

Solutions JEE Main PYQ – 2

Total Time: 1 Hour : 15 Minute

Total Marks: 120

Instructions

Instructions

1. Test will auto submit when the Time is up.
2. The Test comprises of multiple choice questions (MCQ) with one or more correct answers.
3. The clock in the top right corner will display the remaining time available for you to complete the examination.

Navigating & Answering a Question

1. The answer will be saved automatically upon clicking on an option amongst the given choices of answer.
2. To deselect your chosen answer, click on the clear response button.
3. The marking scheme will be displayed for each question on the top right corner of the test window.

Solutions

1. 40 g of glucose (Molar mass = 180) is mixed with 200 mL of water. The freezing point of solution is _____ K. (Nearest integer) (+4, -1)
 [Given: $K_f = 1.86 \text{ K kg mol}^{-1}$; Density of water = 1.00 g cm^{-3} ; Freezing point of water = 273.15 K]
-
2. 1 kg of 0.75 molal aqueous solution of sucrose can be cooled up to -4°C before freezing. The amount of ice (in g) that will be separated out is _____. (Nearest integer) (+4, -1)
 [Given : $K_f(\text{H}_2\text{O}) = 1.86 \text{ K kg mol}^{-1}$]
-
3. Of the following four aqueous solutions, total number of those solutions whose freezing point is lower than that of $0.10 \text{ M C}_2\text{H}_5\text{OH}$ is _____. (Integer answer) (+4, -1)
 (i) $0.10 \text{ M Ba}_3(\text{PO}_4)_2$
 (ii) $0.10 \text{ M Na}_2\text{SO}_4$
 (iii) 0.10 M KCl
 (iv) $0.10 \text{ M Li}_3\text{PO}_4$
-
4. An aqueous KCl solution of density 1.20 g mL^{-1} has a molality of 3.30 mol kg^{-1} . The molarity of the solution in mol L^{-1} is _____. (Nearest integer) (+4, -1)
 [Molar mass of KCl = 74.5]
-
5. 83 g of ethylene glycol dissolved in 625 g of water. The freezing point of the solution is _____ K. (Nearest integer) (+4, -1)
 Use: Molal Freezing point depression constant of water = $1.86 \text{ K kg mol}^{-1}$
 Freezing point of water = 273 K
 Atomic masses: C: 12.0 u, O: 16.0 u, H: 1.0 u
-
6. If equal volumes of AB and XY (both are salts) aqueous solutions are mixed, which of the following combination will give precipitate of AY, at 300 K? (+4, -1)
- K (300 K) for $AB = 5.2 \times 10^3$
 - K (300 K) for $AB = 1.0 \times 10^3$
 - K for 10^{-10} M AB , $5 \times 10^{-10} \text{ M XY}$
 - K for $15 \times 10^{-10} \text{ M XY}$

7. Match List-I with List-II

(+4, -1)

List-I		List-II	
(A)	Solution of chloroform and acetone	(I)	Minimum boiling azeotrope
(B)	Solution of ethanol and water	(II)	Dimeric
(C)	Solution of benzene and toluene	(III)	Maximum boiling azeotrope
(D)	Solution of acetic acid in benzene	(IV)	$\Delta V_{\text{mix}} = 0$

Choose the correct answer from the options given below :

- (A)-(III), (B)-(I), (C)-(IV), (D)-(II)
- (A)-(II), (B)-(IV), (C)-(I), (D)-(III)
- (A)-(III), (B)-(IV), (C)-(I), (D)-(II)
- (A)-(II), (B)-(I), (C)-(IV), (D)-(III)

 8. Liquid A and B form an ideal solution. The vapour pressure of pure liquids A and B are 350 and 750 mm Hg respectively at the same temperature. If x_A and x_B are the mole fraction of A and B in solution while y_A and y_B are the mole fraction of A and B in vapour phase then :

(+4, -1)

- $\frac{x_A}{x_B} < \frac{y_A}{y_B}$
- $\frac{x_A}{x_B} = \frac{y_A}{y_B}$
- $\frac{x_A}{x_B} > \frac{y_A}{y_B}$
- $(x_A - y_A) < (x_B - y_B)$

9. 10 mL of 2 M NaOH solution is added to 20 mL of 1 M HCl solution kept in a beaker. Now, 10 mL of this mixture is poured into a volumetric flask of 100 mL containing 2 moles of HCl and made the volume upto the mark with distilled water. The solution in this flask is :

(+4, -1)

- a. 0.2 M NaCl solution
- b. 20 M HCl solution
- c. 10 M HCl solution
- d. Neutral solution

10. An aqueous solution of HCl with pH 1.0 is diluted by adding equal volume of water (ignoring dissociation of water). The pH of HCl solution would be: (+4, -1)
(Given $\log 2 = 0.30$)

- a. reduce to 0.5
- b. increase to 1.3
- c. remain same
- d. increase to 2

11. Sea water, which can be considered as a 6 molar (6 M) solution of NaCl, has a density of 2 g mL^{-1} . The concentration of dissolved oxygen (O_2) in sea water is 5.8 ppm. Then the concentration of dissolved oxygen (O_2) in sea water, in $x \times 10^{-4} \text{ m}$. $x = \text{-----}$. (Nearest integer) (+4, -1)
Given: Molar mass of NaCl is 58.5 g mol^{-1} Molar mass of O_2 is 32 g mol^{-1} .

12. Which of the following binary mixture does not show the behavior of minimum boiling azeotropes? (+4, -1)

- a. $\text{CS}_2 + \text{CH}_3\text{COCH}_3$
- b. $\text{H}_2\text{O} + \text{CH}_3\text{COC}_2\text{H}_5$
- c. $\text{C}_6\text{H}_5\text{OH} + \text{C}_6\text{H}_5\text{NH}_2$
- d. $\text{CH}_3\text{OH} + \text{CHCl}_3$

13. Which of the following solutions can form a minimum boiling azeotrope? (+4, -1)

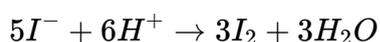
- a. $C_2H_5OH + H_2O$
- b. n-heptane + n-hexane
- c. $CH_3COOH + C_5H_5N$
- d. $C_2H_5Br + C_2H_5I$

14. An aqueous solution of 0.1 M HA shows depression in freezing point of $0.2^\circ C$. If $K_f(H_2O) = 1.86 K kg mol^{-1}$ and assuming molarity = molality, find the dissociation constant of HA. (+4, -1)

- a. 4.50×10^{-5}
- b. 6.25×10^{-3}
- c. 5.625×10^{-4}
- d. 2.65×10^{-4}

15. A solution of sugar is obtained by mixing 200g of its 25% solution and 500g of its 40% solution (both by mass). The mass percentage of the resulting sugar solution is _____ (Nearest integer) (+4, -1)

16. 0.1 M solution of KI reacts with excess of H_2SO_4 and KIO_3 , according to the equation: (+4, -1)



Identify the correct statements:

- (A) 200 mL KI solution reacts with 0.004 mol of KIO_3
 - (B) 200 mL KI solution reacts with 0.006 mol of H_2SO_4
 - (3) 0.5 L KI solution produced 0.005 mol of I_2
 - (4) Equivalent weight of KIO_3 is equal to Molecular weight / 5
- a. (A) and (D) only
- b. (B) and (C) only

- c. (A) and (B) only
- d. (C) and (D) only

17. Concentrated nitric acid is labelled as 75% by mass. The volume in mL of the solution which contains 30 g of nitric acid is: Given: Density of nitric acid solution is 1.25 g/mL. (+4, -1)

- a. 55
- b. 45
- c. 32
- d. 40

18. Arrange the following in increasing order of solubility product: (+4, -1)



- a. $HgS < AgBr < PbS < Ca(OH)_2$
- b. $PbS < HgS < Ca(OH)_2 < AgBr$
- c. $Ca(OH)_2 < AgBr < HgS < PbS$
- d. $HgS < PbS < AgBr < Ca(OH)_2$

19. The purification method based on the following physical transformation is: (+4, -1)



- a. Distillation
- b. Sublimation
- c. Crystallization

d. Extraction

20. 20 mL of 2 M NaOH solution is added to 400 mL of 0.5 M NaOH solution. The final concentration of the solution is _____ x 10^{-2} M. (Nearest integer) (+4, -1)

21. Density of 3 M NaCl solution is 1.25 g/mL. The molality of the solution is: (+4, -1)

a. 2.79 m

b. 1.79 m

c. 3 m

d. 2 m

22. Mass of ethylene glycol (antifreeze) to be added to 18.6 kg of water to protect the freezing point at -24°C is _____ kg (Molar mass in g mol^{-1} for ethylene glycol = 62, K_f of water = $1.86 \text{ K kg mol}^{-1}$). (+4, -1)

23. The density of 'x' M solution ('x' molar) of NaOH is 1.12 g/mL. While in molality, the concentration of the solution is 3 m (3 molal). Then x is: (+4, -1)

Given: Molar mass of NaOH is 40 g/mol

a. 3.5

b. 3

c. 3.8

d. 2.8

24. During the detection of acidic radical present in a salt, a student gets a pale yellow precipitate soluble with difficulty in NH_4OH solution when sodium carbonate extract was first acidified with dil. HNO_3 and then AgNO_3 solution was added. This indicates the presence of: (+4, -1)

a. Br^-

b. CO_3^{2-}

c. I^-

d. Cl^-

25. 2.7 Kg of each of water and acetic acid are mixed. The freezing point of the solution will be $-x$ °C. Consider the acetic acid does not dimerise in water, nor dissociates in water. $x = \underline{\hspace{2cm}}$ (nearest integer). (+4, -1)

[Given: Molar mass of water = 18 g mol^{-1} , acetic acid = 60 g mol^{-1} $K_f \text{ H}_2\text{O} = 1.86 \text{ K kg mol}^{-1}$ $K_f \text{ acetic acid} = 3.90 \text{ K kg mol}^{-1}$ Freezing point: $\text{H}_2\text{O} = 273 \text{ K}$, acetic acid = 290 K]

26. A solution is prepared by adding 1 mole ethyl alcohol in 9 mole water. The mass percent of solute in the solution is $\underline{\hspace{2cm}}$ (Integer Answer) (+4, -1)
(Given : Molar mass in g mol^{-1} Ethyl alcohol : 46, water : 18)

27. Molality of an aqueous solution of urea is 4.44 m. Mole fraction of urea in solution is $x \times 10^{-3}$. Value of x is $\underline{\hspace{2cm}}$. (integer answer) (+4, -1)

28. Molarity (M) of an aqueous solution containing x g of anhyd. CuSO_4 in 500 mL solution at 32°C is 2×10^{-1} M. Its molality will be $\underline{\hspace{2cm}} \times 10^{-3}$ m (nearest integer). (+4, -1)
[Given density of the solution = 1.25 g/mL .]

29. 2.5 g of a non-volatile, non-electrolyte is dissolved in 100 g of water at 25°C . The solution showed a boiling point elevation by 2°C . Assuming the solute concentration is negligible with respect to the solvent concentration, the vapour pressure of the resulting aqueous solution is $\underline{\hspace{2cm}}$ mm of Hg (nearest integer). (+4, -1)
(Given: Molal boiling point elevation constant of water (K_b) = $0.52 \text{ K} \cdot \text{kg} \cdot \text{mol}^{-1}$, 1 atm pressure = 760 mm of Hg, molar mass of water = 18 g mol^{-1})

30. The Molarity (M) of an aqueous solution containing 5.85 g of NaCl in 500 mL water is: (+4, -1)
(Given: Molar Mass Na = 23 and Cl = 35.5 g mol^{-1})

a. 20

b. 0.2

c. 2

d. 4



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Answers

1. Answer: 271 – 271

Explanation:

Step 1: Understanding the Question:

We are asked to calculate the freezing point of an aqueous solution of glucose. This requires using the formula for freezing point depression, a colligative property.

Step 2: Key Formula:

The depression in freezing point (ΔT_f) is given by:

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

where i is the van't Hoff factor, K_f is the cryoscopic constant, and m is the molality of the solution.

Step 3: Calculate Molality (m):

Molality is defined as moles of solute per kilogram of solvent.

- **Solute:** Glucose ($C_6H_{12}O_6$). It is a non-electrolyte, so its van't Hoff factor $i = 1$.

- Moles of glucose = $\frac{\text{mass}}{\text{molar mass}} = \frac{40 \text{ g}}{180 \text{ g/mol}} = \frac{2}{9} \text{ mol}$.

- **Solvent:** Water.

- Mass of water = Volume \times Density = $200 \text{ mL} \times 1.00 \text{ g/mL} = 200 \text{ g}$.

- Mass of water in kg = $\frac{200 \text{ g}}{1000 \text{ g/kg}} = 0.2 \text{ kg}$.

- Molality $m = \frac{\text{moles of solute}}{\text{kg of solvent}} = \frac{2/9 \text{ mol}}{0.2 \text{ kg}} = \frac{2}{9 \times 0.2} = \frac{10}{9} \text{ mol/kg}$.

Step 4: Calculate the Freezing Point Depression (ΔT_f):

$$\Delta T_f = 1 \times (1.86 \text{ K kg mol}^{-1}) \times \left(\frac{10}{9} \text{ mol/kg} \right) = \frac{18.6}{9} \approx 2.067 \text{ K}$$

Step 5: Calculate the New Freezing Point:

The freezing point of the solution is the freezing point of the pure solvent minus the depression.

$$T_{f,\text{solution}} = T_{f,\text{water}} - \Delta T_f$$

$$T_{f,\text{solution}} = 273.15 \text{ K} - 2.067 \text{ K} = 271.083 \text{ K}$$

Rounding to the nearest integer, the freezing point is 271 K.

2. Answer: 518 – 518

Explanation:

Step 1: Understanding the Concept:

When a solution is cooled below its initial freezing point, ice (solvent) separates out, making the remaining solution more concentrated until its freezing point matches the current temperature.

Step 2: Detailed Explanation:

1. Calculate mass of solute and solvent in the initial 1 kg solution:

A 0.75 molal solution has 0.75 moles of sucrose in 1000 g of water.

Molar mass of sucrose ($C_{12}H_{22}O_{11}$) = 342 g/mol.

Mass of sucrose in standard 0.75 molal solution = $0.75 \times 342 = 256.5$ g.

Total mass of standard solution = $1000 + 256.5 = 1256.5$ g.

In our 1000 g (1 kg) solution:

Mass of sucrose (W_2) = $\frac{256.5}{1256.5} \times 1000 \approx 204.14$ g.

Mass of water (W_1) = $1000 - 204.14 = 795.86$ g.

Moles of sucrose = $\frac{204.14}{342} = 0.5969$ mol.

2. Calculate required mass of water at $-4^\circ C$:

$\Delta T_f = 4 K$.

$\Delta T_f = K_f \times m \implies 4 = 1.86 \times \frac{0.5969}{W_{\text{water, final (kg)}}}$.

$$W_{\text{water, final (kg)}} = \frac{1.86 \times 0.5969}{4} = 0.27756 \text{ kg} = 277.56 \text{ g}$$

3. Calculate amount of ice separated:

Ice separated = Initial water – Remaining water

$$\text{Ice} = 795.86 \text{ g} - 277.56 \text{ g} = 518.3 \text{ g}$$

Step 3: Final Answer:

The amount of ice separated is approximately 518 g.

3. Answer: 4 – 4

Explanation:

Step 1: Understanding the Concept:

Freezing point depression (ΔT_f) is a colligative property, meaning it depends on the

number of particles in the solution. The freezing point of a solution is lower than the pure solvent. A higher concentration of particles leads to a lower freezing point.

Step 2: Key Formula or Approach:

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

Since concentrations are given in Molarity (M) and are equal (0.10 M), we can compare the values of the van't Hoff factor (i). Freezing point $\propto -(i \times M)$.

Step 3: Detailed Explanation:

Reference solution: $0.10\text{ M } C_2H_5OH$ (ethanol). Ethanol is a non-electrolyte, so $i = 1$.
Effective concentration of particles = $1 \times 0.10 = 0.10\text{ M}$.

Now consider the given solutions (assuming 100% dissociation):

(i) $Ba_3(PO_4)_2 \rightarrow 3Ba^{2+} + 2PO_4^{3-}$. $i = 5$. Effective conc. = 0.50 M .

(ii) $Na_2SO_4 \rightarrow 2Na^+ + SO_4^{2-}$. $i = 3$. Effective conc. = 0.30 M .

(iii) $KCl \rightarrow K^+ + Cl^-$. $i = 2$. Effective conc. = 0.20 M .

(iv) $Li_3PO_4 \rightarrow 3Li^+ + PO_4^{3-}$. $i = 4$. Effective conc. = 0.40 M .

All four solutions have a higher effective particle concentration ($> 0.10\text{ M}$) than the reference ethanol solution. Therefore, all four will exhibit a greater freezing point depression, resulting in lower freezing points.

Step 4: Final Answer:

The total number of solutions is 4.

4. Answer: 3 - 3

Explanation:

Step 1: Understanding the Concept:

The problem requires converting molality (m) to molarity (M) using the density (d) of the solution and the molar mass of the solute (M_{solute}). Molality is moles of solute per kilogram of solvent, while molarity is moles of solute per liter of solution.

Step 2: Key Formula or Approach:

The relationship between molarity and molality is given by:

$$M = \frac{1000 \times m \times d}{1000 + (m \times M_{solute})}$$

Alternatively, assume 1 kg of solvent (water). Then: Mass of solvent = 1000 g
Moles of KCl = 3.30 mol

Step 3: Detailed Explanation:

1. Find the total mass of the solution:

Mass of solute (KCl) = $3.30 \times 74.5 = 245.85$ g

Total mass of solution = Mass of solvent + Mass of solute = $1000 + 245.85 = 1245.85$ g

2. Find the volume of the solution:

$$\text{Volume} = \frac{\text{Mass}}{\text{Density}} = \frac{1245.85 \text{ g}}{1.20 \text{ g/mL}} \approx 1038.2 \text{ mL} = 1.0382 \text{ L}$$

3. Calculate Molarity (M):

$$M = \frac{\text{moles of solute}}{\text{volume of solution in L}} = \frac{3.30}{1.0382} \approx 3.178 \text{ M}$$

The nearest integer is 3.

Step 4: Final Answer:

The molarity of the solution is 3.

5. Answer: 269 – 269

Explanation:

Step 1: Understanding the Question

We need to calculate the freezing point of an aqueous solution of ethylene glycol. This is a problem based on the colligative property of freezing point depression.

Step 2: Key Formula or Approach

The depression in freezing point (ΔT_f) is given by:

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

where K_f is the molal freezing point depression constant and m is the molality of the solution.

The freezing point of the solution (T_f) is then:

$$T_f = T_f^0 - \Delta T_f$$

where T_f^0 is the freezing point of the pure solvent.

Step 3: Detailed Calculation

Calculate the molar mass of ethylene glycol ($C_2H_6O_2$):

$$\text{Molar Mass} = 2(C) + 6(H) + 2(O) = 2(12.0) + 6(1.0) + 2(16.0) = 24 + 6 + 32 = 62 \text{ g/mol.}$$

Calculate the moles of ethylene glycol:

$$\text{Mass of ethylene glycol} = 83 \text{ g}$$

$$\text{Moles} = \frac{\text{Mass}}{\text{Molar Mass}} = \frac{83 \text{ g}}{62 \text{ g/mol}} \approx 1.3387 \text{ mol}$$

Calculate the molality (m) of the solution:

$$\text{Mass of solvent (water)} = 625 \text{ g} = 0.625 \text{ kg}$$

$$m = \frac{\text{Moles of solute}}{\text{Mass of solvent in kg}} = \frac{1.3387 \text{ mol}}{0.625 \text{ kg}} \approx 2.142 \text{ mol/kg}$$

Calculate the depression in freezing point (ΔT_f):

$$K_f \text{ for water} = 1.86 \text{ K kg mol}^{-1}$$

$$\Delta T_f = 1.86 \text{ K kg mol}^{-1} \times 2.142 \text{ mol kg}^{-1} \approx 3.984 \text{ K}$$

Calculate the freezing point of the solution (T_f):

$$T_f^0 \text{ (water)} = 273 \text{ K}$$

$$T_f = 273 \text{ K} - 3.984 \text{ K} = 269.016 \text{ K}$$

Step 4: Final Answer

The freezing point of the solution to the nearest integer is 269 K.

6. Answer: c

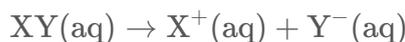
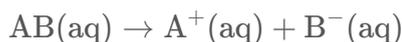
Explanation:

The problem asks to identify which combination of aqueous salt solutions AB and XY, when mixed in equal volumes, will result in the formation of a precipitate of the salt AY. The provided options are fragmented, so we will proceed by analyzing the chemical principles and applying them to the most complete and plausible option.

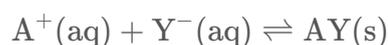
Concept Used:

For a precipitate of a sparingly soluble salt like AY to form, the **Ionic Product (Q)** of its constituent ions in the solution must exceed its **Solubility Product (K_{sp})**.

The dissociation reactions are:



The precipitation reaction is:



The Ionic Product for AY is given by $Q = [A^+][Y^-]$.

The condition for precipitation is:

$$Q > K_{sp}(AY)$$

When equal volumes of two solutions are mixed, the final volume is doubled, and the concentration of each solute is halved.

Step-by-Step Solution:

Step 1: Formulate the expression for the Ionic Product after mixing.

Let the initial concentration of the AB solution be C_{AB} and that of the XY solution be C_{XY} . When equal volumes are mixed, the new concentrations in the mixture become:

$$[A^+] = \frac{C_{AB}}{2} \quad \text{and} \quad [Y^-] = \frac{C_{XY}}{2}$$

The Ionic Product Q is then:

$$Q = [A^+][Y^-] = \left(\frac{C_{AB}}{2}\right) \left(\frac{C_{XY}}{2}\right) = \frac{C_{AB} \times C_{XY}}{4}$$

Step 2: Analyze the provided options.

The options are poorly formatted. However, one option provides a complete set of initial concentrations: "K for 10^{-10} M AB, 5×10^{-10} M XY". We interpret this as a scenario where the initial concentrations are $C_{AB} = 10^{-10}$ M and $C_{XY} = 5 \times 10^{-10}$ M. For precipitation to occur in this case, the K_{sp} of AY must be smaller than the calculated Q .

Step 3: Calculate the Ionic Product (Q) for the plausible scenario.

Using the initial concentrations from the interpreted option:

$$C_{AB} = 1 \times 10^{-10} \text{ M}$$

$$C_{XY} = 5 \times 10^{-10} \text{ M}$$

Now, calculate Q :

$$Q = \frac{(1 \times 10^{-10}) \times (5 \times 10^{-10})}{4} = \frac{5 \times 10^{-20}}{4} = 1.25 \times 10^{-20} \text{ M}^2$$

Step 4: Determine the condition for precipitation.

Precipitation of AY will occur if $K_{sp}(AY)$ is less than the calculated Ionic Product Q .

$$K_{sp}(AY) < 1.25 \times 10^{-20} \text{ M}^2$$

Therefore, the combination that will likely give a precipitate is the one specified: K for $10^{-10} \text{ M } AB$, $5 \times 10^{-10} \text{ M } XY$, assuming an appropriate K_{sp} for AY.

7. Answer: a

Explanation:

To solve this matching problem, we need to understand the properties of the solutions listed in List-I and their corresponding characteristics or behaviors in List-II.

List-I	List-II
(A) Solution of chloroform and acetone	(I) Minimum boiling azeotrope
(B) Solution of ethanol and water	(II) Dimerizes
(C) Solution of benzene and toluene	(III) Maximum boiling azeotrope
(D) Solution of acetic acid in benzene	(IV) $\Delta V_{\text{mix}} = 0$

- Solution of chloroform and acetone:** This mixture forms a maximum boiling azeotrope. The strong hydrogen bonding between chloroform (CHCl_3) and acetone ($\text{C}_3\text{H}_6\text{O}$) leads to this property. Hence, the correct match is **(III) Maximum boiling azeotrope**.
- Solution of ethanol and water:** This solution forms a minimum boiling azeotrope due to its tendency to evaporate more easily than either of its pure components. Hence, the correct match is **(I) Minimum boiling azeotrope**.
- Solution of benzene and toluene:** Benzene and toluene have similar structures and very similar intermolecular forces, which results in nearly ideal behavior with $\Delta V_{\text{mix}} = 0$. Hence, the correct match is **(IV) $\Delta V_{\text{mix}} = 0$** .

4. **Solution of acetic acid in benzene:** Acetic acid in non-polar solvents like benzene tends to form dimers due to hydrogen bonding. Hence, the correct match is **(II) Dimers**.

Thus, the correct arrangement is (A)-(III), (B)-(I), (C)-(IV), (D)-(II), which matches the given correct answer.

8. Answer: c

Explanation:

To solve this problem, we need to understand the behavior of ideal solutions and the concepts of Raoult's law regarding vapour pressure in a solution.

1. Understanding Raoult's Law:

- For an ideal solution, the partial vapour pressure of each component is given by Raoult's Law:
- $P_A = x_A \cdot P_A^\circ$ and $P_B = x_B \cdot P_B^\circ$, where P_A° and P_B° are the vapour pressures of pure components A and B, respectively.

2. Given Data:

- For pure A, $P_A^\circ = 350$ mm Hg
- For pure B, $P_B^\circ = 750$ mm Hg

3. Total Vapour Pressure:

- The total vapour pressure P_{total} is the sum of the partial pressures:
- $P_{\text{total}} = P_A + P_B = x_A \cdot 350 + x_B \cdot 750$

4. Mole Fractions in Vapour Phase:

- The mole fraction of A in the vapour phase, y_A is given by:
- $y_A = \frac{P_A}{P_{\text{total}}} = \frac{x_A \cdot 350}{x_A \cdot 350 + x_B \cdot 750}$
- Similarly, $y_B = \frac{P_B}{P_{\text{total}}} = \frac{x_B \cdot 750}{x_A \cdot 350 + x_B \cdot 750}$

5. Understanding the Concentration Ratio:

- We need to compare $\frac{x_A}{x_B}$ with $\frac{y_A}{y_B}$.
- Expressing $\frac{y_A}{y_B}$ using the above equations:
- $\frac{y_A}{y_B} = \frac{x_A \cdot 350 / (x_A \cdot 350 + x_B \cdot 750)}{x_B \cdot 750 / (x_A \cdot 350 + x_B \cdot 750)}$
- Simplifying gives:
- $\frac{y_A}{y_B} = \frac{x_A \cdot 350}{x_B \cdot 750}$
- Thus, $\frac{y_A}{y_B} = \frac{x_A}{x_B} \cdot \frac{350}{750} = \frac{x_A}{x_B} \cdot \frac{7}{15}$

6. Conclusion:

- Since $\frac{7}{15} < 1$, it follows that $\frac{x_A}{x_B} > \frac{y_A}{y_B}$.

- Thus, the correct answer is $\frac{x_A}{x_B} > \frac{y_A}{y_B}$.

9. Answer: b

Explanation:

To solve the question, let's analyze the steps involved in the whole process:

Determine the reaction between NaOH and HCl in the initial mixture:

- We have 10 mL of 2 M NaOH. Therefore, moles of NaOH = $0.01 \text{ L} \times 2 \text{ mol/L} = 0.02 \text{ mol}$.
- We have 20 mL of 1 M HCl. Therefore, moles of HCl = $0.02 \text{ L} \times 1 \text{ mol/L} = 0.02 \text{ mol}$.
- NaOH and HCl react in a 1:1 ratio: $\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$.
- Both reactants have the same number of moles (0.02 mol each), so they will completely neutralize each other, resulting in a neutral solution of NaCl with no excess HCl or NaOH.

Consider what happens when 10 mL of this neutral solution is added to a volumetric flask containing HCl:

- The mixture is poured into a 100 mL volumetric flask containing 2 moles of HCl.
- Since the initial solution was neutral (containing only NaCl and water), adding it does not change the HCl concentration already in the flask.

Calculate the final concentration of HCl in the volumetric flask:

- Total volume in the flask is 100 mL or 0.1 L.
- Moles of HCl initially in the flask = 2 mol.
- Concentration of HCl in the flask = $\frac{\text{Number of moles}}{\text{Volume in L}} = \frac{2 \text{ mol}}{0.1 \text{ L}} = 20 \text{ M}$.

From this calculation, we see that the solution in the flask becomes a 20 M HCl solution.

Thus, the correct answer is: **20 M HCl solution**.

10. Answer: b

Explanation:

Step 1: Understanding pH and dilution

The pH of a solution is related to the concentration of hydrogen ions ($[H^+]$) in the solution by the equation:

$$\text{pH} = -\log[H^+]$$

For an aqueous HCl solution with pH 1.0, the concentration of hydrogen ions $[H^+]$ is:

$$\text{pH} = 1.0 \Rightarrow [H^+] = 10^{-1} = 0.1 \text{ M}$$

Step 2: Diluting the solution

When an equal volume of water is added to the solution, the concentration of hydrogen ions is halved (since the volume doubles).

Therefore, the new concentration of $[H^+]$ will be:

$$[H^+]_{\text{new}} = \frac{0.1}{2} = 0.05 \text{ M}$$

Step 3: Calculating the new pH

The pH of the diluted solution is given by:

$$\text{pH}_{\text{new}} = -\log(0.05)$$

Using the logarithm property $\log 0.05 = \log(5 \times 10^{-2}) = \log 5 + \log 10^{-2}$, we get:

$$\log 0.05 = \log 5 - 2 = 0.69897 - 2 = -1.30103$$

Thus:

$$\text{pH}_{\text{new}} = -(-1.30103) = 1.30103 \approx 1.3$$

Therefore, the pH increases to 1.3 after dilution.

Thus, the correct answer is option (2).

11. Answer: 2 – 2

Explanation:

Sea water is **6 Molar in NaCl**, which means that **1000 mL** of sea water contains **6 mol** of NaCl.

Step 1: Calculate the mass of the solution

$$\begin{aligned}\text{Mass of solution} &= \text{Volume} \times \text{Density} \\ &= 1000 \times 2 = 2000 \text{ g}\end{aligned}$$

Step 2: Calculate the mass of O₂ from ppm

$$\text{ppm} = \frac{\text{mass of O}_2}{2000} \times 10^6$$

Given that the O₂ concentration is $5.8 \times 2 \times 10^{-3}$:

$$\text{Mass of O}_2 = 1.16 \times 10^{-2} \text{ g}$$

Step 3: Calculate molality of O₂

$$\text{Molality of O}_2 = \frac{1.16 \times 10^{-2}/32}{(2000 - 6 \times 58.5)} \times 1000$$

Simplifying,

$$= \frac{1.16 \times 10^{-2}}{32 \times 1649}$$

$$= 0.000219 = 2.19 \times 10^{-4}$$

Final Answer:

Correct answer = 2

12. Answer: c

Explanation:

This question asks which binary mixture does not form a minimum boiling azeotrope. An azeotrope is a mixture of two or more liquids whose proportions cannot be altered by simple distillation. They have a constant boiling point. Minimum boiling azeotropes have a boiling point lower than either of their individual components.

Let's evaluate each option:

- $\text{CS}_2 + \text{CH}_3\text{COCH}_3$: Carbon disulfide and acetone form a minimum boiling azeotrope because of the strong interactions differing from ideal solutions, which lowers the boiling point.
- $\text{H}_2\text{O} + \text{CH}_3\text{COC}_2\text{H}_5$: Water and ethyl acetate also form a minimum boiling azeotrope. Despite water's strong hydrogen bonding, the solvent interactions disrupt this, leading to an azeotrope.
- $\text{C}_6\text{H}_5\text{OH} + \text{C}_6\text{H}_5\text{NH}_2$: Phenol and aniline do not form an azeotrope. They have significant specific interactions like hydrogen bonding, not favoring azeotropic behavior.
- $\text{CH}_3\text{OH} + \text{CHCl}_3$: Methanol and chloroform form a minimum boiling azeotrope due to their interaction which lowers the boiling point.

Therefore, the correct answer is $\text{C}_6\text{H}_5\text{OH} + \text{C}_6\text{H}_5\text{NH}_2$ as they do not form such an azeotrope due to the specific interactions between the two components that stabilize their separate phases more than their mixture.

13. **Answer: a**

Explanation:

Azeotropes are mixtures of two liquids that boil at a constant temperature and cannot be separated by simple distillation.

A minimum boiling azeotrope is formed when the mixture exhibits a boiling point lower than that of either pure component. **Examine the components of the given mixtures:**

Ethanol ($\text{C}_2\text{H}_5\text{OH}$) and Water (H_2O) form a minimum boiling azeotrope at about 78.2°C .

This azeotrope cannot be separated by distillation, making it the correct option. The other mixtures like n-heptane and n-hexane form ideal solutions and do not form minimum boiling azeotropes. Thus, the correct answer is (1).

14. **Answer: c**

Explanation:

We can use the formula for depression in freezing point:

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

where:

$$\Delta T_f = 0.2 \text{ }^\circ\text{C},$$

$$K_f = 1.86 \text{ K kg mol}^{-1},$$

$$m = 0.1 \text{ mol/kg (molarity = molality)},$$

i is the van't Hoff factor (dissociation constant).

Step 1: Apply the formula for depression in freezing point:

$$0.2 = 1.86 \times 0.1 \times i$$

Step 2: Solve for i :

$$i = \frac{0.2}{1.86 \times 0.1} = \frac{0.2}{0.186} \approx 1.075$$

Step 3: Calculate the dissociation constant (K):

For the dissociation constant, $i = 1 + \alpha$ (where α is the degree of dissociation), so:

$$i = 1 + \alpha = 1.075 \Rightarrow \alpha = 0.075$$

Thus, the dissociation constant is approximately 5.625×10^{-4} .

15. Answer: 36 – 36

Explanation:

Given:

- Solution (I): Mass of sugar = 200 g, sugar percentage = 25%

- Solution (II): Mass of sugar = 500 g, sugar percentage = 40%

Mass of sugar in solution (I):

$$\frac{25}{100} \times 200 = 50 \text{ g}$$

Mass of sugar in solution (II):

$$\frac{40}{100} \times 500 = 200 \text{ g}$$

Total mass of solution = 200 + 500 = 700 g

Total mass of sugar = $50 + 200 = 250$ g Now, the final percentage of sugar is:

$$\frac{250}{700} \times 100 = 35.71 \approx 36$$

Thus, the mass percentage of sugar is 36%. The correct answer is (36).

16. Answer: a

Explanation:

- Statement (A) is correct because 200 mL of 0.1 M KI contains 0.02 moles of KI, and according to the equation, 5 moles of I^- react with 1 mole of KIO_3 . Therefore, 0.02 moles of KI would require 0.004 mol of KIO_3 .
 - Statement (C) is also correct because 0.5 L of 0.1 M KI will contain 0.05 moles of KI, and according to the equation, this will produce 0.005 mol of I_2 .
 - Statement (D) is correct because the equivalent weight of KIO_3 is equal to its molecular weight divided by 5, as 5 moles of iodide react with one mole of KIO_3 .
- Thus, the correct answer is (A), (D).
-

17. Answer: c

Explanation:

To find the volume of the nitric acid solution that contains 30 g of nitric acid in a solution that is 75% nitric acid by mass, we can follow these steps:

1. Calculate the total mass of the solution required to contain 30 g of nitric acid. Since the solution is 75% nitric acid by mass, the formula to find the total mass (m_{total}) is given by:

$$m_{\text{HNO}_3} = \frac{75}{100} \times m_{\text{total}}$$

Given that $m_{\text{HNO}_3} = 30$ g, we have:

$$30 = \frac{75}{100} \times m_{\text{total}}$$

$$m_{\text{total}} = \frac{30 \times 100}{75}$$

$$m_{\text{total}} = 40 \text{ g}$$

2. Calculate the volume of the solution using its density. The density (ρ) of the nitric acid solution is given as 1.25 g/mL. We can use the formula:

$$\text{Volume (mL)} = \frac{\text{Mass (g)}}{\text{Density (g/mL)}}$$

Substituting the values:

$$\text{Volume} = \frac{40}{1.25}$$

$$\text{Volume} = 32 \text{ mL}$$

Thus, the volume of the solution required is **32 mL**.

18. Answer: c

Explanation:

The solubility product constant, K_{sp} , is a measure of the solubility of a compound; the smaller the K_{sp} , the less soluble the compound is. To determine the increasing order of solubility product for the given compounds: Ca(OH)_2 , AgBr , PbS , and HgS , we compare their K_{sp} values.

1. HgS : It has a very low K_{sp} with a value approximately in the order of 10^{-54} , indicating extremely low solubility.

2. PbS : This compound also has a low K_{sp} but is slightly more soluble than HgS , with K_{sp} around 10^{-28} .

3. AgBr : It is more soluble than both HgS and PbS , with a K_{sp} around 10^{-13} .

4. Ca(OH)_2 : This compound has the highest K_{sp} among the given compounds, approximately 10^{-6} , making it the most soluble.

Based on these K_{sp} values, the increasing order of solubility product is:



19. Answer: b

Explanation:

The given physical transformation describes a purification method where a solid is converted to vapor through the application of heat and then back to solid upon cooling. The process involving this sequence of phase changes is known as **sublimation**.

Explanation: Sublimation is a technique used to purify substances that can transition from solid to vapor without passing through a liquid phase. When the solid substance is heated, it turns into vapor. Upon cooling, this vapor directly condenses back into a solid form. This method is effective for separating sublimable compounds from non-sublimable impurities.

The correct answer is **Sublimation**.

20. Answer: 5.7 – 5.7

Explanation:

We can calculate the final concentration of the NaOH solution using the dilution formula:

$$C_1V_1 + C_2V_2 = C_fV_f$$

Where: - $C_1 = 2\text{ M}$ (concentration of first solution), - $V_1 = 20\text{ mL}$ (volume of first solution), - $C_2 = 0.5\text{ M}$ (concentration of second solution), - $V_2 = 400\text{ mL}$ (volume of second solution), - C_f is the final concentration, and - $V_f = V_1 + V_2 = 20 + 400 = 420\text{ mL}$.

Now, substitute the values:

$$(2 \times 20) + (0.5 \times 400) = C_f \times 420$$

$$40 + 200 = C_f \times 420$$

$$C_f = \frac{240}{420} = 0.571\text{ M}$$

Thus, the final concentration is approximately 0.57 M, or 5.7×10^{-2} M.

21. Answer: c

Explanation:

We are given: - Molarity (M) = 3 M (mol/L) - Density of solution = 1.25 g/mL = 1250 g/L

The molality (m) is given by the formula:

$$m = \frac{\text{moles of solute}}{\text{kg of solvent}}$$

From molarity, the number of moles of NaCl in 1 liter of solution is:

$$\text{moles of NaCl} = 3 \text{ mol}$$

To find the mass of NaCl, use the molar mass of NaCl (58.44 g/mol):

$$\text{mass of NaCl} = 3 \text{ mol} \times 58.44 \text{ g/mol} = 175.32 \text{ g}$$

Now, the mass of the solvent (water) is:

$$\text{mass of solvent} = 1250 \text{ g} - 175.32 \text{ g} = 1074.68 \text{ g} = 1.07468 \text{ kg}$$

Thus, the molality is:

$$m = \frac{3 \text{ mol}}{1.07468 \text{ kg}} = 2.79 \text{ m}$$

Therefore, the correct answer is 2.79 m.

22. Answer: 15 - 15

Explanation:

To solve the problem of determining the mass of ethylene glycol needed to protect water from freezing at -24°C , we'll use the concept of freezing point depression, which is given by the formula:

$\Delta T_f = K_f \cdot m$, where ΔT_f is the change in freezing point, K_f is the cryoscopic constant, and m is the molality of the solution.

1. Determine the Freezing Point Depression (ΔT_f):

The normal freezing point of water is 0°C . The desired freezing point is -24°C , so:

$$\Delta T_f = 0 - (-24) = 24^{\circ}\text{C}.$$

2. Calculate Molality (m):

$$m = \frac{\Delta T_f}{K_f} = \frac{24}{1.86} = 12.903 \text{ mol kg}^{-1}.$$

3. Determine the Moles of Solute Needed:

Molality is defined as moles of solute per kilogram of solvent, so:

$$\text{moles of ethylene glycol} = 12.903 \times 18.6 \text{ kg} = 239.9998 \text{ mol}.$$

4. Convert Moles to Mass:

Using the molar mass of ethylene glycol (62 g mol^{-1}):

$$\text{Mass of ethylene glycol} = 239.9998 \text{ mol} \times 62 \text{ g mol}^{-1} = 14,879.9876 \text{ g} = 14.88 \text{ kg}$$

5. Verify the Result Within the Range:

The computed mass of ethylene glycol is 14.88 kg, which falls within the given range of $15 \pm 0.15 \text{ kg}$ (14.85 kg to 15.15 kg).

Thus, the mass of ethylene glycol to be added is **14.88 kg**.

23. Answer: b

Explanation:

We know the relationship between molality and molarity:

$$\text{Molality} = \frac{1000 \times M}{1000 \times d - M \times (\text{Molar mass of solute})}$$

Substituting the values:

$$3 = \frac{1000 \times x}{1000 \times 1.12 - x \times 40}$$

Rearranging:

$$3 \times (1000 \times 1.12 - x \times 40) = 1000 \times x$$

Simplify:

$$3 \times 1120 - 120x = 1000x$$

$$3360 = 1120x$$

Solving:

$$x = 3$$

Thus, the molarity of the solution is 3.0 M.

24. Answer: a

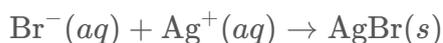
Explanation:

To identify the acidic radical present in a salt, a student performs the following steps:

1. The sodium carbonate extract of the salt is acidified with dilute HNO_3 .
2. AgNO_3 solution is added to the acidified solution.

Upon adding AgNO_3 , a pale yellow precipitate is formed which is soluble with difficulty in NH_4OH (ammonium hydroxide) solution. This behavior suggests the presence of the bromide ion Br^- . Here's the reasoning:

1. **Formation of Precipitate:** When AgNO_3 is added, it reacts with the halide ions to form silver halides. Each halide ion forms a distinct colored precipitate. For bromide ions, the reaction is:



1. The AgBr formed is a pale yellow precipitate.
2. **Solubility in NH₄OH:** The solubility of silver halides in ammonium hydroxide can distinguish between them:
 - AgCl is white and soluble in dilute NH₄OH.
 - AgBr is pale yellow and partially soluble with difficulty in dilute NH₄OH.
 - AgI is yellow and insoluble in dilute NH₄OH.

Given the choices and explanations, the presence of bromide ion Br⁻ is confirmed by the formation of a pale yellow precipitate which is soluble with difficulty in NH₄OH. Therefore, the correct answer is: Br⁻

25. Answer: 31 – 31

Explanation:

Since the moles of water are greater than the moles of CH₃COOH, water acts as the solvent. The freezing point depression is calculated as:

$$T_f^0 - (T_f)_s = K_f \times m$$

Calculating the molality m :

$$m = \frac{\text{moles of solute}}{\text{kg of solvent}} = \frac{2700/60}{2700/1000} = 1 \text{ mol kg}^{-1}$$

Applying the freezing point depression formula:

$$0 - (T_f)_s = 1.86 \times 1$$

$$(T_f)_s = -1.86 \approx -31^{\circ}\text{C}$$

26. Answer: 22 – 22

Explanation:

We are given the mass of ethyl alcohol and water, and we need to calculate the percentage by mass of ethyl alcohol in the solution:

Mass of ethyl alcohol = 1 mole \times MM

$$\Rightarrow 46 \text{ g}$$

Mass of water = 9 moles \times MM

$$\Rightarrow 162 \text{ g}$$

The percentage by mass of ethyl alcohol is given by:

$$\begin{aligned} \% \text{ by mass of ethyl alcohol} &= \frac{46}{162 + 46} \times 100 \\ &\Rightarrow 22\% \text{ (approx.)} \end{aligned}$$

Thus, the percentage by mass of ethyl alcohol is approximately 22%.

27. Answer: 74 – 74

Explanation:

To find the mole fraction of urea in an aqueous solution given the molality, we start by noting the essential relationships and calculations.

Molality (m) is defined as the number of moles of solute per kilogram of solvent. Here, the solute is urea ($\text{CH}_4\text{N}_2\text{O}$).

Given: **Molality (m) = 4.44 m**

Let the mass of water be 1 kg. This implies the number of moles of urea is 4.44 moles since molality is moles of solute per kg of solvent.

The mole fraction of a solute (urea) is given by:

$$\text{Mole fraction of urea} = \frac{\text{moles of urea}}{\text{moles of urea} + \text{moles of water}}$$

Moles of water: Given the mass of water is 1 kg (1000 g) and the molar mass of water is 18 g/mol:

$$\text{Moles of water} = \frac{1000}{18} \approx 55.56 \text{ moles}$$

Substitute these values into the equation:

$$\text{Mole fraction of urea} = \frac{4.44}{4.44 + 55.56}$$

$$\text{Mole fraction of urea} = \frac{4.44}{60} \approx 0.074$$

To express the mole fraction in terms of $x \times 10^{-3}$:

$$0.074 = x \times 10^{-3}$$

$$x = 0.074 \times 10^3 = 74$$

Therefore, the value of x is **74**, which lies within the range (74 to 74).

28. Answer: 164 – 164

Explanation:

To find the molality of the solution, we first need to determine the number of moles of anhydrous CuSO_4 in the solution. Given the molarity (M) is 2×10^{-1} M in a 500 mL solution, we calculate the moles of CuSO_4 as follows: Moles of $\text{CuSO}_4 = \text{Molarity} \times \text{Volume in L} = 2 \times 10^{-1} \times 0.5 = 0.1$ mol.

The molecular weight of CuSO_4 is $63.5 + 32 + 4 \times 16 = 159.5$ g/mol. Therefore, $x = \text{moles} \times \text{molecular weight} = 0.1 \times 159.5 = 15.95$ g.

Next, calculate the mass of the solution using the given density: Mass of solution = Density \times Volume = $1.25 \times 500 = 625$ g.

Subtracting the mass of CuSO_4 , the mass of the solvent (water) is: $625 - 15.95 = 609.05$ g or 0.60905 kg.

The molality (m) is defined as moles of solute per kg of solvent: Molality =

$$\frac{\text{Moles of CuSO}_4}{\text{kg of solvent}} = \frac{0.1}{0.60905} \approx 0.164 \text{ mol/kg or } 164 \times 10^{-3} \text{ m.}$$

Thus, the molality of the solution is 164×10^{-3} m, which is within the expected range of 164,164.

29. Answer: 707 – 707

Explanation:

Determine the Molality of the Solution:

The boiling point elevation ΔT_b is related to molality (m) as follows:

$$\Delta T_b = K_b \times m$$

Given:

$$\Delta T_b = 2^\circ C, \quad K_b = 0.52 \text{ K kg mol}^{-1}$$

$$m = \frac{\Delta T_b}{K_b} = \frac{2}{0.52} \approx 3.85 \text{ mol kg}^{-1}$$

Calculate the Moles of Solute:

Since molality m is defined as moles of solute per kilogram of solvent:

$$\text{moles of solute} = m \times \text{mass of solvent (in kg)}$$

Given that the mass of solvent (water) is 100 g or 0.1 kg:

$$\text{moles of solute} = 3.85 \times 0.1 = 0.385 \text{ moles}$$

Determine the Molar Mass of the Solute:

Given mass of solute = 2.5 g,

$$\text{Molar mass of solute} = \frac{\text{mass of solute}}{\text{moles of solute}} = \frac{2.5}{0.385} \approx 6.49 \text{ g/mol}$$

Calculate the Vapour Pressure Lowering:

The vapour pressure lowering ΔP is given by:

$$\Delta P = P^0 \times \frac{\text{moles of solute}}{\text{moles of solvent}}$$

where $P^0 = 760 \text{ mm Hg}$ and moles of solvent (water) =

$$\frac{100}{18} \approx 5.56 \text{ moles.}$$

Calculate ΔP :

$$\Delta P = 760 \times \frac{0.385}{5.56} \approx 52.61 \text{ mm Hg}$$

Calculate the Vapour Pressure of the Solution:

$$P_{\text{solution}} = P^0 - \Delta P = 760 - 52.61 \approx 707 \text{ mm Hg}$$

Conclusion:

The vapour pressure of the resulting aqueous solution is approximately 707 mm Hg.

30. Answer: b

Explanation:

To calculate the molarity of the solution, first determine the molar mass of NaCl:

$$\text{Molar mass of NaCl} = 23 \text{ g/mol} + 35.5 \text{ g/mol} = 58.5 \text{ g/mol}$$

Calculate the number of moles of NaCl:

$$n_{\text{NaCl}} = \frac{\text{Mass of NaCl}}{\text{Molar Mass of NaCl}} = \frac{5.85 \text{ g}}{58.5 \text{ g/mol}} = 0.1 \text{ mol}$$

Given that the volume of the solution is 500 mL = 0.5 L, the molarity M is calculated as:

$$M = \frac{n_{\text{NaCl}}}{V_{\text{sol}} (\text{in L})} = \frac{0.1 \text{ mol}}{0.5 \text{ L}} = 0.2 \text{ M}$$