0.3)\ ST$ ...(ii)

Hence, $\pi_1 = \pi_2$ which means that both the solutions will be isotonic which means both have same osmotic pressure.

34. Among the following solutions

a. 0.01 M NaCl
b. 0.05 M glucose
c. 0.01 M $CaCl_2$
d. 0.02 M KCl

The correct order of decreasing boiling point can be given as (assuming same dissociation)

(1) a > b > c > d (2) b > d > c > a (3) a > c > d > b (4) d > c > b > a

Sol. Answer (2)

$\Delta T_b = i \times k_b \times m$

For glucose, i = 1 as $\alpha = 0$

[Miscellaneous]

35. Freezing point of pure liquid A is T K. If some amount of non-electrolyte non-volatile impurity is added in A, an ideal solution is formed. On cooling at 200 K, only 30% (by mass) liquid A is present and at 201 K, 60% (by mass) liquid A is present. The value of T is

(1) 199 (2) 202 (3) 204 (4) 206

Sol. Answer (2)

$$(\Delta T_f)_1 = T - 201 = K_f \frac{n_{solute}}{\text{wt. of solvent}}$$

$$\frac{(\Delta T_f)_1}{(\Delta T_f)_2} = \frac{T-201}{T-200} = \frac{1}{2}$$

$\Rightarrow$ T = 202 K

36. Liquid A and B form ideal solution at temperature T. Mole fraction of A in liquid and vapour phase are 0.4 and 4/13 respectively, when total pressure is 130 torr. The vapour pressure (in torr) of A and B in pure state at temperature T are respectively

(1) 100, 200 (2) 200, 100 (3) 100, 150 (4) 150, 100

Sol. Answer (3)

$$P_T = P_A^\circ x_A + P_B^\circ x_B$$

$$P_A = P_A^\circ \cdot x_A = y_A \cdot P_T = \frac{4}{13} \times 130 = 40 \text{ torr}$$

$$P_A^\circ = \frac{40}{0.4} = 100 \text{ torr}$$

$$P_B^\circ = \frac{90}{0.6} = 150 \text{ torr}$$

37. Which of the following pair of solution (aq.) contain isotonic solution at same temperature? (Assume 100% ionisation of electrolytes)]

(1) 0.1 M NaCl and 0.2 M $CaCl_2$
(2) 0.1 M NaCl and 0.3 M $AlCl_3$
(3) 0.3 M NaCl and 0.1 M $AlCl_3$
(4) 0.3 M NaCl and 0.2 $CaCl_2$

Sol. Answer (4)

Isotonic solutions has same osmotic pressure.

$\pi = iCRT$

38. A mixture weighing 228 g contain $CaCl_2$ and NaCl. If this mixture is dissolved in 10 kg of water and form ideal solution that boil at 100.364 °C. The mol % of NaCl in mixture is [K_b of water = 0.52 K mol^{-1} kg]

(1) 33.3% (2) 66.67% (3) 50% (4) 75%

Sol. Answer (2)

Mass of NaCl in mixture = x

Moles of NaCl in mixture = $\frac{x}{58.5}$

Moles of $CaCl_2$ in mixture = $\frac{228-x}{111}$

$$\Delta T_b = 0.52\left[\frac{2x}{10\times 58.5}+\frac{3(228-x)}{10\times 111}\right]$$

x = 117 g

n_{NaCl} = 2

n_{CaCl_2} = 1

39. Henry's constant of four gases A, B, C and D in water are 40.3, 1.67, 0.413 and 0.611 bar at 298 K and 1 atm. The gas which has maximum solubility in water at 298 K and 1 atm is

(1) A (2) B (3) C (4) D

Sol. Answer (3)

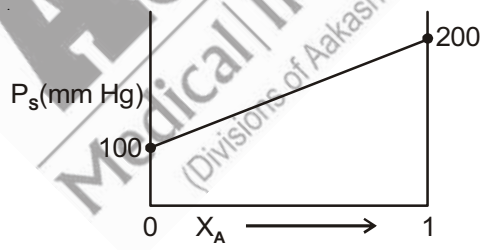
Henry's law

$P = K_H \times$ mole fraction

At same T and P condition

as $K_H \uparrow$ solubility $\downarrow$

40. Consider the graph of total vapour pressure (P_S) for ideal solution of A and B at temperature T versus mole fraction of A (X_A)



Select the correct statement.

(1) Boiling point of pure A is more than B

(2) Vapour pressure of pure A at temperature T is 100 mm Hg

(3) Vapour pressure of pure B at temperature T is 200 mm Hg

(4) Boiling point of pure A is less than B

Sol. Answer (4)

From diagram : $P_A^\circ > P_B^\circ$

$\therefore$ $(\text{Boiling Temp.})_A < (\text{Boiling Temp.})_B$

41. 6 g of non volatile, non-electrolytic solute X is present in 1 litre and this solution is isotonic with 0.2925 (w/v)% NaCl solution. (Assume NaCl completely dissociates and temperature of both solution is 27 °C). Molar mass of X (in g/mol) is

(1) 30 (2) 60 (3) 90 (4) 120

Sol. Answer (2)

$\pi = CRT$

$\Rightarrow \quad 2\times\frac{0.2925\times10}{58.5\times1}RT = \frac{6}{M\times1}RT$

$\Rightarrow$ M = 60 g/mol

42. Consider the following three aqueous solution of CH_3COOH

I – 0.1 m

II – 0.01 m

III – 0.001 m

If i_1, i_2 and i_3 represents the value of van't Hoff factor for solution I, II and III respectively, the correct order of i_1, i_2 and i_3 is

(1) $i_1 > i_2 > i_3$ (2) $i_1 < i_2 < i_3$ (3) $i_2 < i_1 < i_3$ (4) $i_1 < i_3 < i_2$

Sol. Answer (2)

Van't Hoff factor i increases as concentration of electrolyte decreases.

43. Consider two solutions I and II having osmotic pressure π_I and π_{II} at temperature T K respectively

Statement A : If $\pi_I = \pi_{II}$, then I and II are isotonic with each other.

Statement B : If $\pi_I > \pi_{II}$, then I is hypertonic w.r.t. II.

Statement C : If $\pi_I > \pi_{II}$, then II is hypotonic w.r.t. I.

The correct statement(s) is(are)

(1) Only A (2) B and C only (3) A, B and C (4) A and B only

Sol. Answer (3)

All three statements A, B and C are correct.

44. K_f, molal depression constant or cryoscopic constant, does not depend on

(1) Nature of solvent (2) Amount of solvent

(3) Freezing point of solvent (4) $(\Delta H)_{fusion}$ of solvent

Sol. Answer (2)

$K_f = \frac{R\times M\times T_f^2}{1000\times(\Delta H)_{fus}}$

45. Which of the following pair of components results into a binary solution which shows negative deviation from Raoult's law?

(1) Ethanol and acetone (2) Benzene and toluene

(3) Bromoethane and chloroethane (4) Chloroform and acetone

Sol. Answer (4)

Mixture of acetone and chloroform shows negative deviation from Raoult's law.

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