OBJECTIVE QUESTIONS

1. The vapor pressure of an aqueous solution of sucrose at 373 K is found to be 750 mm Hg. The molality of the solution at the same temperature will be:
   (a) 0.26 (b) 0.73 (c) 0.74 (d) 0.039
2. Estimate the lowering of vapor pressure due to the solute (glucose) in a 1.0 M aqueous solution at 100°C:
   (a) 10 torr (b) 18 torr (c) 13.45 torr (d) 24 torr
3. Calculate the weight of non-volatile solute having molecular weight 40, which should be dissolved in 57 g octane to reduce its vapor pressure to 80%:
   (a) 47.2 g (b) 5 g (c) 106.2 g (d) None of these
4. An ideal solution has two components A and B. A is more volatile than B, i.e., $P_A^\circ > P_B^\circ$ and also $P_A^\circ > P_{total}$. If X_A and Y_A are more fractions of components A in liquid and vapor phases, then:
   (a) $X_A = Y_A$ (b) $X_A > Y_A$
   (c) $X_A < Y_A$ (d) Data insufficient
5. Two liquids A and B have vapor pressure in the ratio $P_A^\circ : P_B^\circ = 1:3$ at a certain temperature. Assume A and B form an ideal solution and the ratio of mole fractions of A to B in the vapor phase is 4 : 3. Then the mole fraction of B in the solution at the same temperature is:
   (a) $\frac{1}{5}$ (b) $\frac{2}{3}$ (c) $\frac{4}{5}$ (d) $\frac{1}{4}$
6. The total vapor pressure of a mixture of 1 mol of volatile component A (P_A° = 100 mm Hg) and 3 mol of volatile component B (P_B° = 80 mm Hg) is 90 mm Hg. For such case:
   (a) there is a positive deviation from Raoult's law
   (b) boiling point has been lowered
   (c) force of attraction between A and B is smaller than that between A and A or between B and B
   (d) all the above statements are correct
7. Water and chlorobenzene are immiscible liquids. Their mixture boils at 89°C under a reduced pressure of 7.7×10^4 Pa. The vapor pressure of pure water at 89°C is 7×10^4 Pa. Weight percent of chlorobenzene in the distillate is:
   (a) 50 (b) 60 (c) 78.3 (d) 38.46
8. Which of the following aqueous solutions having the indicated mole fraction of solute should have the highest vapor pressure?
   (a) 0.02 M NaCl at 50°C (b) 0.03 M sucrose at 15°C
   (c) 0.005 M $CaCl_2$ at 50°C (d) 0.005 M $CaCl_2$ at 25°C
9. The number of moles of Na_2SO_4 to be dissolved in 12 mol water to lower its vapor pressure by 10 mm Hg at a temperature at which vapor pressure of pure water is 50 mm is:
   (a) 1.5 mol (b) 2 mol (c) 1 mol (d) 3 mol

10. A compound has the empirical formula $C_{10}H_8Fe$. A solution of 0.26 g of the compound in 11.2 g of benzene (C_6H_6) boils at 80.26°C. The boiling point of benzene is 80.10°C and K_b is 2.53°C/molal. What is the molecular formula of the compound?

(a) $C_{30}H_{24}Fe_3$ (b) $C_{10}H_8Fe$ (c) C_5H_4Fe (d) $C_{20}H_{16}Fe_2$

11. What will be the minimum freezing point for 1 molal solution of each compound, assuming complete ionization in each case?

(a) $[Fe(H_2O)_6]Cl_3$ (b) $[Fe(H_2O)5Cl]Cl_2 \cdot H_2O$

(c) $[Fe(H_2O)_4Cl_2]Cl \cdot 2H_2O$ (d) $[Fe(H_2O)_3Cl_3] \cdot 3H_2O$

12. Which of the following aqueous solutions should have the highest boiling point?

(a) 1.0 M NaOH (b) 1.0 M Na_2SO_4

(c) 1.0 M NH_4NO_3 (d) 1.0 M KNO_3

13. A complex is represented as $CoCl_3 \cdot xNH_3$. Its 0.1 molal solution in water shows $\Delta T_f = 0.558$ K. K_f for H_2O is 1.86 K per molality. Assuming 100% ionization of complex and coordination number of Co is six, calculate formula of the complex:

(a) $[Co(NH_3)_6]Cl_3$ (b) $[Co(NH_3)_5Cl]Cl_2$

(c) $[Co(NH_3)_4Cl_2]Cl$ (d) None of these

14. When mercuric iodide is added to the aqueous solution of KI, then the:

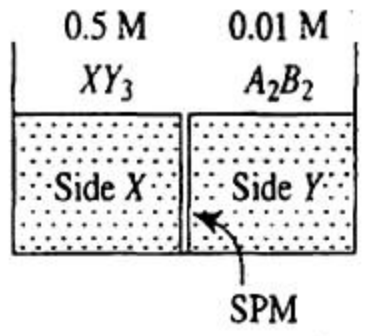
(a) freezing point is raised (b) freezing point is lowered

(c) freezing point does not change (d) boiling point does not change

15. Phenol associates in benzene to a certain extent to form a dimer. A solution containing 0.02 kg of phenol in 1.0 kg of benzene has its freezing point depressed to 0.69 K. Hence, the degree of association of phenol dimerized will be [$K_f(C_6H_6) = 5.12$ (K kg)/mol]:

(a) 0.63 (b) 0.73 (c) 0.83 (d) 0.93

16. X_3Y_2 ($i = 5$) when reacted with A_2B_3 ($i = 5$) in aqueous solution gives brown color. These are separated by a semipermeable membrane AB as shown in the adjacent figure. Due to osmosis, there is:



(a) brown color formation in side X

(b) brown color formation in side Y

(c) brown color formation in both of the sides X and Y

(d) no brown color formation

17. At 48°C, the vapor pressure of pure CS_2 is 850 torr. A solution of 2.0 g of sulphur in 100 g of CS_2 has a vapor pressure 844.9 torr. Determine the atomicity of sulphur molecule:

(a) 1 (b) 2 (c) 4 (d) 8

18. What is the molarity of 4.9% H_3PO_4 solution by mass (d of H_3PO_4 = 1.22 g/mL)?

(a) 0.61 M (b) 4.9 M (c) 1.22 M (d) 1 M

19. Among the following, the solution which shows highest osmotic pressure is:

(a) 0.05 M NaCl (b) 0.10 M $BaCl_2$

(c) 0.05 M $FeCl_3$ (d) 0.05 M Na_2SO_4

20. The molality of 1 M $NaNO_3$ solution is (d = 1.25 g/mL):

(a) 0.8 m (b) 0.858 m (c) 1.6 m (d) 1 m

21. The vapor 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 the total vapor pressure of the solution is 84 torr at 27°C. The vapor pressure of pure liquid B at 27°C is:

(a) 140 torr (b) 50 torr (c) 14 torr (d) 70 torr

22. If relative decrease in vapor pressure is 0.4 for a solution containing 1 mol NaCl in 3 mol of H_2O, then NaCl ionized is:

(a) 60% (b) 80% (c) 40% (d) 100%

23. The value of observed molecular weight of silver nitrate is 132.5 g/mol in an aqueous solution. The degree of dissociation of silver nitrate in this solution may be:

(a) 79% (b) 32% (c) 28% (d) 44%

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

(a) 0.6 (b) 0.4 (c) 0.2 (d) 0.8

25. About 75 g ethylene glycol is dissolved in 500 g water. The solution is placed in a refrigerator to maintain a temperature of –263.7 K. What amount of ice will separate at this temperature? (K_f water = 1.86 K/molality)

(a) 300 g (b) 200 g (c) 178 g (d) 258 g

26. Which of the following aqueous solution has the highest freezing point (assuming $m = M$)?

(a) 0.1 M KNO_3 (b) 0.2 M Na_3PO_4

(c) 0.25 M $FeCl_3$ (d) 0.01 M Na_2SO_4

27. When mercuric iodide is added to an aqueous solution of KI, the:

(a) boiling point increases (b) boiling point decreases

(c) freezing point decreases (d) osmotic pressure increases

28. On adding solute to a solvent having vapor pressure 0.80 atm, vapor pressure reduces to 0.60 atm. The mole fraction of solute is:

(a) 0.25 (b) 0.75 (c) 0.50 (d) 0.33

29. Vapor pressure of a solution of 5 g of non-electrolyte in 100 g of water at a particular temperature is 2985 N/m^2. The vapor pressure of pure water is 3000 N/m^2. The molecular weight of the solute is:

(a) 60 (b) 120 (c) 180 (d) 380

30. Azeotropic mixture of HCl and water has:

(a) 84% HCl (b) 22.2% HCl (c) 63% HCl (d) 20.2% HCl

31. The osmotic pressure at 17°C of an aqueous solution containing 1.75 g of sucrose per 150 mL solution is:

(a) 0.8 atm (b) 0.08 atm (c) 8.1 atm (d) 9.1 atm

32. A 1.2 of solution of NaCl is isotonic with 7.2 of solution of glucose. Calculate the Van't Hoff's factor of NaCl solution:

(a) 2.36 (b) 1.50 (c) 1.95 (d) 1.00

33. About 0.6 g of a solute is dissolved in 0.1 L of a solvent which develops an osmotic pressure of 1.23 atm at 27°C. The molecular mass of the substance is:

(a) 149.5 g/mol (b) 120 g/mol (c) 430 g/mol (d) None of these

34. The boiling point of a solution of 0.1050 g of a substance in 15.84 g of ether was found to be 100°C higher than that of pure ether. What is the molecular weight of the substance [molecular elevation constant of ether per 100 g = 21.6]?

(a) 144.50 (b) 143.18 (c) 140.28 (d) 146.66

35. Boiling point of chloroform was raised by 0.323 K, when 0.5143 g of anthracene was dissolved in 35 g of chloroform. Molecular mass of anthracene is:

(K_b for $CHCl_3$ = 3.9 kg/mol)

(a) 79.42 g/mol (b) 132.32 g/mol (c) 177.42 g/mol (d) 242.32 g/mol

36. Normal boiling point of water is 373 K (at 760 mm). Vapor pressure of water at 298 K is 23 mm. If the enthalpy of evaporation is 40.656 kJ/mol, the boiling point of water at 23 mm pressure will be:

(a) 250 K (b) 294 K (c) 51.6 K (d) 12.5 K

37. A 0.2 molal aqueous solution of a weak acid (HX) is 20% ionized. The freezing point of this solution is (given $K_f = 1.86^\circ$ C/m for water):

(a) -0.31°C (b) -0.45°C (c) -0.53°C (d) -0.90°C

38. A 0.001 molal solution of $[Pt(NH_3)_4Cl_4]$ in water had a freezing point depression of 0.0054°C . If K_f for water is 1.80, the correct formulation for the above molecule is:

(a) $[Pt(NH_3)_4Cl_3]Cl$ (b) $[Pt(NH_3)_4Cl]Cl_2$

(c) $[Pt(NH_3)_4Cl_2]Cl_3$ (d) $[Pt(NH_3)_4Cl_4]$

39. An aqueous solution of a weak monobasic acid containing 0.1 g in 21.7 g of water freezes at 272.813 K. If the value of K_f for water is 1.86 K/m, what is the molecular mass of the monobasic acid?

(a) 50 g/mol (b) 46 g/mol (c) 55 g/mol (d) 60 g/mol

40. K_f of 1,4-dioxane is 4.9 mol^{-1} for 1000 g. The depression in freezing point for a 0.001 m solution in dioxane is:

(a) 0.0049 (b) 4.9 + 0.001 (c) 4.9 (d) 0.49

41. How many liters of CO_2 at STP will be formed when 100 mL of 0.1 M H_2SO_4 reacts with excess of Na_2SO_3?

(a) 22.4 (b) 2.24 (c) 0.224 (d) 5.6

42. A solution is obtained by dissolving 12 g of urea (molecular weight 60) in a liter of water. Another solution is obtained by dissolving 68.4 g of cane sugar (molecular weight 342) in a liter of water at the same temperature. The lowering of vapor pressure in the first solution is:

(a) same as that of the second solution

(b) nearly one-fifth of the second solution

(c) double that of the second solution

(d) nearly five times that of the second solution

43. The values of observed and calculated molecular weights of silver nitrate are 92.64 and 170, respectively. The degree of dissociation of silver nitrate is:

(a) 60% (b) 83.5% (c) 47.7% (d) 60.23%

44. If a solute undergoes dimerization and trimerization, the minimum values of the Van't Hoff factors are respectively:

(a) 0.5 and 1.50 (b) 1.5 and 1.33 (c) 0.5 and 0.33 (d) 0.25 and 0.67

HINTS AND SOLUTIONS

1. (c) Given $P_A = 750$ mm Hg

373 K is boiling point of water

Thus, $P_A^\circ = 760$ mm Hg

$$m = \left(\frac{P^\circ - P}{P}\right) \times \frac{1000}{M_{\text{solvent}}}$$

$$\Rightarrow \quad \frac{10}{750} \times \frac{1000}{18} = 0.74$$

2. (c) Normal boiling point of water is 100°C, hence

$P^\circ(H_2O) = 760$ torr; $M(H_2O) = 18$ g/mol

$$m = \left(\frac{P^\circ - P}{P}\right) \times \frac{1000}{M_{H_2O}}$$

$$\Rightarrow \quad P = 746.5; \qquad \Delta P = 13.45 \text{ torr}$$

3. (b) $P_s = \left(\frac{80}{100}\right)P°, w = ?$

$M_{\text{solute}} = 40, w = 114\text{ g}, M_{\text{solvent}} = 114$

$$\frac{P° - P_s}{P_s} = \frac{w \times M_{\text{solvent}}}{M_{\text{solute}} \times W}$$

or $$\frac{P° - (80/100)P°}{(80/100)P°} = \frac{w \times 114}{40 \times 57}$$

$\therefore \quad w = 5\text{ g}$

4. (c) We know that

$$Y_A = \frac{P_A^{\circ} X_A}{P_{\text{total}}} \text{ or } \frac{Y_A}{X_A} = \frac{P_A^{\circ}}{P_{\text{total}}}$$

$$P_A^{\circ} > P_{\text{total}} \text{ or } \frac{Y_A}{X_A} > 1 \text{ or } Y_A > X_A$$

5. (a) $y_A = \frac{p_A}{p} \Rightarrow \frac{p_A^{\circ} x_A}{p}$ and $y_B = \frac{P_B^{\circ} x_B}{p}$

$$\frac{y_A}{y_B} = \frac{p_A^{\circ}}{P_B^{\circ}} \times \frac{x_A}{x_B} \Rightarrow \frac{4}{3} = \frac{1}{3} \times \frac{x_A}{(1 - x_A)}$$

$$x_A = \frac{4}{5} \text{ or } x_B = \frac{1}{5}$$

6. (d) $p_{\text{ideal}} = p_A^{\circ} x_A + p_B^{\circ} x_B$

$$= 100 \times \frac{1}{4} + 80 \times \frac{3}{4} = 85\text{ mm Hg}$$

$p_{\text{actual}} = 90\text{ mm Hg}$

Actual vapor pressure is greater than the vapor pressure of ideal solution. Hence, a positive deviation from Raoult's law.

7. (d) $\frac{W_A}{W_B} = \frac{P_A^{\circ}}{P_B^{\circ}} \times \frac{M_A}{M_B} \Rightarrow \frac{0.7}{7} \times \frac{112.5}{18} = 0.625$

$$\% \frac{W_A}{W_A + W_B} \times 100 = \frac{0.625}{1.625} \times 100 = 38.46$$

8. (c) For high vapor pressure, concentration of solute should be low and temperature should be high.

9. (c)

10. (d) $\Delta T_b = 80.26$

$$0.16 = 2.53 \times \frac{0.26/M}{11.20} \times 1000;\ M \approx 367$$

This is almost equal to molar mass of $C_{20}H_{16}Fe_2$.

11. (a)

12. (b)

13. (b) $\Delta T_f = K_f \times \text{Molality} \times i$

$0.558 = 1.86 \times 0.1 \times i$ or $i = 3$

Thus, complex is $[CoCl \cdot x \cdot NH_3] \cdot Cl_2$. Since coordination number of CO is six. Thus, complex is $[CO(NH_3)_5Cl]Cl_2$.

14. (a) The reaction when KI is added in HgI_2

$$HgI_2 + 2KI \rightarrow K_2HgI_4 \rightleftharpoons 2K^+ + HgI_4^{2-}$$

Since, the number of ions decreases, so freezing point increases.

15. (b) $\Delta T_f = K_f \cdot M \cdot i$

$\Rightarrow i = 0.633;$

$$i = 1 - \alpha + \frac{\alpha}{2} \Rightarrow \alpha = 0.73$$

16. (d) Only solvent molecules can passed through semipermeable membrane, so only dilution is possible.

17. (d) $\dfrac{p^\circ - p}{p} = \dfrac{n}{N} \Rightarrow \dfrac{W}{W \times N}$

$$\Rightarrow \frac{850 - 84.9}{844.9} = \frac{2 \times 76}{M \times 100}$$

$$M = 252;\ n = \frac{252}{32} \approx 8$$

Therefore, atomicity of sulphur is 8.

18. (a)

19. (b)

20. (b)

21. (a)

22. (d)

23. (c)

24. (b)

25. (d)

26. (d)

27. (b)

28. (a) $\dfrac{P^\circ - P_s}{P^\circ} = \dfrac{n}{n+N};\ P^\circ = 0.80,\ P_s = 0.60$

$$\therefore \frac{n}{n+N} = \frac{0.2}{0.8} = 0.25$$

29. (c) $\dfrac{P^\circ - P_s}{P^\circ} = \dfrac{(W_2/M_2)}{(W_1/M_1)} = \dfrac{3000 - 2985}{3000} = \dfrac{(5/M_2)}{(100/18)}$ or $M_2 = 180$

30. (d) It is known that azeotropic mixture of HCl and water has 20.2% HCl.

31. (a) $\pi = CRT = \frac{n}{V}RT = \frac{(1.75/342)}{(150/1000)} \times 0.0821 \times 290$

$= 0.8095 \approx 0.81$ atm

32. (c) Van't Hoff factor of NaCl is 1.95, because it will be ionized into two ions.

$NaCl \rightleftharpoons Na^+ + Cl^-$

33. (b) $m = \frac{wRT}{PV} = \frac{0.6 \times 0.082 \times 300}{1.23 \times 0.1} = 120$

34. (b) $m = \frac{K_b \times w \times 1000}{\Delta T_b \times W} = 143.18$

35. (c) Here: $\Delta T_b = 0.323\,K$

w = weight of Anthracene.

W = weight of chloroform

K_b = Molal elevation constant (3.9 K-kg/mol)

$$m = \frac{K_b \times w \times 1000}{W \times \Delta T_b} = \frac{3.9 \times 0.5143 \times 1000}{0.323 \times 35} = 177.42 \text{ g/mol}$$

36. (b) Applying Clausius–Clapeyron equation, we get

$$\log \frac{P_2}{P_1} = \frac{\Delta H_V}{2.303R}\left[\frac{T_2 - T_1}{T_1 \times T_2}\right]$$

$$\log \frac{760}{23} = \frac{40656}{2.303 \times 8.314}\left[\frac{373 - T_1}{373T}\right]$$

This gives $T_1 = 294.4\,K$.

37. (b) $\Delta T_f = \text{Molality} \times K_f \times (1 + \alpha)$

$\alpha = 0.2$, Molality = 0.2, $K_f = 1.86$

$\Delta T_f = 0.2 \times 1.2 \times 1.86 = 0.4464°$

Freezing point = $-0.45°C$.

38. (b) $\Delta T_f = imK_f$; $0.0054 = i \times 1.8 \times 0.001$

$i = 3$. So it is $[Pt(NH_3)_4Cl]Cl_2$.

39. (d) $m = \frac{K_f \times w \times 1000}{\Delta T_f \times W} = 60\,g/mol$

40. (a) $\Delta T = K_f \times \text{Molality} = 4.9 \times 0.001 = 0.0049\,K$

41. (c) $Na_2CO_3 + \underset{98g(2mol)}{H_2SO_4} \rightarrow \underset{1mol}{Na_2SO_4} + \underset{1mol}{CO_2HO}$

$$0.02 = \frac{0.02 \times 22.4}{2} = 0.224$$

42. (a) We know that in the first solution,

Number of the moles of urea

$$= \frac{\text{Mass of urea}}{\text{Molecular weight of urea}} \times \frac{1}{V} = \frac{12}{60} \times \frac{1}{1} = 0.2$$

In second solution,

Number of moles of cane sugar

$$= \frac{\text{Mass of cane sugar}}{\text{Molecular weight of cane sugar}} = \frac{68.4}{342} \times \frac{1}{1} = 0.2 .$$

43. (b)

44. (c)