Long Answer Questions

Long Answer Questions (PYQ)

Q.1. Define the following terms:

Q. Define the following terms:

a. **Azeotrope**
b. **Osmotic pressure**
c. **Colligative properties**

Ans. (a) The binary mixtures of liquids having same composition in liquid and vapour phase and boil at a constant temperature are called azeotropes.

(b) The excess of pressure which must be applied to the solution side to prevent the passage of solvent into it through a semipermeable membrane is called osmotic pressure.

(c) The properties of solutions which depend only on the number of solute particles in the solution but independent of their nature are called colligative properties.

Q. Calculate the molarity of 9.8% (w/w) solution of H_2SO_4 if the density of the solution is 1.02 g mL^{-1}.

(Molar mass of H_2SO_4 = 98 g mol^{-1})

[*CBSE (F) 2014*]

Ans.

Let the mass of solution = 100 g

$\therefore$ Mass of H_2SO_4 = 9.8 g

$$\text{Number of mole of } H_2SO_4 = \frac{\text{Mass of } H_2SO_4}{\text{Molar Mass}}$$

$$= \frac{9.8\ g}{98\ g\ mol^{-1}} = 0.1\ \text{mol}$$

$$\text{Volume of solution} = \frac{\text{Mass of solution}}{\text{Density of solution}}$$

$$= \frac{100\ g}{1.02\ g\ \ mL^{-1}} = \frac{100}{1.02} mL$$

$$= \frac{100}{1.02} mL \times \frac{1}{1000\ \ mL\ \ L^{-1}}$$

$$= \frac{1}{10.2} L$$

$$\text{Molarity} = \frac{\text{Moles of solute}, H_2SO_4}{\text{Volume of solution (in } L)}$$

$$= \frac{0.1\ \ mol}{\frac{1}{10.2} L} = 1.02\ mol\ L^{-1} \text{ or } 1.02\ M]$$

Q.2. Answer the following question :

Q. 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}]

Ans.

Here, W_B = 2.56 g, W_A = 100 g, ΔT_f = 0.383 K

K_f = 3.83 K kg mol^{-1}

Substituting these values in the expression, we get

$$M_B = \frac{K_f \times W_B \times 1000}{\Delta T_f \times W_A}$$

$$M_B = \frac{3.83\ K\ \ kg\ \ mol^{-1} \times 2.56\ g \times 1000\ g\ \ kg^{-1}}{100\ g \times 0.383\ K} = 256\ g\ mol^{-1}$$

Now, molecular mass of $S_x = x \times 32 = 256$

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

Therefore, formula of sulphur = S_8

Q. Blood cells are isotonic with 0.9 % sodium chloride solution. What happens if we place blood cells in a solution containing

a. **1.2% sodium chloride solution?**
b. **0.4% sodium chloride solution?**

[*CBSE Delhi 2016*]

Ans. (a) Water will flow out of the cell and they would shrink.

(b) Water will flow into the cell and they would swell.

Q.3. Answer the following question :

Q. Define the following terms:

a. **Molarity**
b. **Molal elevation constant (K_b)**

Ans. (a) Molarity may be defined as number of moles of solute dissolved in one litre of solution.

$$\text{Molarity} = \frac{\text{Moles of solute}}{\text{Volume of solution (in litre)}}$$

(b) Molal elevation constant may be defined as the elevation in boiling point when one mole of solute is dissolved in 1000 grams of the solvent.

Q. A solution containing 15 g urea (molar mass = 60 g mol^{-1}) per litre of solution in water has the same osmotic pressure (isotonic) as a solution of glucose (molar mass = 180 g mol^{-1}) in water. Calculate the mass of glucose present in one litre of its solution.

[*CBSE (AI) 2014*]

Ans.

$$\text{Osmotic pressure, } \pi = \frac{W_B \times R \times T}{M_B \times V}$$

$$\text{Osmotic pressure of urea solution} = \frac{15 \times R \times T}{60 \times 1}$$

$$\text{Osmotic pressure of glucose solution} = \frac{W_B \times R \times T}{180 \times 1}$$

As, Osmotic pressure of urea solution = Osmotic pressure of glucose solution

Therefore, $\frac{15 \times R \times T}{60 \times 1} = \frac{W_B \times R \times T}{180 \times 1}$

Mass of glucose, $W_B = \frac{15 \times 180}{60} = 45\ g$

Q.4. Answer the following question :

Q. Non-ideal solutions exhibit either positive or negative deviations from Raoult's law. What are these deviations and how are they caused?

Ans. Positive deviation from Raoult's law: When the partial vapour pressure of each component (A and B) consequently the total vapour pressure is greater than the pressure expected on the basis of Raoult's law then the deviation is termed as positive deviation.

Cause of positive deviation: This type of deviation is observed by solution in which the forces of attraction between A–A molecules and between B–B molecules is greater than the forces of attraction between A–B molecules.

$\gamma_{A-B} \quad < \quad \gamma_{A-A} \quad \text{or} \quad \gamma_{B-B}$

Negative deviation from Raoult's law: When the partial vapour pressure of each component of solution is less than the vapour pressure expected on the basis of Raoult's law then the deviation is called as negative deviation.

Causes of negative deviation: This type of deviation is shown by solutions in which the forces of attraction between A–A and B–B molecules is less than the forces of attraction between A and B molecules.

$\gamma_{A-B} \quad > \quad \gamma_{A-A} \quad \text{or} \quad \gamma_{B-B}$

Q. **What mass of NaCl (molar mass = 58.5 g mol^{-1}) must be dissolved in 65g of water to lower the freezing point by 7.50°C? The freezing point depression constant, K_f for water is 1.86 K kg mol^{-1}. Assume van't Hoff factor for NaCl is 1.87.**

[*CBSE (F) 2010*]

Ans.

Given: $M_B = 58.5$ g mol^{-1} $\quad W_A = 65$ g, $W_B = ?$, $\quad \Delta T_f = 7.5$°C or 7.5 K,

$K_f = 1.86$ K kg mol^{-1} $\quad i = 1.87$

We know that, $\Delta T_f = iK_f \times \frac{W_B}{M_B} \times \frac{1000}{W_A}$

$$\Rightarrow \quad 7.5 = 1.87 \times 1.86 \times \frac{W_B}{58.5} \times \frac{1000}{65} = 8.199\ g$$

$$W_B = \frac{7.5 \times 58.5 \times 65}{1.87 \times 1.86 \times 100} = 8.199\ g$$

Q.5. Answer the following question :

Q. Explain why on addition of 1 mol glucose to 1 litre water the boiling point of water increases.

Ans. On addition of glucose, a non-volatile solute to water (a volatile solvent) the vapour pressure of water decreases. In order to make the solution boil, its vapour pressure must be increased by raising the temperature above the boiling point of pure water. In other words, there is an increase in the boiling point of water.

Q. Henry's law constant for CO_2 in water is 1.67×10^8 Pa at 298 K. Calculate the number of moles of CO_2 in 500 ml of soda water when packed under 2.53×10^5 Pa at the same temperature.

[*CBSE (AI) 2017C*]

Ans.

According to Henry's law, $P_{CO_2} = K_H \times x_{CO_2}$ or $x_{CO_2} = \frac{P_{CO_2}}{K_H}$

$$\therefore x_{CO_2} = \frac{2.53 \times 10^5\ \text{Pa}}{1.67 \times 10^8\ \text{Pa}} = 1.51 \times 10^{-3}$$

Mass of water = Density of water × volume of water

$= 1\ \text{g mL}^{-1} \times 500\ \text{mL} = 500\ \text{g}$

$$\text{Moles of water, } n = \frac{\text{Mass of water}}{\text{Molar mass}} = \frac{500\ g}{18\ g\ \text{mol}^{-1}} = 27.78\ \text{mol}$$

$$x_{CO_2} = \frac{n_{CO_2}}{n_{H_2O} + n_{CO_2}} = \frac{n_{CO_2}}{n_{H_2O}} \text{ or } n_{CO_2} = x_{CO_2} \times n_{H_2O}$$

$n_{CO_2} = 1.51 \times 10^{-3} \times 27.78\ \text{mol} = \mathbf{0.042\ mol}$

Long Answer Questions (OIQ)

Q.1. Discuss biological and industrial importance of osmosis.

[NCERT Exemplar]

Ans. (i) The process of osmosis is of great biological and industrial importance as is evident from the following examples:

(ii) Movement of water from soil into plant roots and subsequently into upper portion of the plant occurs partly due to osmosis.

(iii) Preservation of meat against bacterial action by adding salt.

(iv) Preservation of fruits against bacterial action by adding sugar. Bacterium in canned fruit loses water through the process of osmosis, shrivels and dies.

(v) Reverse osmosis is used for desalination of water.

Q.2. Answer the following question :

Q. Calculate the molality of a sulphuric acid solution in which the mole fraction of water is 0.85.

Ans.

$$\frac{n_A}{n_A + n_B} = 0.85 \qquad \ldots(i)$$

$$\therefore \quad \frac{n_B}{n_A+n_B} = 1 - 0.85 = 0.15 \qquad \ldots(ii)$$

Dividing (ii) by (i), we get

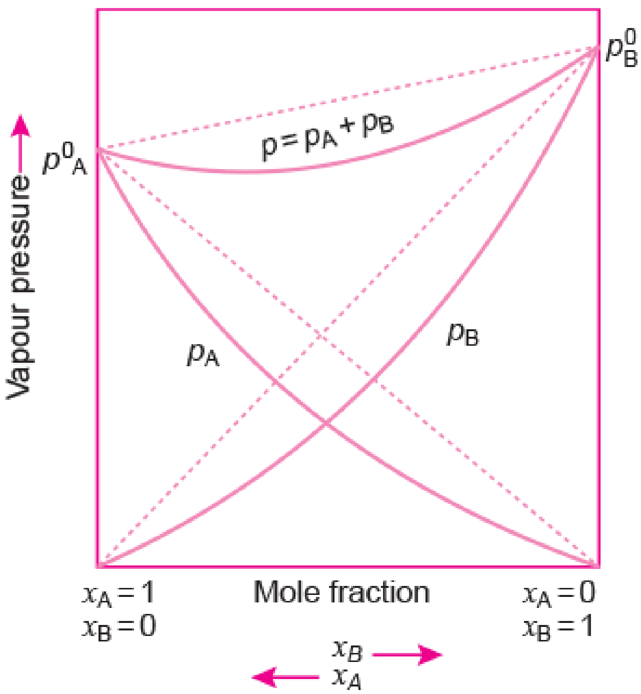
$$\frac{n_B}{n_A} = \frac{0.15}{0.85} \qquad \text{or} \qquad \frac{n_B}{1000/18} = \frac{0.15}{0.85}$$

$$\text{or} \qquad n_B = \frac{0.15}{0.85} \times \frac{1000}{18} = 9.8 \text{ mol}$$

Hence, molality = **9.8 m**

Q. The graphical representation of vapour pressures of two component system as a function of composition is given alongside. By graphic inspection, answer the following questions:

a. **Are the A–B interactions weaker, stronger or of the same magnitude as A–A and B–B?**
b. **Name the type of deviation shown by this system from Raoult's law.**
c. **Predict the sign of $\Delta_{mix}H$ for this system.**
d. **Predict the sign of $\Delta_{mix}V$ for this system.**
e. **Give an example of such a system.**
f. **What type of azeotrope will this system form, if possible?**



Ans.

a. Stronger
b. Negative deviation
c. –ve
d. –ve
e. A liquid mixture consisting of 20% acetone and 80% chloroform by mass.
f. Maximum boiling azeotrope.

Q.3. Answer the following question :

Q. What is the freezing point of 0.4 molal solution of acetic acid in benzene in which it dimerises to the extent of 85%? Freezing point of benzene is 278.4 K and its molar heat of fusion is 10.042 kJ mol^{-1}.

Ans.

Given, $M = 78 \text{ g mol}^{-1}$, $T_f^0 = 278.4 \text{ K}$, $\Delta_{fus} H = 10.042 \text{ kJ mol}^{-1}$

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

$$K_f = \frac{8.314 \times 10^{-3} \times (278.4)^2 \times 78}{1000 \times 10.042} = 5.0 \text{ K kg mol}^{-1}$$

$$2CH_3COOH \rightarrow \underset{\text{Dimer}}{(CH_3\,COOH)_2}$$

$$\alpha = \frac{i-1}{\frac{1}{n}-1} \qquad \Rightarrow \qquad 0.85 = \frac{i-1}{\frac{1}{2}-1}$$

or $\qquad i = 1 - 0.425 = 0.575$

$$\Delta T_f = iK_f\, m$$

$$= 0.575 \times 5 \times 0.4 = 1.15 \text{ K}$$

$$T_f = T_f^0 - \triangle T_f$$

$$= 278.4 \text{ K} - 1.15 \text{ K} = \mathbf{277.25\ K}$$

Q. Explain the following:

a. **Solution of chloroform and acetone is an example of maximum boiling azeotrope.**
b. **A doctor advised a person suffering from high blood pressure to take less quantity of common salt.**

Ans.

a. This solution has lesser vapour pressure due to stronger interactions (hydrogen bonds) between chloroform and acetone molecules.
b. Because higher quantity of NaCl will increase number of sodium and chloride ions in the body fluid which can increase the osmotic pressure of body fluid, i.e., blood pressure of a person.

Q.4. Answer the following question :

Q. Why a person suffering from high blood pressure is advised to take minimum quantity of common salt?

Ans. Osmotic pressure is directly proportional to the concentration of the solutes. Our body fluid contains a number of solutes. On taking large amount of common salt, Na+ and Cl– ions enter into the body fluid thereby raising the concentration of the solutes. As a result, osmotic pressure increases which may rupture the blood cells.

Q. g of benzoic acid (C_6H_5COOH) dissolved in 25 g of benzene shows a depression in freezing point equal to 1.62 K. Molal depression constant for benzene is 4.9 K kg mol^{-1}. What is the percentage association of acid if it forms dimer in solution?

Ans.

The given quantities are

$W_B = 2$ g, $W_A = 25$ g, $\Delta T_f = 1.62$ K, $K_f = 4.9$ K kg mol^{-1}

Substituting these values in equation $M_B = \dfrac{K_f \times W_B \times 1000}{\Delta T_f \times W_A}$, we get

$$M_B = \frac{4.9K\,\text{kg mol}^{1} \times 2\ g \times 1000\ g\ \text{kg}^{1}}{1.62\ K \times 25\ g} = 241.98\ g\ \text{mol}^{1}$$

Thus, observed molecular mass of benzoic acid in benzene = 241.98 g mol^{-1}

Normal molecular mass of C_6H_5COOH = 122 g mol^{-1}

$$\therefore \quad i = \frac{Normalmolecularmass}{Observedmolecularmass} = \frac{122\ g\ \text{mol}^{1}}{241.98\ gmol^{1}} = 0.504$$

$$i = 0.504 \qquad \ldots(i)$$

If α represents the degree of association of solute then we would have (1 – α) mole of benzoic acid left in unassociated form and corresponding $\frac{\alpha}{2}$ as associated moles of benzoic acid at equilibrium.

Now, consider the following equilibrium for the acid:

$$\begin{array}{ll} 2(C_6H_5\text{—COOH}) \rightleftharpoons & (C_6H_5\text{—COOH})_2 \\ 1\ \text{mol} & 0 \\ (1-\alpha)\ \text{mol} & \frac{\alpha}{2}\ \text{mol} \end{array}$$

Thus, total number of moles of particles at equilibrium

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

$i = \frac{Total number of moles of particles after association}{Number of moles of particles before association}$

$i = \frac{1-\frac{\alpha}{2}}{1} = 1 - \frac{\alpha}{2}$ $\quad \ldots(ii)$

From (i) and (ii), we have

$0.504 = 1 - \frac{\alpha}{2}$

$\frac{\alpha}{2} = 1 - 0.504 = 0.496$

or $= 0.496 \times 2 = 0.992$

Therefore, degree of association of benzoic acid in benzene is **99.2%.**

Q. 5 . Answer the following question :

Q. Give reasons for the following:

a. **At higher altitudes, people suffer from a disease called anoxia. In this disease, they become weak and cannot think clearly.**
b. **When mercuric iodide is added to an aqueous solution of KI, the freezing point is raised.**

Ans.

a. At higher altitudes, partial pressure of oxygen is less than that at ground level, so that oxygen concentration becomes less in blood or tissues. Hence, people suffer from anoxia.
b. Due to the formation of complex $K_2[HgI_4]$, number of particles in the solution decreases and hence the freezing point is raised.

Q. 0.6 mL of acetic acid (CH_3COOH), having density 1.06 g mL^{-1}, is dissolved in 1 litre of water. The depression in freezing point observed for this strength of acid was 0.0205°C. Calculate the van't Hoff factor and the dissociation constant of acid.

Ans.

Mass = Density × Volume

$\therefore$ Mass of acetic acid = 1.06 g mL^{-1} × 0.6 mL = 0.636 g

Number of moles of acetic acid = $\frac{Mass of acetic acid}{Molar mass}$

$= \frac{0.636\ g}{60\ g\ mol^{-1}}$ = 0.0106 mol

Mass of water = 1 g mL^{-1} × 1000 mL = 100 g

Molality = $\frac{\text{Number of moles of acetic acid}}{\text{Mass of water in grams}} \times 1000$

$= \frac{0.0106}{1000}$ × 1000 = 0.0106 mol kg^{-1}

$\Delta T_f = K_f \cdot m$

= 1.86 K kg mol^{-1} × 0.0106 mol kg^{-1}

= 0.0197 K

van't Hoff Factor (i) = $\frac{Observed freezing point}{Calculated freezing point} = \frac{0.0205\ K}{0.0197\ K}$

i = **1.041** ...(i)

If α is the degree of dissociation of acetic acid, then we would have $n(1 - \alpha)$ moles of undissociated acid, $n\alpha$ moles of CH_3—COO^- and $n\alpha$ moles of H^+ ions at equilibrium.

$$
\begin{array}{lll}
CH^3\text{—}COOH \rightleftharpoons & H^+ + CH^3\text{—}COO^- & \\
n \text{ mol} & 0 & 0 \\
n(1-\alpha) & n\alpha \text{ mol} & n\alpha \text{ mol}
\end{array}
$$

Thus total moles of particles = $n - n\alpha + n\alpha + n\alpha = n(1 + \alpha)$

$$i = \frac{Totalnumberofmolesofparticlesafterdissociation}{Numberofmolesofparticlesbeforedissociation}$$

$$i = \frac{n(1 + \alpha)}{n} = 1 + \alpha \qquad ...(ii)$$

From (i) and (ii), we have

$$1.041 = 1 + \alpha \quad \Rightarrow \quad \alpha = 1.041 - 1 = 0.041$$

$$K_a = \frac{[CH_3 - COO\ ]\ [H^+]}{[CH_3 - COOH]}$$

$$[CH_3\text{—}COOH] = n(1 - \alpha) = 0.0106\ (1 - 0.041)$$

$$= 0.0106 \times 0.959$$

$$[H^+] = n\alpha = 0.106 \times 0.041;$$

$$[CH_3\text{—}COO^-] = n\alpha = 0.0106 \times 0.041$$

$$\therefore \qquad K_a = \frac{0.0106 \times 0.041 \times 0.0106 \times 0.041}{0.0106 \times 0.959}$$

$$= \mathbf{1.86 \times 10^{-5}}$$