Solutions JEE Main PYQ - 3

Total Time: 1 Hour : 15 Minute **Total Marks:** 120

Instructions

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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. The molarity of 1 L orthophosphoric acid (H_3PO_4) having 70% purity by weight (specific gravity $1.54\,\mathrm{g\,cm^{-3}}$) is ______ M. **(+4, -1)**
(Molar mass of $H_3PO_4 = 98\,\mathrm{g\,mol^{-1}}$)

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2. The vapour pressure of pure benzene and methyl benzene at $27^\circ\mathrm{C}$ is given as 80 Torr and 24 Torr, respectively. The mole fraction of methyl benzene in vapour phase, in equilibrium with an equimolar mixture of those two liquids (ideal solution) at the same temperature, is $\ldots\ \times 10^{-2}$ (nearest integer). **(+4, -1)**

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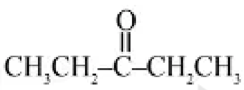
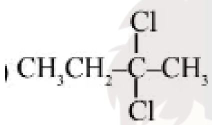
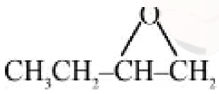
3. Which of the following compound can give positive iodoform test when treated with aqueous KOH solution followed by potassium hypoiodite. **(+4, -1)**

a. 

b. 

c. $CH_3CH_2CH_2CHO$

d. 

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4. Identify the mixture that shows positive deviations from Raoult's Law **(+4, -1)**

a. $(\mathrm{CH_3})_2\mathrm{CO} + \mathrm{C_6H_5NH_2}$

b. $\mathrm{CHCl_3} + \mathrm{C_6H_6}$

c. $\mathrm{CHCl_3} + (\mathrm{CH_3})_2\mathrm{CO}$

d. $(\mathrm{CH_3})_2\mathrm{CO} + \mathrm{CS_2}$

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5. NaCl reacts with conc. H_2SO_4 and $K_2Cr_2O_7$ to give reddish fumes (B), which react with NaOH to give yellow solution (C). (B) and (C) respectively are: **(+4, -1)**

a. CrO_2Cl_2, Na_2CrO_4

b. Na_2CrO_4, CrO_2Cl_2

c. $CrO_2Cl_2, KHSO_4$

d. $CrO_2Cl_2, Na_2Cr_2O_7$

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6. A solution of two miscible liquids showing negative deviation from Raoult's law will have: (+4, -1)

a. Increased vapour pressure, increased boiling point

b. Increased vapour pressure, decreased boiling point

c. Decreased vapour pressure, decreased boiling point

d. Decreased vapour pressure, increased boiling point

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7. Molality of 0.8 M H_2SO_4 solution (density 1.06 g cm^{-3}) is ______ $\times 10^{-3}$ m. (+4, -1)

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8. The osmotic pressure of a dilute solution is 7×10^5 Pa at $273K$. Osmotic pressure of the same solution at $283K$ is _____ $\times 10^4 Nm^2$ (+4, -1)

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9. A solution of H_2SO_4 is 31.4% H_2SO_4 by mass and has a density of $1.25\,g/mL$. The molarity of the H_2SO_4 solution is _____ M (nearest integer). (+4, -1)
[Given molar mass of $H_2SO_4 = 98\,g/mol$]

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10. (+4, -1)
Volume of 3 M NaOH (formula weight 40 g mol^{-1}) which can be prepared from 84 g of NaOH is _____ $\times$ 10^{-1} dm^3.

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11. 20 mL of 0.1 M NaOH is added to 50 mL of 0.1 M acetic acid solution. The pH of the resulting solution is____ x 10^{-2} (Nearest integer) (+4, -1)
Given: pKa (CH_3COOH) = 4.76
log 2 = 0.30
log 3 = 0.48

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12. 80 mole percent of $MgCl_2$ is dissociated in aqueous solution. The vapour pressure of 1.0 molal aqueous solution of M_gCl_2 at 38°C is ____mm Hg. (Nearest integer) (+4, -1)
Given : Vapour pressure of water at 38°C is 50 mm Hg.

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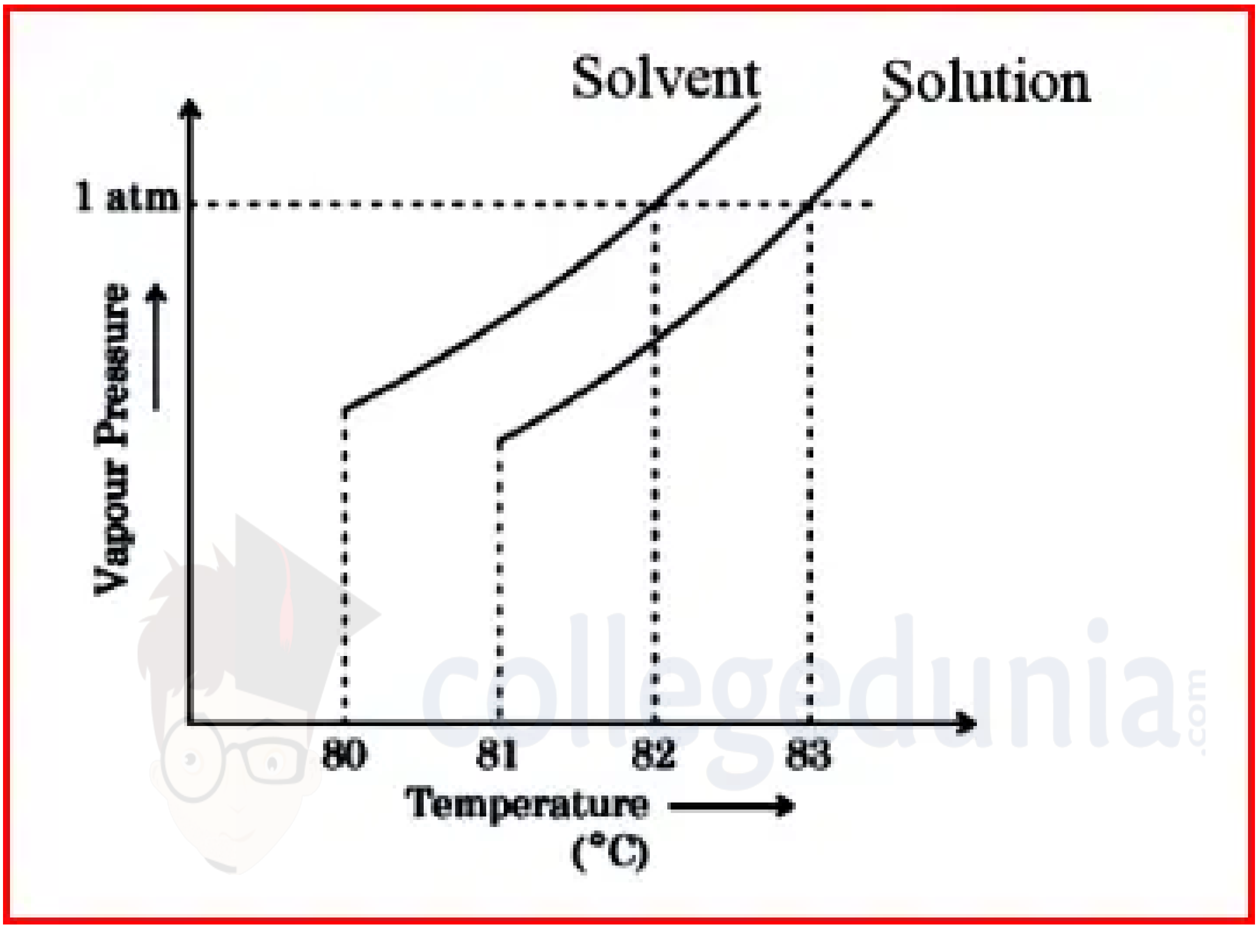
13. Consider the following pairs of solution which will be isotonic at the same temperature. The number of pairs of solutions is/are...... (+4, -1)
A. 1 M aq. NaCl and 2 M aq. Urea
B. 1 M aq. $CaCl_2$ and 1.5 M aq. KCl

C. 1.5 M aq. $AlCl_3$ and 2 M aq. Na_2SO_4
D. 2.5 M aq. KCl and 1 M aq. $Al_2(SO_4)_3$

14. The vapour pressure vs. temperature curve for a solution solvent system is shown below. **(+4, -1)**



The boiling point of the solvent is _____°C.

15. 20 mL of 0.5 M NaCl is required to coagulate 200 mL of As2S3 solution in 2 hours. The coagulating value of NaCl is____ **(+4, -1)**

16. The standard electrode potential of M^{+}/M in aqueous solution does not depend on **(+4, -1)**

a. Sublimation of a solid metal

b. Ionisation of a gaseous metal atom

c. Ionisation of a solid metal atom

d. Hydration of a gaseous metal ion

17. Which of the following statements is incorrect? **(+4, -1)**

a. $KMnO_4$ and NaOH can be used as secondary standard

b. Primary standard should not undergo change in air

c. Reaction of primary standard with another substance should not be instantaneous

d. Primary standard should be soluble in H_2O

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18. One litre solution of 0.2 M glucose is separated with its pure solvent with semi-permeable membrane, 0.1 moles of NaCl is added to the solution. The change in osmotic pressure of solution will be at 300 K _____ . (take R = 0.083) **(+4, -1)**

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19. What weight of glucose must be dissolved in 100 g of water to lower the vapour pressure by 0.20 mm Hg? **(+4, -1)**
(Assume dilute solution is being formed)
Given : Vapour pressure of pure water is 54.2 mm Hg at room temperature. Molar mass of glucose is 180 g mol^{-1} .

a. 4.69 g

b. 2.59 g

c. 3.59 g

d. 3.69 g

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20. Given below are two statements. one is labelled as Assertion A and the other is labelled as Reason R. **(+4, -1)**
Assertion A : A solution of the product obtained by heating a mole of glycine with a mole of chlorine in presence of red phosphorous generates chiral carbon atom.
Reason R : A molecule with 2 chiral carbons is always optically active.
In the light of the above statements, choose the correct answer from the options given below:

a. A is true but R is false

b. Both A and R are true but R is NOT the correct explanation of A

c. Both A and R are true and R is the correct explanation of A

d. A is false but R is true

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21. The specific conductance of 0.0025 M acetic acid is $5 \times 10^{-5} S\ cm^{-1}$ at a certain temperature. The dissociation constant of acetic acid is ___________ $\times 10^{-7}$. (Nearest integer) Consider limiting molar conductivity of CH_3COOH as $400\ \ Scm^2 mol^{-1}$. **(+4, -1)**

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22. An aqueous solution of volume 300 cm^3 contains 0.63 g of protein. The osmotic pressure of the solution at 300 K is 1.29 mbar. The molar mass of the protein is ____ g mol^{-1}.
Given: R = 0.083 L bar K^{-1} mol^{-1} **(+4, -1)**

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23. Given below are two statements: one is labelled as Assertion A and the other is labelled as Reason R: **(+4, -1)**

Assertion A: 3.1500 g of hydrated oxalic acid dissolved in water to make 250.0 mL solution will result in 0.1 M oxalic acid solution.

Reason R: Molar mass of hydrated oxalic acid is 126 g mol^{-1}.

In the light of the above statements, choose the correct answer from the options given below.

a. A is false but R is true

b. Both A and R are true but R is NOT the correct explanation of A

c. Both A and R are true and R is the correct explanation of A

d. A is true but R is false

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24. Lime reacts exothermally with water to give 'A' which has low solubility in water. Aqueous solution of 'A' is often used for the test of CO2 , a test in which insoluble B is formed. If B is further reacted with CO2 then soluble compound is formed 'A' is **(+4, -1)**

a. Quick lime

b. Lime water

c. Slaked lime

d. White lime

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25. If the boiling points of two solvents X and Y (having same molecular weights) are in the ratio 2:1 and their enthalpy of vaporizations are in the ratio 1:2, then the boiling point elevation constant of X is m times the boiling point elevation constant of Y. The value of m is ______ (nearest integer). **(+4, -1)**

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26. Solid Lead nitrate is dissolved in 1 litre of water. The solution was found to boil at $100.15^{\circ}C$. When 0.2 mol of NaCl is added to the resulting solution, it was observed that the solution froze at $-0.8^{\circ}C$. The solubility product of $PbCl_2$ formed is ________ $\times 10^{-6}$ at 298 K. (Nearest integer) Given: $Kb = 0.5K\ \text{kg mol}^{-1}$ and $Kf = 1.8K\ \text{kg mol}^{-1}$.
Assume molality to be equal to molarity in all cases. **(+4, -1)**

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27. Which of the following salt solutions would coagulate the colloid solution formed when $FeCl_3$ is added to NaOH solution, at the fastest rate? **(+4, -1)**

a. 10 mL of 0.1 mol dm^{-3} $Ca3(PO_4)_2$

b. 10 mL of 0.2 mol dm^{-3} $AlCl_3$

c. 10 mL of 0.1 mol dm^{-3} Na_2SO_4

d. 10 mL of 0.15 mol dm^{-3} $CaCl_2$

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28. During the borax bead test with $CuSO_4$, a blue-green colour of the bead was observed in oxidizing flame due to the formation of **(+4, -1)**

a. CuO

b. $Cu(BO_2)_2$

c. Cu_3B_2

d. Cu

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29. The alkaline earth metal sulphate(s) which are readily soluble in water is/are: **(+4, -1)**
(a) $BeSO_4$
(b) $MgSO_4$
(c) $CaSO_4$
(d) $SrSO_4$
(e) $BaSO_4$
Choose the correct answer from the options given below:

a. Only a and b

b. Only a, b, c

c. Only d and e

d. Only a and e

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30. 1.80 g of solute A was dissolved in 62.5 cm^3 of ethanol and freezing point of the solution was found to be 155.1 K. The molar mass of solute A is ____ g mol^{-1}. (+4, -1)
[Given : Freezing point of ethanol is 156.0 K, Density of ethanol is 0.80 g cm^{-3}, Freezing point depression constant of ethanol is 2.00 K kg mol^{-1}]

Answers

1. Answer: 11 - 11

Explanation:

To find the molarity of orthophosphoric acid (H_3PO_4) given 70% purity by weight and specific gravity of $1.54\,\text{g cm}^{-3}$, follow these steps:

1. Determine the density of the acid:
Specific gravity is the ratio of the substance's density to that of water. Thus, density of H_3PO_4 is: $1.54 \times 1\,\text{g cm}^{-3} = 1.54\,\text{g cm}^{-3} = 1540\,\text{g L}^{-1}$ (since $1\,\text{cm}^3 = 1\,\text{mL}$ and $1000\,\text{mL} = 1\,\text{L}$).

2. Calculate mass of H_3PO_4 in 1 L solution:
Given 70% purity by weight, the mass of H_3PO_4 in the solution is $0.7 \times 1540\,\text{g} = 1078\,\text{g}$.

3. Convert mass to moles:
The number of moles of H_3PO_4 is given by $\frac{1078\,\text{g}}{98\,\text{g mol}^{-1}} = 11\,\text{mol}$.

4. Calculate molarity:
Molarity is moles of solute per liter of solution, which is simply $11\,\text{M}$ since we calculated 11 moles in 1 L.

Thus, the molarity of the solution is **11 M**.

Finally, we verify this value against the range of 11–11. The computed molarity is exactly 11 M, which fits perfectly within the specified range.

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2. Answer: 23 - 23

Explanation:

To find the mole fraction of methyl benzene in the vapor phase, we need to use Raoult's Law and Dalton's Law of Partial Pressures, given that it's an ideal solution with pure benzene and methyl benzene. Assume the mole fractions of benzene (X_{Benzene}) and methylbenzene ($X_{\text{Methylbenzene}}$) in the liquid phase are both 0.5, as the mixture is equimolar.

Step 1: Apply Raoult's Law.

Raoult's Law states that the partial pressure of a component in an ideal solution is the mole fraction of the component in the liquid phase multiplied by its vapor pressure as a pure liquid:

$$P_{\text{Benzene}} = X_{\text{Benzene}} \cdot P_{\text{Benzene}}^{\text{pure}}$$

$$P_{\text{Methylbenzene}} = X_{\text{Methylbenzene}} \cdot P_{\text{Methylbenzene}}^{\text{pure}}$$

Substitute the given values:

$$P_{\text{Benzene}} = 0.5 \times 80 = 40\,\text{Torr}$$

$$P_{\text{Methylbenzene}} = 0.5 \times 24 = 12\,\text{Torr}$$

Step 2: Apply Dalton's Law of Partial Pressures to find the total pressure.

The total vapor pressure P_{Total} is given by the sum of the partial pressures:

$$P_{\text{Total}} = P_{\text{Benzene}} + P_{\text{Methylbenzene}} = 40 + 12 = 52\,\text{Torr}$$

Step 3: Determine the mole fraction in the vapor phase.

The mole fraction of a component in the vapor phase (Y) is the ratio of its partial pressure to the total pressure:

$$Y_{\text{Methylbenzene}} = \frac{P_{\text{Methylbenzene}}}{P_{\text{Total}}} = \frac{12}{52}$$

Calculating this gives:

$$Y_{\text{Methylbenzene}} \approx 0.2308$$

To express this as $\times 10^{-2}$, multiply by 100:

$$Y_{\text{Methylbenzene}} \times 100 = 23.08$$

Rounding to the nearest integer, the solution is **23×10^{-2}**.

This value is within the specified range (23,23), confirming its correctness.

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3. **Answer: b**

Explanation:

The iodoform test is a chemical reaction used to identify the presence of methyl ketones (a ketone with a methyl group, $-COCH_3$) or specific alcohols that can be oxidized to methyl ketones. The reaction involves the compound being treated with aqueous potassium hydroxide (KOH) followed by potassium hypoiodite (KI/I_2 solution).

To determine which compound among the given options can give a positive iodoform test, we need to check for the presence of the $-COCH_3$ group or an alcohol that can be oxidized to it.

1. Examine each compound:

- ◦ **Compound 1:** Does not have the $-COCH_3$ group or an alcohol group that can be oxidized to give it.
- ◦ **Compound 2:** Contains a methyl ketone group ($-COCH_3$), which fits the criteria for the iodoform test.
- ◦ **Compound 3:** Does not have the $-COCH_3$ group and cannot be oxidized to form one.
- ◦ **Compound 4:** Also lacks the $-COCH_3$ group and cannot be easily oxidized to form one.

2. Thus, **Compound 2** is the only one that can give a positive iodoform test because it contains the necessary methyl ketone group.

Thus, the correct answer is **Compound 2**

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4. Answer: d

Explanation:

To identify the mixture that shows positive deviations from Raoult's Law, we first need to understand the concept of Raoult's Law and deviations from it:

- **Raoult's Law:** It states that the partial vapor pressure of a component in a mixture is directly proportional to its mole fraction in the solution and the vapor pressure of the pure component. It applies primarily to ideal solutions.
- **Positive Deviation:** A mixture shows positive deviation from Raoult's Law when the interactions between different molecules are weaker than interactions between like molecules. This causes the components to evaporate more easily, hence increasing the vapor pressure compared to what is predicted by Raoult's Law.

Now, let's analyze each given option for deviations:

1. $(CH_3)_2CO + C_6H_5NH_2$: In this mixture, acetone and aniline are involved. Aniline is capable of forming hydrogen bonds. Both interactions are different, and this can lead to deviation, but typically not positive as hydrogen bonding can strengthen interactions.
2. $CHCl_3 + C_6H_6$: Chloroform ($CHCl_3$) and benzene (C_6H_6) form a mixture that shows deviations, but these are generally negative deviation due to the induction of dipoles.
3. $CHCl_3 + (CH_3)_2CO$: Chloroform and acetone mixtures can show deviation; however, chloroform interacts strongly with acetone due to dipole-dipole interactions, often leading to negative deviation.
4. $(CH_3)_2CO + CS_2$: Acetone and carbon disulfide (CS_2) form mixtures where the interactions between unlike molecules (acetone and CS_2) are weaker than the interactions between like molecules. This causes a higher vapor pressure leading to a positive deviation from Raoult's Law.

Conclusion: Given the explanations for interactions and deviations, the correct answer is $(\mathrm{CH_3})_2\mathrm{CO} + \mathrm{CS_2}$. This mixture shows positive deviations from Raoult's Law due to weaker interactions between acetone and carbon disulfide than within the like pairs.

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5. **Answer: a**

Explanation:

To solve this problem, we need to interpret the chemical reactions based on the given information and identify the compounds involved.

1. We start by considering the reaction of NaCl with concentrated H_2SO_4 and $K_2Cr_2O_7$. The species formed in this reaction are known to produce chromyl chloride, which has the formula CrO_2Cl_2. This compound appears as reddish vapors. Thus, compound (B) from the question is CrO_2Cl_2.
2. Next, these reddish fumes of CrO_2Cl_2 react with NaOH. The reaction is as follows:

$$CrO_2Cl_2 + 4NaOH \rightarrow Na_2CrO_4 + 2NaCl + 2H_2O$$

1. Here, Na_2CrO_4 is the yellow solution formed. Hence, compound (C) is Na_2CrO_4.
2. We have now identified the solutions as (B) and (C), which are CrO_2Cl_2 and Na_2CrO_4 respectively.

Now, let's look at the answer choices:

- CrO_2Cl_2, Na_2CrO_4 - This matches our solution.
- Na_2CrO_4, CrO_2Cl_2 - This is incorrect as the sequence of products is reversed.
- $CrO_2Cl_2, KHSO_4$ - This is incorrect because $KHSO_4$ is not involved in the reaction with $NaOH$ to form the yellow solution.
- $CrO_2Cl_2, Na_2Cr_2O_7$ - This is incorrect as $Na_2Cr_2O_7$ is not formed in the reaction with NaOH.

Thus, the correct answer is CrO_2Cl_2, Na_2CrO_4.

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6. **Answer: d**

Explanation:

To understand the behavior of a solution of two miscible liquids showing negative deviation from Raoult's Law, let's explore the concepts involved:

Raoult's Law

According to Raoult's Law, the partial vapor pressure of each component in an ideal solution is directly proportional to its mole fraction. Mathematically, it is expressed as:

$$P_A = x_A \cdot P_A^0$$

Where:

- P_A is the partial vapor pressure of component A.
- x_A is the mole fraction of component A in the solution.
- P_A^0 is the vapor pressure of pure component A.

Negative Deviation

A negative deviation from Raoult's Law occurs when the interactions between different components of the solution are stronger than those in the pure liquids. This leads to a situation where:

- The vapor pressure of the solution is lower than expected from Raoult's Law.
- The solution shows exothermic mixing (release of heat).
- Stronger adhesive forces lead to decreased vapor escapement, thus reducing vapor pressure.

Boiling Point

The boiling point of a solution is the temperature at which its vapor pressure equals the external pressure. Since the vapor pressure is decreased, more heat is required to reach the boiling point compared to the pure solvents.

Conclusion

Thus, for a solution showing negative deviation from Raoult's Law:

- The vapor pressure is decreased.
- The boiling point is increased, as more heat is necessary to reach the vapor pressure of boiling.

Therefore, the correct answer is: **Decreased vapour pressure, increased boiling point**.

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7. **Answer: 815 - 815**

Explanation:

To determine the molality of a 0.8 M H_2SO_4 solution with density 1.06 g cm^{-3}, follow these steps:
1. **Understand the Definitions**: Molality (m) is the moles of solute per kilogram of solvent,

while molarity (M) is the moles of solute per liter of solution.
2. **Calculate the Mass of Solution**: Given the density, 1.06 g/cm^3, the mass of 1 L (1000 cm^3) of solution is:

$$1.06\ \mathrm{g/cm^3} \times 1000\ \mathrm{cm^3} = 1060\ \mathrm{g}.$$

3. **Find Moles of Solute**: The solution is 0.8 M, meaning 0.8 moles of H_2SO_4 in 1 L of solution.
4. **Calculate Mass of Solute**: The molar mass of H_2SO_4 is 98.08 g/mol, so the mass is:

$$0.8\ \mathrm{mol} \times 98.08\ \mathrm{g/mol} = 78.464\ \mathrm{g}.$$

5. **Find Mass of Solvent**: Subtract the mass of solute from the total mass of solution:

$$1060\ \mathrm{g} - 78.464\ \mathrm{g} = 981.536\ \mathrm{g}.$$

Convert this to kg:

$$981.536\ \mathrm{g} = 0.981536\ \mathrm{kg}.$$

6. **Calculate Molality**: Use the formula:

$$m = \frac{\text{moles of solute}}{\text{kilograms of solvent}} = \frac{0.8\ \mathrm{mol}}{0.981536\ \mathrm{kg}} = 0.8149\ \mathrm{m}.$$

7. **Express in Required Form**: The molality is expressed as:

$$0.8149 \times 10^3\ \mathrm{m} \quad \text{or} \quad 814.9 \times 10^{-3}\ \mathrm{m}.$$

8. **Verify Range**: The calculated molality (814.9) is within the given range 815,815.
Thus, the molality of the solution is approximately 815 $\times 10^{-3}\ \mathrm{m}$.

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8. Answer: 72.56 - 72.56

Explanation:

The osmotic pressure (π) is given by the formula:

$$\pi = CRT$$

Since concentration (C) and R are constants, we can use the ratio:

$$\frac{\pi_1}{\pi_2} = \frac{T_1}{T_2}$$

Rearranging to find π_2:

$$\pi_2 = \pi_1 \cdot \frac{T_2}{T_1} = 7 \times 10^5 \times \frac{283}{273}$$

Calculating π_2:

$$\pi_2 = 72.56 \times 10^4\,\text{Nm}^{-2}$$

Thus, the osmotic pressure at 283 K is approximately:

So, the correct answer is: 72.56 or 73

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9. **Answer: 4 - 4**

Explanation:

To find the molarity (M), use the formula:

$$M = \frac{n_{\text{solute}}}{V} \times 1000$$

Given that the solution is 31.4% H_2SO_4, with a density of 1.25 g/mL:

Step 1: Calculate the mass of H_2SO_4 in 100 g of solution:

Mass of $H_2SO_4 = 31.4\,\text{g}$

Step 2: Convert this to moles:

$$\frac{31.4}{98} = 0.32\,\text{mol}$$

Step 3: Find the volume of the solution:

$$\text{Volume} = \frac{\text{Mass of solution}}{\text{Density}} = \frac{100}{1.25} = 80\,\text{mL}$$

Step 4: Calculate molarity:

$$M = \frac{0.32\,\text{mol}}{80\,\text{mL}} \times 1000 = 4.005 \approx 4\,\text{M}$$

So, the correct answer is: 4M

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10. **Answer: 7 - 7**

Explanation:

The problem requires determining the volume of 3 M NaOH solution that can be prepared from 84 g of NaOH. We begin by finding the number of moles of NaOH from the given mass:

1. Determine the number of moles using the formula:
moles of NaOH = mass of NaOH / molar mass of NaOH.

Given:

- Mass of NaOH = 84 g
- Molar mass of NaOH = 40 g/mol

Calculate the moles:

- moles = 84 g / 40 g/mol = 2.1 mol

2. To find the volume of a 3 M solution, use the formula: *Molarity (M) = moles of solute / volume of solution in liters*.

Solve for volume:

- Volume (V) = *moles of NaOH / Molarity* = 2.1 mol / 3 mol/L = 0.7 L

Convert volume from liters to dm^3:

- 0.7 L = 0.7 dm^3

3. The requested format is $\_ \times 10^{-1}\,\mathrm{dm}^3$. Expressing 0.7 as 7×10^{-1} dm^3 ensures it conforms to this format.

Finally, verify if this value meets the range 7,7. Given that $7 \times 10^{-1} = 0.7$, it fits the specified range.

The volume of 3 M NaOH solution that can be prepared is **7×10^{-1} dm^3**.

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11. Answer: 458 - 458

Explanation:

1. Reaction between CH_3COOH and NaOH:

$$\mathrm{CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O}.$$

Initially:

$$\text{Moles of CH}_3\text{COOH} = 50\,\text{mL} \times 0.1\,\text{M} = 5\,\text{mmol}.$$

$$\text{Moles of NaOH} = 20\,\text{mL} \times 0.1\,\text{M} = 2\,\text{mmol}.$$

After reaction: - CH_3COOH remaining = $5 - 2 = 3\,\text{mmol}$. - CH_3COONa formed = $2\,\text{mmol}$. The resulting solution is a buffer solution containing CH_3COOH (acid) and CH_3COONa (salt). 2. Henderson-Hasselbalch equation:

$$\text{pH} = \text{p}K_a + \log_{10}\left(\frac{[\text{Salt}]}{[\text{Acid}]}\right).$$

Substitute the values:

$$\text{pH} = 4.76 + \log_{10}\left(\frac{2}{3}\right).$$

3. Simplify using logarithm values:

$$\log_{10}\left(\frac{2}{3}\right) = \log_{10}(2) - \log_{10}(3).$$

Given $\log 2 = 0.30$ and $\log 3 = 0.48$:

$$\log_{10}\left(\frac{2}{3}\right) = 0.30 - 0.48 = -0.18.$$

Substituting back:

$$\text{pH} = 4.76 - 0.18 = 4.58.$$

4. Convert to scientific notation:

$$\text{pH} = 4.58 \times 10^{-2}.$$

5. Final Answer:

$$\boxed{458 \times 10^{-2}}$$

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12. Answer: 48 - 48

Explanation:

<p>
Solution:

1. Calculate the van't Hoff factor (i):

   MgCl2 dissociates into Mg²⁺ and 2Cl⁻, so it dissociates into 3 ions.
   The dissociation reaction is: MgCl2 → Mg²⁺ + 2Cl⁻
   Degree of dissociation (α) = 80% = 0.8
   i = 1 + α(n - 1), where n is the number of ions produced.
   i = 1 + 0.8 (3 - 1) = 1 + 0.8 * 2 = 1 + 1.6 = 2.6

2. Calculate the effective molality:

   Effective molality = i * molality
   Effective molality = 2.6 * 1.0 molal = 2.6 molal

3. Calculate the mole fraction of the solute (x_solute):

For a dilute solution, mole fraction of solute ≈ (molality of solute * molar mass of water) / 1000
Molar mass of water (H2O) = 18 g/mol
x_solute = (2.6 * 18) / 1000 = 0.0468

4. Calculate the mole fraction of the solvent (x_solvent):

x_solvent = 1 - x_solute
x_solvent = 1 - 0.0468 = 0.9532

5. Calculate the vapour pressure of the solution (P_solution):

P_solution = x_solvent * P°_water, where P°_water is the vapour pressure of pure water.
P_solution = 0.9532 * 50 mm Hg = 47.66 mm Hg

6. Round to the nearest integer:

P_solution ≈ 48 mm Hg

Therefore, the vapour pressure of the 1.0 molal aqueous solution of MgCl2 at 38°C is approximately 48 mm Hg.
</p>

---

13. **Answer: 4 - 4**

Explanation:

Isotonic Solution Analysis

Isotonic solutions have the same osmotic pressure. Osmotic pressure is directly proportional to the concentration of solute particles. Therefore, isotonic solutions have the same concentration of solute particles. We need to determine the concentration of particles in each solution, considering dissociation of ionic compounds.

- **A.** NaCl dissociates into 2 ions (Na^+ and Cl^-). So, 1 M NaCl gives $1\ \mathrm{M} \times 2 = 2\ \mathrm{M}$ ions. Urea does not dissociate, so 2 M urea remains 2 M particles. These solutions are isotonic.
- **B.** $\mathrm{CaCl_2}$ dissociates into 3 ions (Ca^{2+} and $2\mathrm{Cl}^-$). So, 1 M $\mathrm{CaCl_2}$ gives $1\ \mathrm{M} \times 3 = 3\ \mathrm{M}$ ions. KCl dissociates into 2 ions (K^+ and Cl^-). So, 1.5 M KCl gives $1.5\ \mathrm{M} \times 2 = 3\ \mathrm{M}$ ions. These solutions are isotonic.
- **C.** $\mathrm{AlCl_3}$ dissociates into 4 ions (Al^{3+} and $3\mathrm{Cl}^-$). So, 1.5 M $\mathrm{AlCl_3}$ gives $1.5\ \mathrm{M} \times 4 = 6\ \mathrm{M}$ ions. $\mathrm{Na_2SO_4}$ dissociates into 3 ions ($2\mathrm{Na}^+$ and $\mathrm{SO_4^{2-}}$). So, 2 M $\mathrm{Na_2SO_4}$ gives $2\ \mathrm{M} \times 3 = 6\ \mathrm{M}$ ions. These solutions are isotonic.
- **D.** KCl dissociates into 2 ions (K^+ and Cl^-). So, 2.5 M KCl gives $2.5\ \mathrm{M} \times 2 = 5\ \mathrm{M}$ ions. $\mathrm{Al_2(SO_4)_3}$ dissociates into 5 ions ($2\mathrm{Al}^{3+}$ and $3\mathrm{SO_4^{2-}}$). So, 1 M $\mathrm{Al_2(SO_4)_3}$ gives $1\ \mathrm{M} \times 5 = 5\ \mathrm{M}$

ions. These solutions are isotonic.

Conclusion:

All four pairs are isotonic. Therefore, the number of isotonic pairs is **4**.

---

14. **Answer: 82 - 82**

Explanation:

The boiling point is defined as the temperature at which the vapor pressure equals 1 atm. From the graph, the solvent's boiling point corresponds to the temperature at which the vapor pressure reaches 1 atm, which is clearly 82°C.

---

15. **Answer: 50 - 50**

Explanation:

Coagulating Value Calculation

Definition: The coagulating value is defined as the amount of electrolyte (in millimoles) required to coagulate 1L of colloidal solution in 2 hours.

Calculation

1. **Moles of NaCl used:**

Moles = M × V = 0.5 × 20 mL = 10 mmol

1. **Coagulating Value:**

Coagulating Value = 10 200 × 1000 = 50

Final Answer

The coagulating value is **50**.

---

16. **Answer: c**

Explanation:

The standard electrode potential (E°) of a half-cell reaction is influenced by the following factors:

- **Hydration enthalpy:** Energy released when a metal ion (M^+) is hydrated in water.
- **Lattice enthalpy:** Energy required to break the ionic lattice of the solid metal salt, allowing the metal ions to dissolve in water.
- **Concentration of ions:** The activity of the ions in the solution also affects the potential, as described by the Nernst equation.

However, **ionisation of a solid metal atom** (the process of removing an electron from the solid metal) is not directly involved in determining the standard electrode potential. Instead, the process begins with the metal ion already present in solution (M^+) and does not depend on the ionisation energy of the metal in its solid state.

Conclusion:

The standard electrode potential does not depend on the ionisation of a solid metal atom. Therefore, the correct answer is (C).

---

17. **Answer: c**

Explanation:

The Correct answer is option is (C) : Reaction of primary standard with another substance should not be instantaneous

---

18. **Answer: 5 - 5**

Explanation:

The correct answer is 5.

---

19. **Answer: d**

Explanation:

Step 1: Formula for Relative Lowering of Vapor Pressure

For a dilute solution, the relative lowering of vapor pressure is given by:

$$\frac{P_0 - P_s}{P_0} = \frac{n}{N},$$

where:

- P_0: Vapor pressure of the pure solvent
- P_s: Vapor pressure of the solution
- n: Number of moles of solute
- N: Number of moles of solvent

Step 2: Substitute the Given Values

Given:

- $\frac{P_0 - P_s}{P_0} = \frac{0.2}{54.2}$
- $N = 100\,\text{moles}$

Substitute into the equation:

$$\frac{0.2}{54.2} = \frac{n}{100}.$$

Step 3: Solve for n

Rearranging and solving for n:

$$n = \frac{100 \times 0.2}{54.2} = \frac{20}{54.2} \approx 0.369\,\text{moles}.$$

Step 4: Calculate the Mass of the Solute (w)

The mass of the solute is given by:

$$w = n \times M,$$

where $M = 180\,\text{g/mol}$ is the molar mass of the solute. Substituting the values:

$$w = 0.369 \times 180 \approx 3.69\,\text{g}.$$

Final Answer:

The mass of the solute is $w = 3.69\,\text{g}$.

In vapor pressure calculations, ensure the solution is dilute and units for molar mass and pressure are consistent.

---

20. Answer: a

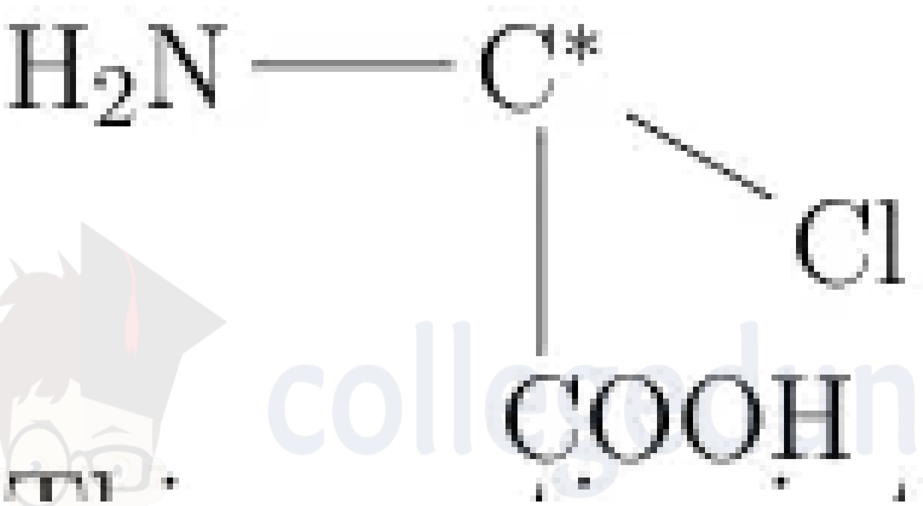
Explanation:

Assertion (A):

Glycine (NH_2CH_2COOH) reacts with chlorine (Cl_2) in the presence of red phosphorus to undergo alpha-halogenation. The reaction produces 2-chloroacetic acid ($NH_2CHClCOOH$) as the product:

$$NH_2CH_2COOH + Cl_2 \xrightarrow{\text{Red P}} NH_2CHClCOOH$$

In the product, 2-chloroacetic acid (α-chloroacetic acid), the carbon marked with an asterisk is a chiral carbon:



This assertion is true.

Reason (R):

The reason states that a molecule with two chiral carbons is always optically active. This is **false**, as a molecule with two chiral centers can be optically inactive if it has an internal plane of symmetry. Such molecules are called *meso compounds*.

Final Answer:

Assertion (A) is true, but Reason (R) is false.

---

21. **Answer: 66 - 66**

Explanation:

We are given:

$$k = 5 \times 10^{-5}\,\mathrm{S\,cm^{-1}}, \quad C = 0.0025\,\mathrm{M}, \quad \Lambda_m\,(\text{limiting molar conductivity}) = 400\,\mathrm{S\,cm^2 mol^{-1}}$$

Step 1: Calculate molar conductivity

$$\Lambda_\mathrm{m} = \frac{k \times 1000}{C}$$

Substitute the given values:

$$\Lambda_\mathrm{m} = \frac{5 \times 10^{-5} \times 1000}{0.0025} = \frac{5 \times 10^{-2}}{2.5 \times 10^{-3}} = 20\,\mathrm{S\ cm^2 mol^{-1}}$$

Step 2: Degree of dissociation

$$\alpha = \frac{20}{400} = \frac{1}{20}$$

Step 3: Calculate dissociation constant K_a

$$K_a = \frac{C\alpha^2}{1-\alpha}$$

Substitute the values:

$$K_a = \frac{0.0025 \times \left(\frac{1}{20}\right)^2}{1 - \frac{1}{20}} = \frac{0.0025 \times \frac{1}{400}}{\frac{19}{20}} = \frac{0.0025 \times 10^{-6}}{19/20} = 66 \times 10^{-7}$$

Thus, the dissociation constant K_a is 66×10^{-7}.

---

22. Answer: 40535 - 40535

Explanation:

Given: Volume (V) = 300 cm³ = 0.3 L Mass (m) = 0.63 g Osmotic pressure (π) = 1.29 mbar = 1.29×10^{-3} bar Temperature (T) = 300 K R = 0.083 L bar K^{-1} mol^{-1} Using the formula: $\pi = cRT$, where c is the molarity. Calculate molarity (c):

$$c = \frac{\pi}{RT} = \frac{1.29 \times 10^{-3}\ \mathrm{bar}}{0.083\ \mathrm{L\ bar\ K^{-1} mol^{-1}} \times 300\ \mathrm{K}}$$

$$c \approx 5.18 \times 10^{-5}\ \mathrm{mol/L}$$

Calculate moles (n):

$$n = c \times V = 5.18 \times 10^{-5}\ \mathrm{mol/L} \times 0.3\ \mathrm{L}$$

$$n \approx 1.554 \times 10^{-5}\ \mathrm{mol}$$

Calculate molar mass (M):

$$M = \frac{m}{n} = \frac{0.63\ \mathrm{g}}{1.554 \times 10^{-5}\ \mathrm{mol}}$$

$$M \approx 40540 \text{ g/mol}$$

The molar mass of the protein is approximately 40540 g/mol.

---

23. Answer: c

Explanation:

Step 1: Verifying the Assertion A
Given mass of hydrated oxalic acid = 3.1500 g
Molar mass of hydrated oxalic acid = 126 g/mol
Volume of solution = 250.0 mL = 0.250 L
To calculate molarity (M), we use the formula:

$$M = \frac{\text{moles of solute}}{\text{volume of solution in liters}}$$

Moles of solute:

$$\text{moles} = \frac{3.1500\,\text{g}}{126\,\text{g/mol}} = 0.0250\,\text{mol}$$

Thus, molarity:

$$M = \frac{0.0250\,\text{mol}}{0.250\,\text{L}} = 0.1\,\text{M}$$

So, Assertion A is correct.
Step 2: Verifying the Reason R
The molar mass of hydrated oxalic acid is indeed 126 g/mol, as given in the question. This confirms that Reason R is correct.
Thus, both Assertion A and Reason R are true, and Reason R explains Assertion A.

---

24. Answer: c

Explanation:

Step 1: Reaction of CaO with Water (Forming 'A')

The reaction of calcium oxide (CaO) with water forms calcium hydroxide ('A'):

$$\text{CaO}(s) + \text{H}_2\text{O}(l) \rightarrow \text{Ca(OH)}_2(aq)$$

The product, calcium hydroxide, is known as slaked lime, and its aqueous solution is called lime water.

Step 2: Reaction of 'A' with CO_2 (Forming 'B')

The reaction of calcium hydroxide with carbon dioxide forms calcium carbonate ('B'):

$$Ca(OH)_2(aq) + CO_2(g) \rightarrow CaCO_3(s) + H_2O(l)$$

The product, calcium carbonate, is insoluble in water.

Step 3: Reaction of 'B' with More CO_2

When calcium carbonate reacts with more water and carbon dioxide, it forms calcium hydrogencarbonate, which is soluble in water:

$$CaCO_3(s) + H_2O(l) + CO_2(g) \rightarrow Ca(HCO_3)_2(aq)$$

Final Answer:

The substance 'A' is calcium hydroxide (slaked lime).

---

25. **Answer: 8 - 8**

Explanation:

The boiling point elevation constant is given by:

$$K_b = \frac{RT_b^2 M}{1000 \Delta H_{\text{vap}}}$$

Where:

- R: Universal gas constant
- T_b: Boiling point
- M: Molecular weight
- ΔH_{vap}: Enthalpy of vaporization

Step 1: Ratio of Boiling Point Elevation Constants

For solvents X and Y, taking the ratio of their boiling point elevation constants:

$$\frac{(K_b)_X}{(K_b)_Y} = \frac{\left(\frac{RT_b^2 M}{\Delta H_{\text{vap}}}\right)_X}{\left(\frac{RT_b^2 M}{\Delta H_{\text{vap}}}\right)_Y}$$

Step 2: Simplify

The equation simplifies to:

$\frac{(K_b)_X}{(K_b)_Y} = \frac{(T_b^2)_X}{(T_b^2)_Y} \times \frac{(\Delta H_{vap})_Y}{(\Delta H_{vap})_X}$

Step 3: Substitute Given Ratios

- $\frac{(T_b)_X}{(T_b)_Y} = 2$
- $\frac{(\Delta H_{vap})_X}{(\Delta H_{vap})_Y} = \frac{1}{2}$

Substituting these values:

$\frac{(K_b)_X}{(K_b)_Y} = \frac{2^2}{1^2} \times \frac{2}{1}$

Step 4: Calculate

$\frac{(K_b)_X}{(K_b)_Y} = \frac{4}{1} \times \frac{2}{1} = \frac{8}{1}$

Conclusion:

The ratio of boiling point elevation constants, m, is **8.**

---

26. **Answer: 13 - 13**

Explanation:

Step 1: Determine the molality from boiling point elevation:
The boiling point elevation ΔT_b is given by:

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

where m is the molality of the solution. Substituting the values:

$$0.15 = 0.5 \times m \quad \Longrightarrow \quad m = \frac{0.15}{0.5} = 0.3 \text{ mol/kg}.$$

Step 2: Total molality after adding NaCl:
NaCl dissociates into two ions (Na^+ and Cl^-). When 0.2 mol of NaCl is added to the solution, the molality increases by $0.2 \times 2 = 0.4$ mol/kg
Total molality after adding NaCl is:

$$m_{\text{total}} = 0.3 + 0.4 = 0.7 \text{ mol/kg}.$$

Step 3: Freezing point depression:
The freezing point depression ΔT_f is given by:

$$\Delta T_f = K_f \times m_{\text{total}}.$$

Substituting the given freezing point depression and K_f:

$$0.8 = 1.8 \times m_{\text{total}} \implies m_{\text{total}} = \frac{0.8}{1.8} = 0.444 \text{ mol/kg}.$$

Step 4: Solubility product of $PbCl_2$:
Lead chloride ($PbCl_2$) dissociates as:

$$\text{PbCl}_2 \leftrightharpoons \text{Pb}^{2+} + 2\text{Cl}^-.$$

Let s be the molarity of $PbCl_2$ in solution. The concentrations of the ions at equilibrium are:

$$[\text{Pb}^{2+}] = s, \quad [\text{Cl}^-] = 2s.$$

The solubility product K_{sp} is:

$$K_{sp} = [\text{Pb}^{2+}] \times [\text{Cl}^-]^2 = s \times (2s)^2 = 4s^3.$$

From freezing point depression, the effective molality of ions is 0.444 mol/kg. Using the relation for ionic dissociation:

$$m_{\text{total}} = s + 2s = 3s \implies s = \frac{0.444}{3} = 0.148 \text{ mol/L}.$$

Step 5: Calculate K_{sp}:
Substituting $s = 0.148$ into the expression for K_{sp}:

$$K_{sp} = 4 \times (0.148)^3 = 4 \times 0.00323 = 0.01292 \quad \text{or} \quad 13 \times 10^{-6}.$$

Final Answer: 13.

---

27. **Answer: b**

Explanation:

- The colloidal solution formed when $FeCl_3$ is added to NaOH is negatively charged.
- The coagulation of colloidal solutions is governed by the Schulze-Hardy rule: \textbf{the higher the valence of the oppositely charged ion, the greater its coagulating power.
Analysis:

Among the given options:
$AlCl_3$ contains Al^{3+} ions, which have the highest coagulating power compared to other cations such as Ca^{2+} or Na^+.
Therefore, the solution containing Al^{3+} ions ($AlCl_3$) will coagulate the colloidal solution at the fastest rate.
Final Answer: (1) 10 mL of 0.2 mol dm^{-3} $AlCl_3$.

---

28. Answer: b

Explanation:

Borax Bead Test:
1. Definition: The borax bead test is a qualitative test used to identify metal ions based on the colour imparted to the bead in the oxidizing or reducing flame.
In this test, borax ($Na_2B_4O_7 \cdot 10H_2O$) decomposes to form sodium metaborate ($NaBO_2$) and boric anhydride (B_2O_3) when heated:

$$Na_2B_4O_7 \xrightarrow{\Delta} 2NaBO_2 + B_2O_3.$$

2. Reaction with $CuSO_4$: Copper ions react with boric anhydride (B_2O_3) to form copper metaborate ($Cu(BO_2)_2$) in the oxidizing flame:

$$CuSO_4 + B_2O_3 \rightarrow Cu(BO_2)_2 + SO_3.$$

3.Observation: $Cu(BO_2)_2$ is responsible for the blue-green colour observed in the oxidizing flame.
Final Answer: (3) $\mathbf{Cu(BO_2)_2}$.

---

29. Answer: a

Explanation:

Step 1: Understand the Solubility Trends of Alkaline Earth Metal Sulphates
The solubility of alkaline earth metal sulphates decreases down the group due to the decrease in hydration energy. Hydration energy is the energy released when ions interact with water molecules. Higher hydration energy leads to better solubility.
Step 2: Analyze $BeSO_4$ and $MgSO_4$
-$BeSO_4$: Due to its small size and high charge density, the Be^{2+} ion exhibits very high hydration energy. This makes $BeSO_4$ highly soluble in water.

-$MgSO_4$: The Mg^{2+} ion also has high hydration energy, leading to good solubility of $MgSO_4$ in water.
Step 3: Analyze the Remaining Sulphates
$CaSO_4$, $SrSO_4$, and $BaSO_4$: As we move down the group, the size of the cations increases, reducing the charge density and hydration energy. This results in lower solubility. Hence, these sulphates are sparingly soluble or insoluble in water.
Conclusion:
From the analysis, $BeSO_4$ and $MgSO_4$ are the only sulphates that are readily soluble in water. Therefore, the correct answer is (3) A and B.

---

30. **Answer: 80 - 80**

Explanation:

To find the molar mass of solute A, we will use the formula for freezing point depression: $\Delta T_f = iK_f m$, where ΔT_f is the change in freezing point, K_f is the freezing point depression constant, and m is the molality of the solution. Since solute A is non-electrolyte, i=1.
1. Calculate ΔT_f: ΔT_f = 156.0 K - 155.1 K = 0.9 K.
2. Determine the mass of ethanol in kg: Volume = 62.5 cm^3, Density = 0.80 g/cm^3.
Mass = Density × Volume = 0.80 g/cm^3 × 62.5 cm^3 = 50 g = 0.050 kg.
3. Calculate molality (m): m = $n_{solute}/mass_{solvent}$ (kg). We rearrange $\Delta T_f = K_f$ m to find m = $\Delta T_f/K_f$ = 0.9 K / 2.00 K kg mol^{-1} = 0.45 mol/kg.
4. Express molality as n_{solute}/0.050 kg = 0.45 mol/kg, yielding n_{solute} = 0.0225 mol.
5. Calculate molar mass (M) of solute A: M = $mass_{solute}/n_{solute}$ = 1.80 g / 0.0225 mol = 80 g/mol.
6. Verification: The calculated molar mass (80 g/mol) lies within the given range (80, 80). Thus, the molar mass of solute A is confirmed to be 80 g/mol.

Concepts:

1. Solutions:

A solution is a homogeneous mixture of two or more components in which the particle size is smaller than 1 nm.

For example, salt and sugar is a good illustration of a solution. A solution can be categorized into several components.

Types of Solutions:

The solutions can be classified into three types:

- **Solid Solutions -** In these solutions, the **solvent** is in a Solid-state.
- **Liquid Solutions-** In these solutions, the solvent is in a Liquid state.
- **Gaseous Solutions -** In these solutions, the solvent is in a Gaseous state.

On the basis of the amount of solute dissolved in a solvent, solutions are divided into the following types:

1. **Unsaturated Solution-** A solution in which more solute can be dissolved without raising the temperature of the solution is known as an unsaturated solution.
2. **Saturated Solution-** A solution in which no solute can be dissolved after reaching a certain amount of temperature is known as an unsaturated saturated solution.
3. **Supersaturated Solution-** A solution that contains more solute than the maximum amount at a certain temperature is known as a supersaturated solution.