PHYSICAL / INORGANIC CHEMISTRY

DPP

DAILY PRACTICE PROBLEMS

DPP No. 4

Total Marks : 38

Max. Time : 40 min.

Topic : Solution Colligative Properties

Type of Questions		M.M., Min.
Single choice Objective ('–1' negative marking) Q.1 to Q.5	(3 marks, 3 min.)	[15, 15]
Subjective Questions ('–1' negative marking) Q.6 to Q.7	(4 marks, 5 min.)	[8, 10]
Comprehension ('–1' negative marking) Q.8 to Q.12	(3 marks, 3 min.)	[15, 15]

1. The osmotic pressure of equimolar solutions of $BaCl_2$, NaCl and glucose will be in the order

(A) glucose > NaCl > $BaCl_2$
(B) $BaCl_2$ > NaCl > glucose
(C) NaCl > $BaCl_2$ > glucose
(D) NaCl > glucose > $BaCl_2$

2. A 0.004 M solution of Na_2SO_4 is isotonic with 0.010 M solution of glucose at same temperature. The apparent percentage dissociation of Na_2SO_4 is :

(A) 25%
(B) 50%
(C) 75%
(D) 85%

3. An electrolyte A gives 3 ions and B is a non-electrolyte. If 0.1 M solution of B produces an osmotic pressure P, then 0.05 M solution of A will produce an osmotic pressure, assuming that the electrolyte is completely ionised:

(A) 1.5 P
(B) P
(C) 0.5 P
(D) 0.75 P

4. 2.56g of sulfur in 100g of CS_2 has depression in freezing point of 0.01^0C.K_f = 0.1^0molal^{-1}. Hence, the atomicity of sulfur in CS_2 is :

(A) 2
(B) 4
(C) 6
(D) 8

5. **Statement-1 :** The freezing point of water is depressed by the addition of glucose.

Statement-2 : Entropy of solution is less than entropy of pure solvent.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

6. A 0.01 m solution of NH_4Cl (M – 53.5) solidifies at – 0.0358°C. Determine the degree of dissociation in this solution and the apparent molar mass of the salt if $K_f = 1.86 \frac{K}{kg-mol}$ for water ?

7. Calculate the molecular weight of cellulose acetate if its 0.2% (wt./vol.) solution in acetone (sp. gr. 0.8) shows an osmotic rise of 2.58 cm against pure acetone at 27°C.

Comprehension # (Q.8 to Q.12)

Read the following comprehension carefully and answer the questions (8 to 12).

A system of greater disorder of molecules is more probable. The disorder of molecules is reflected by the entropy of the system. A liquid vaporises to form a more disordered gas. When a solute is present, there is additional contribution to the entropy of the liquid due to increased randomness. As the entropy of solution is higher than that of pure liquid, there is weaker tendency to form the gas. Thus, a solute (non volatile) lowers the vapour pressure of a liquid, and hence a higher boiling point of the solution.

Similarly, the greater randomness of the solution opposes the tendency to freeze. In consequence, a lower the temperature must be reached for achieving the equilibrium between the solid (frozen solvent) and the solution. Elevation of B.Pt. (ΔT_b) and depression of F.Pt. (ΔT_f) of a solution are the colligative properties which depend only on the concentration of particles of the solute, not their identity. For dilute solutions, ΔT_b

and ΔT_f are proportional to the molality of the solute in the solution.

$\Delta T_b = K_b m$ K_b = Ebullioscopic constant = $\frac{RT_b^{o2} M}{1000\ \Delta H_{vap}}$

And $\Delta T_f = K_f m$ K_f = Cryoscopic constant = $\frac{RT_f^{o2} M}{1000\ \Delta H_{fus}}$ (M = molecular mass of the solvent)

The values of K_b and K_f do depend on the properties of the solvent. For liquids, $\frac{\Delta H_{vap}}{T_b^o}$ is almost constant.[**Troutan's Rule**, this constant for most of the **unassociated liquids**(not having any strong bonding like Hydrogen bonding in the liquid state) is equal to 90 J/mol.]

For solutes undergoing change of molecular state is solution (ionization or association), the observed ΔT values differ from the calculated ones using the above relations. In such situations, the relationships are modified as $\Delta T_b = i K_b m$; $\Delta T_f = i K_f m$

where i = Van't-Hoff factor, greater than unity for ionization and smaller than unity for association of the solute molecules.

8. Depression of freezing point of which of the following solutions does represent the cryoscopic constant of water?

(A) 6% by mass of urea is aqueous solution

(B) 100g of aqueous solution containing 18 g of glucose

(C) 59 g of aqueous solution containing 9 g of glucose

(D) 1 M KCl solution in water.

9. Dissolution of a non-volatile solute into a liquid leads to the :

(A) decrease of entropy

(B) increase in tendency of the liquid to freeze

(C) increases in tendency to pass into the vapour phase.

(D) decrease in tendency of the liquid to freeze

10. To aqueous solution of NaI, increasing amounts of solid HgI_2 is added. The vapor pressure of the solution

(A) decreases to a constant value

(B) increases to a constant value

(C) increases first and then decreases

(D) remains constant because HgI_2 is sparingly soluble in water.

11. A liquid possessing which of the following characteristics will be most suitable for determining the molecular mass of a compound by cryoscopic measurements?

(A) That having low freezing point and small enthalpy of freezing

(B) That having high freezing point and small enthalpy of freezing

(C) That having high freezing point and small enthalpy of vaporisation

(D) That having large surface tension

12. A mixture of two immiscible liquids at a constant pressure of 1 atm boils at a temperature

(A) equal to the normal boiling point of more volatile liquid

(B) equal to the mean of the normal boiling points of the two liquids

(C) greater than the normal boiling point of either of the liquid

(D) smaller than the normal boiling point of either of the liquid.

Answer Key

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1.	(B)	**2.**	(C)	**3.**	(A)	**4.**	(D)	**5.**	(C)
6.	0.9247, 27.796 g/mole.			**7.**	M = 24,600	**8.**	(C)	**9.**	(D)
10.	(B)	**11.**	(B)	**12.**	(D)				

Hints & Solutions

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1. (b) $\pi \propto$ No. of particles/ions.
$BaCl_2 = 3$, $NaCl = 2$ glucose = 1
So. order of π = $BaCl_2$ > NaCl > glucose

2. $Na_2SO_4 \rightleftharpoons 2Na^+ + SO_4^{2-}$
$a(1-\alpha)$ $\quad 2a\alpha \quad a\alpha$

$i = \dfrac{a(1+2\alpha)}{a} = 1 + 2\alpha$

Where α is degree of dissociation of Na_2SO_4
Solution of Na_2SO_4 & glucose are isotonic

So $\quad \pi_{Na_2SO_4} = \pi_{glucose}$

$\Rightarrow \quad i \times 0.004 \times R \times T = 0.010 \times R \times T$

$\Rightarrow \quad (1+2\alpha) = \dfrac{10}{4}$

$1 + 2\alpha = 2.5$

$\alpha = 0.75$

$\Rightarrow$ % dissociation = 75 %

3. Experimental molarity = 3 × 0.05 = 0.15; So osmotic pressure = 1.5P.

4. $\Delta T_f = K_f m$
$10^{-2} = 0.1 \times m \Rightarrow m = 0.1$ m

molality = $\dfrac{2.56 \times 1000}{M \times 100} = 0.1 \Rightarrow M = 256 \quad \Rightarrow \quad$ atomicity = $\dfrac{256}{32} = 8$.

5. On addition of non volatile solute, freezing point decreases.
Entropy of solution is more than entropy of pure solvent.

6. $\Delta T_f = 0.0358° C$
$\Delta T_f = i \times K_f \times m$
$0.0358 = i \times 1.86 \times 0.01$
$i = 1.9247$
For NH_4Cl. $i = (1 + \alpha)$
$\Rightarrow 1 + \alpha = 1.9247$
$\alpha = 0.9247$

& $i = \dfrac{M_T}{M_{ob}}$

$\Rightarrow M_{ob} = \dfrac{53.5}{1.9247} = 27.796$ g/mole

7. 0.2 percent solution means 0.2 g of cellulose acetate dissolved in 100 ml of solution.
Osmotic pressure = 2.58 cm of acetone

$P = 2.58 \times \dfrac{0.80}{13.6}$ cm of Hg = 0.152 cm of Hg

$P = \dfrac{0.152}{76}$ atm $= 2 \times 10^{-3}$ atm (1atm = 76 cm of Hg)

suppose M is the molecular weight of cellulose acetate.

$n = \dfrac{0.2}{M}$, V = 100 ml = 0.1 litre ; R = 0.082

and T = 300 K

Now $P = \dfrac{n}{V} RT$

$2 \times 10^{-3} = \dfrac{0.2/M}{0.1} \times 0.082 \times 300$

M = 24,600

8. Cryoscopic constant $K_f = \Delta T_f$ of solution having unit molality of normal solutes

Molality of glucose solution in (c) $= \dfrac{9 \times 1000}{(59 - 9) \times 180} = 1$

9. Since the solution has greater entropy (disorder) than the pure liquid, so former has lesser tendency to freeze i.e., the temperature has to be lowered to freeze the solution.

10. $2Na^+ (aq) + 2I^- (aq) + HgI_2(s) \longrightarrow 2Na^+ (aq) + HgI_4^{2-} (aq)$
The number of mole particle decreases from 4 ($2Na^+ + 2I^-$) to 3 ($2Na^+ + HgI_4^{2-}$). Hence, the colligative property will decrease and, the vapour pressure will increase to a constant value until NaI is completely consumed.

11. $K_f = \dfrac{RT_f^{02}M}{1000\Delta H_{fus}}$ would be larger for larger value of $T°_f$ and smaller value of enthalpy of fusion of the solid solvent.

12. The vapour pressure of a mixture of two immiscible liquids is the sum of their vapour pressures in the pure states, independent of their relative amounts. Hence, B.Pt. of the mixture will be less than that of either of the liquids, remaining constant throughout.