CUET UG Chemistry Sample Paper - 6

Duration: 1 Hour **Maximum Marks: 250**

Instructions

- This paper contains a total of 50 Multiple Choice Questions.
- Each correct answer carries **+5 marks**.
- Each incorrect answer carries **-1 mark**.
- No negative marking for unattempted questions.

Q1. At 298 K, the vapor pressure of pure benzene is 100 mm Hg and that of pure toluene is 50 mm Hg. For an ideal solution containing equal moles of both, the mole fraction of benzene in the vapor phase is:

(A) 0.50
(B) 0.67
(C) 0.33
(D) 0.75

Q2. Which of the following 0.1 M aqueous solutions will exhibit the maximum elevation in boiling point?

(A) Urea
(B) NaCl
(C) $MgCl_2$
(D) $FeCl_3$

Q3. The Van't Hoff factor (i) for a dilute aqueous solution of the strong electrolyte $Ba(OH)_2$ is:

(A) 0
(B) 1

(C) 2

(D) 3

Q4. An aqueous solution of non-volatile solute freezes at $-0.186°\text{C}$. If $K_f = 1.86$ K kg mol^{-1} and $K_b = 0.512$ K kg mol^{-1}, the elevation in boiling point is:

(A) 0.186 K

(B) 0.512 K

(C) 0.0512 K

(D) 0.0186 K

Q5. According to Raoult's law, the relative lowering of vapor pressure for a solution containing a non-volatile solute is equal to:

(A) Mole fraction of the solvent

(B) Mole fraction of the solute

(C) Molality of the solution

(D) Molarity of the solution

Q6. For the cell reaction $\text{Zn(s)} + \text{Cu}^{2+}\text{(aq)} \rightarrow \text{Zn}^{2+}\text{(aq)} + \text{Cu(s)}$, the Nernst equation at 298 K is represented as $E_{\text{cell}} = E^\circ_{\text{cell}} - \frac{0.059}{n} \log Q$. The value of n is:

(A) 1

(B) 2

(C) 3

(D) 4

Q7. The molar conductivity of a 0.05 M BaCl_2 solution is 230 S cm^2 mol^{-1} at 25°C. Its conductivity (κ) is:

(A) 0.0115 S cm^{-1}

(B) 0.115 S cm^{-1}

(C) 1.15 S cm^{-1}

(D) 2.30 S cm^{-1}

Q8. Kohlrausch's law states that at infinite dilution, each ion makes a definite contribution to:

(A) Ionic mobility
(B) Equivalent conductance
(C) Molar conductivity
(D) Degree of dissociation

Q9. How much electricity in Faradays is required to produce 20 g of calcium from molten $CaCl_2$ (At. mass of Ca = 40)?

(A) 1 F
(B) 2 F
(C) 0.5 F
(D) 4 F

Q10. In a Hydrogen-Oxygen fuel cell, the reaction occurring at the cathode is:

(A) $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$
(B) $2H_2 + 4OH^- \rightarrow 4H_2O + 4e^-$
(C) $H_2 + O_2 \rightarrow H_2O_2$
(D) $H^+ + e^- \rightarrow \frac{1}{2}H_2$

Q11. The standard reduction potential for three metals A, B, and C are +0.5 V, −2.0 V, and −1.2 V respectively. The reducing power of these metals follows the order:

(A) $B > C > A$
(B) $A > C > B$
(C) $C > B > A$

(D) $A > B > C$

Q12. For a first-order reaction, the time required for 99.9% completion is approximately how many times the half-life ($t_{1/2}$)?

(A) 2 times

(B) 5 times

(C) 10 times

(D) 100 times

Q13. The rate constant of a reaction is $k = 3.4 \times 10^{-4}$ mol^{-1} L s^{-1}. The order of the reaction is:

(A) Zero

(B) First

(C) Second

(D) Third

Q14. The activation energy of a reaction can be determined from the slope of which graph?

(A) k vs T

(B) $\ln k$ vs T

(C) $\ln k$ vs $1/T$

(D) T vs $1/k$

Q15. If the initial concentration of the reactant is doubled for a zero-order reaction, the half-life ($t_{1/2}$):

(A) Is doubled

(B) Is halved

(C) Remains same

(D) Becomes triple

Q16. In the Arrhenius equation $k = Ae^{-E_a/RT}$, A represents:

(A) Activation energy

(B) Rate constant at infinite temperature

(C) Equilibrium constant

(D) Enthalpy of reaction

Q17. Lanthanoid contraction is caused due to:

(A) Perfect shielding of $4f$ electrons

(B) Imperfect shielding of $4f$ electrons

(C) Increase in nuclear charge

(D) Both B and C

Q18. Which of the following transition metal ions is colorless in aqueous solution?

(A) Ti^{4+}

(B) V^{3+}

(C) Cr^{3+}

(D) Mn^{2+}

Q19. The magnetic moment of Mn^{2+} (At. no. 25) is:

(A) 5.92 BM

(B) 4.90 BM

(C) 3.87 BM

(D) 1.73 BM

Q20. When $KMnO_4$ reacts with KI in acidic medium, the product formed is:

(A) I_2

(B) IO_3^-

(C) I^-

(D) KIO_4

Q21. The IUPAC name of $[Pt(NH_3)_2Cl(NO_2)]$ is:

(A) Diamminechloridonitrito-N-platinum(II)

(B) Diamminechloridonitrito-N-platinum(IV)

(C) Diamminechloronitroplatinum(II)

(D) Platinumdiamminechloronitrite

Q22. How many geometrical isomers are possible for the complex $[Pt(NH_3)_2Cl_2]$?

(A) 1

(B) 2

(C) 3

(D) 4

Q23. According to Crystal Field Theory, the arrangement of ligands in increasing order of crystal field splitting (Δ_o) is called:

(A) Electrochemical series

(B) Spectrochemical series

(C) Isomeric series

(D) Periodic series

Q24. The hybridization of central metal in $[\mathrm{Fe(CN)_6}]^{3-}$ is:

(A) sp^3d^2

(B) d^2sp^3

(C) dsp^2

(D) sp^3

Q25. Which of the following is an outer orbital complex?

(A) $[\mathrm{Co(NH_3)_6}]^{3+}$

(B) $[\mathrm{Mn(CN)_6}]^{3-}$

(C) $[\mathrm{CoF_6}]^{3-}$

(D) $[\mathrm{Fe(CN)_6}]^{4-}$

Q26. The color of $[\mathrm{Ti(H_2O)_6}]^{3+}$ is due to:

(A) $d-d$ transition

(B) Charge transfer

(C) $p-d$ transition

(D) Presence of water

Q27. Which of the following will undergo S_N1 reaction most rapidly?

(A) $\mathrm{CH_3Cl}$

(B) $\mathrm{(CH_3)_2CHCl}$

(C) $\mathrm{(CH_3)_3CCl}$

(D) $\mathrm{CH_3CH_2Cl}$

Q28. The reaction $R - X + 2\text{Na} + X - R \xrightarrow{\text{dry ether}} R - R + 2\text{NaX}$ is known as:

(A) Finkelstein reaction

(B) Wurtz reaction

(C) Swarts reaction

(D) Friedel-Crafts reaction

Q29. Racemization occurs in which type of mechanism?

(A) S_N1

(B) S_N2

(C) $E1$

(D) $E2$

Q30. Identify the product in Finkelstein reaction: $CH_3Br + NaI \xrightarrow{\text{Acetone}} ?$

(A) CH_3I

(B) CH_3F

(C) CH_3Na

(D) CH_3CH_3

Q31. The osmotic pressure of a solution containing 4.0 g of a polymer in 1 L of solution at 27°C is 3.0×10^{-4} atm. The molar mass of the polymer is ($R = 0.082$ L atm K^{-1} mol^{-1}):

(A) 3.28×10^5 g/mol

(B) 1.15×10^4 g/mol

(C) 2.49×10^5 g/mol

(D) 4.12×10^5 g/mol

Q32. Which of the following liquid pairs shows a negative deviation from Raoult's law?

(A) Ethanol and Acetone

(B) Benzene and Toluene

(C) Phenol and Aniline

(D) Chloroform and Ethanol

Q33. The limiting molar conductivities for NaCl, KBr, and KCl are 126, 152, and 150 S cm^2 mol^{-1} respectively. The Λ_m° for NaBr is:

(A) 128 S cm^2 mol^{-1}

(B) 176 S cm^2 mol^{-1}

(C) 278 S cm^2 mol^{-1}

(D) 302 S cm^2 mol^{-1}

Q34. While charging a lead storage battery:

(A) $PbSO_4$ on cathode is reduced to Pb

(B) $PbSO_4$ on anode is oxidized to PbO_2

(C) Specific gravity of H_2SO_4 increases

(D) All of the above

Q35. The cell constant of a conductivity cell:

(A) Changes with the concentration of electrolyte

(B) Changes with the nature of electrolyte

(C) Remains constant for a given cell

(D) Changes with temperature

Q36. For a reaction $A + B \longrightarrow C$, doubling the concentration of A quadruples the rate, but doubling B has no effect. The rate law is:

(A) Rate $= k[A][B]$

(B) Rate $= k[A]^2$

(C) Rate $= k[A]^2[B]$

(D) Rate $= k[A][B]^2$

Q37. The decomposition of phosphine (PH_3) on tungsten at low pressure is a first-order reaction because:

(A) Rate is proportional to surface coverage

(B) Rate is inversely proportional to surface coverage

(C) Rate is independent of surface coverage

(D) It is an elementary reaction

Q38. If the rate constant k of a reaction is $1.6 \times 10^{-3}\ \text{s}^{-1}$, the time required for 5 g of the reactant to reduce to 1.25 g is:

(A) 433 s

(B) 866 s

(C) 1249 s

(D) 216 s

Q39. The correct order of ionic radii of Y^{3+}, La^{3+}, Eu^{3+}, and Lu^{3+} is:

(A) $Y^{3+} < Lu^{3+} < Eu^{3+} < La^{3+}$

(B) $La^{3+} < Eu^{3+} < Lu^{3+} < Y^{3+}$

(C) $Lu^{3+} < Eu^{3+} < La^{3+} < Y^{3+}$

(D) $Y^{3+} < La^{3+} < Eu^{3+} < Lu^{3+}$

Q40. $K_2Cr_2O_7$ is preferred over $Na_2Cr_2O_7$ in volumetric analysis (titrations) because:

(A) $K_2Cr_2O_7$ is more soluble in water

(B) $Na_2Cr_2O_7$ is hygroscopic

(C) $K_2Cr_2O_7$ is a stronger oxidizing agent

(D) $Na_2Cr_2O_7$ is poisonous

Q41. Interstitial compounds are formed when small atoms like H, C, or N are trapped inside the crystal lattice of metals. Which is NOT a property of these compounds?

(A) They have high melting points

(B) They are very hard

(C) They retain metallic conductivity

(D) They are chemically very reactive

Q42. Which of the following complexes is expected to absorb visible light?

(A) $[Sc(H_2O)_6]^{3+}$

(B) $[Ti(en)_2(NH_3)_2]^{4+}$

(C) $[Cr(NH_3)_6]^{3+}$

(D) $[Zn(NH_3)_6]^{2+}$

Q43. The spin-only magnetic moment of $[CoF_6]^{3-}$ is 4.90 BM. This indicates that the complex is:

(A) High spin, sp^3d^2

(B) Low spin, d^2sp^3

(C) Low spin, sp^3d^2

(D) High spin, d^2sp^3

Q44. The number of ions given by $[Pt(NH_3)_4Cl_2]Cl_2$ in aqueous solution is:

(A) 2

(B) 3

(C) 4

(D) 5

Q45. Facial and Meridional (fac-mer) isomerism is associated with which general formula?

(A) $[MA_3B_3]$

(B) $[MA_4B_2]$

(C) $[M(AA)_3]$

(D) $[MA_2B_4]$

Q46. In the S_N2 reaction of (S) – 2-bromooctane with OH^-, the product formed is:

(A) (R) $- octan - 2 - ol$

(B) (S) $- octan - 2 - ol$

(C) Racemic mixture of octan-2-ol

(D) 2-octene

Q47. Chlorobenzene is extremely less reactive towards nucleophilic substitution compared to haloalkanes due to:

(A) Resonance effect

(B) Difference in hybridization of carbon (sp^2 vs sp^3)

(C) Instability of phenyl cation

(D) All of the above

Q48. Which of the following will have the highest boiling point?

(A) CH_3Cl

(B) CH_2Cl_2

(C) $CHCl_3$

(D) CCl_4

Q49. The reaction of $CH_3CH_2CH_2Br$ with alcoholic KOH gives:

(A) Propene

(B) Propan-1-ol

(C) Propan-2-ol

(D) Propane

Q50. Which reagent is used for the conversion of an alkyl halide into an alkyl isocyanide ($R-\mathrm{NC}$)?

(A) KCN

(B) AgCN

(C) HCN

(D) NH_4CN

Detailed Solutions

Q1.

Solution

Concept: For an ideal solution, the partial vapor pressure of a component is given by Raoult's Law:

$$P_i = P_i^\circ \cdot x_i$$

The mole fraction of a component in the vapor phase (y_i) is given by Dalton's Law:

$$y_i = \frac{P_i}{P_{total}} = \frac{P_i^\circ x_i}{P_A^\circ x_A + P_B^\circ x_B}$$

Solution: Given that the solution contains equal moles of benzene (B) and toluene (T):

$$x_B = 0.5, \quad x_T = 0.5$$

Pure vapor pressures at 298 K:

$$P_B^\circ = 100 \text{ mm Hg}, \quad P_T^\circ = 50 \text{ mm Hg}$$

Step 1: Calculate partial vapor pressures:

$$P_B = P_B^\circ \cdot x_B = 100 \times 0.5 = 50 \text{ mm Hg}$$

$$P_T = P_T^\circ \cdot x_T = 50 \times 0.5 = 25 \text{ mm Hg}$$

Step 2: Calculate total vapor pressure:

$$P_{total} = P_B + P_T = 50 + 25 = 75 \text{ mm Hg}$$

Step 3: Calculate mole fraction of benzene in vapor phase (y_B):

$$y_B = \frac{P_B}{P_{total}} = \frac{50}{75} = \frac{2}{3} \approx 0.67$$

Answer: (B)

Q2.

Solution

Concept: Elevation in boiling point (ΔT_b) is a colligative property given by:

$$\Delta T_b = i \cdot K_b \cdot m$$

Since concentration (m) and K_b are constant for all given solutions, the elevation in boiling point depends solely on the van't Hoff factor (i):

$$\Delta T_b \propto i$$

where i represents the number of particles (ions/molecules) produced after dissociation.
Solution: Analyzing the dissociation of each 0.1 M solution:

- **Urea:** Non-electrolyte, does not dissociate. $i = 1$
- **NaCl:** Dissociates as $Na^+ + Cl^-$. $i = 2$
- **MgCl**2: Dissociates as $Mg^{2+} + 2Cl^-$. $i = 3$
- **FeCl**3: Dissociates as $Fe^{3+} + 3Cl^-$. $i = 4$

Since $FeCl_3$ has the highest van't Hoff factor ($i = 4$), it will produce the maximum number of solute particles and thus exhibit the maximum elevation in boiling point.

Answer: (D)

Q3.

Solution

Concept: The van't Hoff factor (i) is the ratio of the actual concentration of particles produced when the substance is dissolved to the concentration of the substance as calculated from its mass. For a strong electrolyte, it is equal to the total number of ions produced per formula unit upon complete dissociation.

Solution: Barium hydroxide, $Ba(OH)_2$, is a strong electrolyte. In a dilute aqueous solution, it undergoes complete dissociation according to the following chemical equation:

$$\mathrm{Ba(OH)_2(aq)} \longrightarrow \mathrm{Ba^{2+}(aq)} + \mathrm{2OH^-(aq)}$$

Counting the total number of ions produced:

- 1 Barium ion (Ba^{2+})
- 2 Hydroxide ions (OH^-)

Total number of ions (n) = $1 + 2 = 3$.For strong electrolytes with complete dissociation ($\alpha = 1$):

$$i = n = 3$$

Answer: (D)

Q4.

Solution

Concept: For a solution containing a non-volatile solute, the depression in freezing point (ΔT_f) and elevation in boiling point (ΔT_b) are given by:

$$\Delta T_f = i \cdot K_f \cdot m \quad \text{and} \quad \Delta T_b = i \cdot K_b \cdot m$$

Dividing the two equations:

$$\frac{\Delta T_b}{\Delta T_f} = \frac{K_b}{K_f} \Rightarrow \Delta T_b = \Delta T_f \cdot \frac{K_b}{K_f}$$

Solution: Given:Freezing point of solution = −0.186°CFreezing point of pure water = 0°C

$$\Delta T_f = 0 - (-0.186) = 0.186 \text{ K}$$

$K_f = 1.86$ K kg mol^{-1}$K_b = 0.512$ K kg mol^{-1}Substitute the values:

$$\Delta T_b = 0.186 \times \frac{0.512}{1.86}$$

$$\Delta T_b = \frac{0.186}{1.86} \times 0.512 = 0.1 \times 0.512$$

$$\Delta T_b = 0.0512 \text{ K}$$

Answer: (C)

Q5.

Solution

Concept: Raoult's Law for a solution containing a non-volatile solute states that the vapor pressure of the solution is directly proportional to the mole fraction of the solvent. Mathematically, the relative lowering of vapor pressure (RLVP) is defined as:

$$\frac{P^\circ - P_s}{P^\circ} = \chi_{\text{solute}}$$

where P° is the vapor pressure of the pure solvent and P_s is the vapor pressure of the solution. **Solution:** The expression $\frac{P^\circ - P_s}{P^\circ}$ represents the relative lowering of vapor pressure. According to the formula derived from Raoult's Law:

$$\text{RLVP} = \chi_{\text{solute}}$$

This indicates that the relative lowering of vapor pressure is exactly equal to the mole fraction of the solute present in the solution.

Answer: (B)

Q6.

Solution

Concept: In the Nernst equation, n represents the number of moles of electrons transferred in the balanced chemical reaction. This is determined by looking at the oxidation and reduction half-reactions.
Solution: The given cell reaction is:

$$\mathrm{Zn(s)} + \mathrm{Cu^{2+}(aq)} \longrightarrow \mathrm{Zn^{2+}(aq)} + \mathrm{Cu(s)}$$

Breaking it into half-reactions: Oxidation: $\mathrm{Zn(s)} \rightarrow \mathrm{Zn^{2+}(aq)} + 2e^-$ Reduction: $\mathrm{Cu^{2+}(aq)} + 2e^- \rightarrow \mathrm{Cu(s)}$In both half-reactions, 2 electrons are involved. Therefore, the total number of electrons transferred in the balanced equation is $n = 2$.

Answer: (B)

Q7.

Solution

Concept: Molar conductivity (Λ_m) is related to conductivity (κ) and molarity (M) by the formula:

$$\Lambda_m = \frac{\kappa \times 1000}{M}$$

where Λ_m is in S cm^2 mol^{-1} and κ is in S cm^{-1}.
Solution: Given:$\Lambda_m = 230$ S cm^2 mol^{-1}$M = 0.05$ MRearranging the formula to find κ:

$$\kappa = \frac{\Lambda_m \times M}{1000}$$

$$\kappa = \frac{230 \times 0.05}{1000} = \frac{11.5}{1000}$$

$$\kappa = 0.0115 \text{ S cm}^{-1}$$

Answer: (A)

Q8.

Solution

Concept: Kohlrausch's law of independent migration of ions states that at infinite dilution, where dissociation is complete and inter-ionic effects are negligible, each ion migrates independently of its co-ion.

Solution: The law specifically states that the limiting molar conductivity of an electrolyte can be represented as the sum of the individual contributions of the anion and cation.

$$\Lambda_m^\circ = \nu_+\lambda_+^\circ + \nu_-\lambda_-^\circ$$

Thus, each ion makes a definite contribution to the total molar conductivity of the electrolyte.

Answer: (C)

Q9.

Solution

Concept: According to Faraday's Law, the charge required to deposit one mole of a substance is given by $Q = nF$, where n is the number of electrons involved in the reduction and F is Faraday's constant (1 F is the charge of 1 mole of electrons).

Solution: The reduction of Calcium ions from molten $CaCl_2$ is:

$$Ca^{2+} + 2e^- \longrightarrow Ca(s)$$

From the equation, 1 mole of Ca requires 2 F. Molar mass of Ca = 40 g/mol. So, 40 g of Ca requires 2 F of electricity.For 20 g of Ca:

$$\text{Electricity required} = \frac{2\text{ F}}{40\text{ g}} \times 20\text{ g} = 1\text{ F}$$

Answer: (A)

Q10.

Solution

Concept: In a fuel cell, oxidation occurs at the anode (loss of electrons) and reduction occurs at the cathode (gain of electrons). In a basic H_2-O_2 fuel cell, oxygen is reduced at the cathode.

Solution: At the Anode: $2H_2 + 4OH^- \longrightarrow 4H_2O + 4e^-$ At the Cathode: $O_2 + 2H_2O + 4e^- \longrightarrow 4OH^-$The cathode reaction involves the reduction of oxygen gas in the presence of water to form hydroxide ions.

Answer: (A)

Q11.

Solution

Concept: Reducing power is inversely proportional to the standard reduction potential (E°).

- A lower (more negative) E° means the metal is more easily oxidized and is, therefore, a stronger reducing agent.
- A higher (more positive) E° means the metal is a weaker reducing agent.

Solution: Given Standard Reduction Potentials:$E^\circ_A = +0.5\text{ V}E^\circ_B = -2.0\text{ V}E^\circ_C = -1.2\text{ V}$Ordering from most negative to most positive:$-2.0\text{ V}(B) < -1.2\text{ V}(C) < +0.5\text{ V}(A)$Since a lower potential indicates higher reducing power: Reducing Power: $B > C > A$

Answer: (A)

Q12.

Solution

Concept: For a first-order reaction:

$$t = \frac{2.303}{k}\log\frac{[A]_0}{[A]_t} \quad \text{and} \quad t_{1/2} = \frac{0.693}{k}$$

For 99.9% completion, $[A]_t = [A]_0 - 0.999[A]_0 = 0.001[A]_0$.

Solution:

$$t_{99.9\%} = \frac{2.303}{k}\log\frac{[A]_0}{0.001[A]_0} = \frac{2.303}{k}\log(10^3)$$

$$t_{99.9\%} = \frac{2.303\times 3}{k} = \frac{6.909}{k}$$

Comparing with $t_{1/2}$:

$$\frac{t_{99.9\%}}{t_{1/2}} = \frac{6.909/k}{0.693/k} \approx 10$$

Thus, $t_{99.9\%} \approx 10 \times t_{1/2}$.

Answer: (C)

Q13.

Solution

Concept: The units of the rate constant k are given by:

$$\text{Unit} = (\text{mol L}^{-1})^{1-n}\ \text{s}^{-1}$$

where n is the order of the reaction.

Solution: Given $k = 3.4 \times 10^{-4}$ mol^{-1} L s^{-1}.This unit can be written as L mol^{-1} s^{-1} or $(\text{mol L}^{-1})^{-1}$ s^{-1}.Equating the powers: $1 - n = -1 \Rightarrow n = 2$.The reaction is of second order.

Answer: (C)

Q14.

Solution

Concept: The Arrhenius equation is $k = Ae^{-E_a/RT}$. Taking the natural log on both sides:

$$\ln k = \ln A - \frac{E_a}{R}\left(\frac{1}{T}\right)$$

This is in the form of a straight line equation $y = mx + c$.

Solution: Comparing $\ln k = -\frac{E_a}{R}\left(\frac{1}{T}\right) + \ln A$ with $y = mx + c$:

- y-axis: $\ln k$
- x-axis: $1/T$
- Slope (m): $-E_a/R$

Therefore, E_a is determined from the slope of the $\ln k$ vs $1/T$ graph.

Answer: (C)

Q15.

Solution

Concept: For a zero-order reaction, the half-life ($t_{1/2}$) is related to the initial concentration $[A]_0$ by the formula:

$$t_{1/2} = \frac{[A]_0}{2k}$$

Solution: From the formula, $t_{1/2} \propto [A]_0$.If the initial concentration $[A]_0$ is doubled, the half-life $t_{1/2}$ will also be doubled.

Answer: (A)

Q16.

Solution

Concept: In the Arrhenius equation $k = Ae^{-E_a/RT}$, A is known as the Arrhenius factor, frequency factor, or pre-exponential factor.**Solution:**As $T \rightarrow \infty$, the term $e^{-E_a/RT}$ becomes $e^0 = 1$. In this limit, $k = A$. Therefore, A represents the value of the rate constant at an infinitely high temperature (or the frequency of collisions with proper orientation).

Answer: (B)

Q17.

Solution

Concept: Lanthanoid contraction refers to the steady decrease in the size of atoms and ions with increasing atomic number in the lanthanoid series.
Solution: This occurs because of:**Imperfect shielding:** The $4f$ electrons have poor shielding effects due to the diffused shape of f-orbitals.**Increasing nuclear charge:** As the atomic number increases, the effective nuclear charge increases, pulling the outer electrons closer.Thus, both factors contribute.

Answer: (D)

Q18.

Solution

Concept: Transition metal ions are colorless if they have a completely empty (d^0) or completely filled (d^{10}) d-subshell, as $d - d$ transitions are not possible.
Solution:

- Ti^{4+} : $[Ar]3d^0$ (Colorless)
- V^{3+} : $[Ar]3d^2$ (Colored)
- Cr^{3+} : $[Ar]3d^3$ (Colored)
- Mn^{2+} : $[Ar]3d^5$ (Colored)

Ti^{4+} has no electrons in the d-orbital.

Answer: (A)

Q19.

Solution

Concept: The spin-only magnetic moment (μ) is calculated using the formula:

$$\mu = \sqrt{n(n+2)}\ \text{BM}$$

where n is the number of unpaired electrons.

Solution: Mn (At. no. 25) configuration: $[Ar]3d^5 4s^2$Mn^{2+} configuration: $[Ar]3d^5$Number of unpaired electrons (n) = 5.

$$\mu = \sqrt{5(5+2)} = \sqrt{35} \approx 5.92\ \text{BM}$$

Answer: (A)

Q20.

Solution

Concept: In an acidic medium, $KMnO_4$ acts as a strong oxidizing agent and reduces to Mn^{2+}. It oxidizes iodide ions (I^-) from KI.

Solution: The ionic reaction is:

$$2MnO_4^- + 10I^- + 16H^+ \longrightarrow 2Mn^{2+} + 5I_2 + 8H_2O$$

Iodide (I^-) is oxidized to molecular iodine (I_2).

Answer: (A)

Q21.

Solution

Concept: IUPAC naming follows the order: Ligands in alphabetical order → Central metal → Oxidation state in Roman numerals.

Solution: Complex: $[Pt(NH_3)_2Cl(NO_2)]$Ligands: Diammine (2 NH_3), chlorido (1 Cl), nitrito-N (1 NO_2).Oxidation state of Pt (x): $x + 2(0) + (-1) + (-1) = 0 \Rightarrow x = +2$.Name: Diamminechloridonitrito-N-platinum(II).

Answer: (A)

Q22.

Solution

Concept: The complex [Pt(NH_3)$_2$$Cl_2$] is a square planar complex of the type $[MA_2B_2]$. **Solution:**Square planar $[MA_2B_2]$ complexes exhibit two geometrical isomers:**Cis-isomer:** Similar ligands are adjacent (90° apart).**Trans-isomer:** Similar ligands are opposite (180° apart).

Answer: (B)

Q23.

Solution

Concept: Ligands vary in their ability to cause crystal field splitting. **Solution:**The series in which ligands are arranged in the order of increasing field strength (and thus increasing crystal field splitting energy, Δ_o) is known as the spectrochemical series.

Answer: (B)

Q24.

Solution

Concept: Hybridization depends on the coordination number and the strength of the ligands. **Solution:**In $[Fe(CN)_6]^{3-}$:Fe is in +3 state ($3d^5$). CN^- is a **strong field ligand**, which causes pairing of electrons in the $3d$ orbitals. This leaves two $3d$ orbitals empty for hybridization.The empty orbitals used are $two 3d$, $one 4s$, and $three 4p$, resulting in d^2sp^3 hybridization (inner orbital complex).

Answer: (B)

Q25.

Solution

Concept: An outer orbital complex uses $(n)d$ orbitals for hybridization (usually sp^3d^2), which typically happens with weak field ligands. **Solution:**

- NH_3 and CN^- are strong field ligands (usually form inner orbital d^2sp^3).
- F^- is a **weak field ligand**.

In $[CoF_6]^{3-}$, the weak ligand F^- cannot pair the electrons in Co(III), so it uses the $4d$ orbitals, forming an sp^3d^2 (outer orbital) complex.

Answer: (C)

Q26.

Solution

Concept: The color of transition metal complexes is generally explained by the excitation of an electron from a lower energy d-orbital to a higher energy d-orbital.

Solution: In $[Ti(H_2O)_6]^{3+}$, Ti is in the +3 oxidation state ($3d^1$). The single electron in the t_{2g} level can be excited to the e_g level by absorbing light in the visible region. This is called a $d-d$ transition.

Answer: (A)

Q27.

Solution

Concept: S_N1 reaction rate depends on the stability of the carbocation formed. Carbocation stability order: $3^\circ > 2^\circ > 1^\circ >$ Methyl.

Solution:

- $(CH_3)_3CCl$ forms a **tertiary** (3°) carbocation.
- $(CH_3)_2CHCl$ forms a secondary (2°) carbocation.
- CH_3CH_2Cl forms a primary (1°) carbocation.
- CH_3Cl forms a methyl carbocation.

Tertiary carbocations are the most stable, so $(CH_3)_3CCl$ reacts most rapidly.

Answer: (C)

Q28.

Solution

Concept: Named reactions in organic chemistry describe specific pathways to form carbon-carbon bonds or exchange functional groups.

Solution: The reaction of alkyl halides with sodium metal in dry ether to produce higher alkanes (symmetric) is the Wurtz reaction.

Answer: (B)

Q29.

Solution

Concept: S_N1 reactions involve the formation of a planar carbocation intermediate.
Solution: Since the carbocation is planar, the nucleophile can attack from either side with equal probability. This results in a 50:50 mixture of two enantiomers, leading to racemization. S_N2 leads to inversion of configuration.

Answer: (A)

Q30.

Solution

Concept: The Finkelstein reaction is a halogen exchange reaction used to prepare alkyl iodides.
Solution: Alkyl chlorides or bromides react with Sodium Iodide (NaI) in dry acetone.

$$\mathrm{CH_3Br + NaI \xrightarrow{Acetone} CH_3I + NaBr} \downarrow$$

The precipitate of NaBr is removed, driving the reaction forward.

Answer: (A)

Q31.

Solution

Concept: The osmotic pressure (π) is a colligative property given by the formula:

$$\pi = CRT = \frac{w}{M \cdot V} RT$$

where w is the mass of solute, M is the molar mass, V is the volume in liters, R is the gas constant, and T is the temperature in Kelvin.
Solution: Given:$w = 4.0$ g, $V = 1$ L, $\pi = 3.0 \times 10^{-4}$ atm, $R = 0.082$ L atm K^{-1} mol^{-1}$T = 27°\text{C} = 27 + 273 = 300$ KRearranging for Molar Mass (M):

$$M = \frac{wRT}{\pi V}$$

$$M = \frac{4.0 \times 0.082 \times 300}{3.0 \times 10^{-4} \times 1}$$

$$M = \frac{4.0 \times 24.6}{3.0 \times 10^{-4}} = \frac{98.4}{3.0 \times 10^{-4}}$$

$$M = 32.8 \times 10^4 = 3.28 \times 10^5 \text{ g/mol}$$

Answer: (A)

Q32.

Solution

Concept: Negative deviation from Raoult's law occurs when the intermolecular forces between the two components (A-B) are stronger than the forces in the pure components (A-A and B-B). This results in lower vapor pressure than predicted.Getty Images**Solution:**

- **Phenol and Aniline:** The phenolic -OH group can form strong intermolecular hydrogen bonds with the amino -NH_2 group of aniline. This interaction is stronger than the pure-pure interactions, leading to a negative deviation.
- Ethanol and Acetone / Chloroform and Ethanol: Usually show positive deviations due to disruption of hydrogen bonds.
- Benzene and Toluene: Form a nearly ideal solution.

Answer: (C)

Q33.

Solution

Concept: According to Kohlrausch's law of independent migration of ions, the limiting molar conductivity of an electrolyte is the sum of the individual contributions of its ions.

$$\Lambda_m^\circ(\text{NaBr}) = \lambda^\circ(\text{Na}^+) + \lambda^\circ(\text{Br}^-)$$

Solution: We can calculate the value for NaBr using the given electrolytes:

$$\Lambda_m^\circ(\text{NaBr}) = \Lambda_m^\circ(\text{NaCl}) + \Lambda_m^\circ(\text{KBr}) - \Lambda_m^\circ(\text{KCl})$$

Substituting the values:

$$\Lambda_m^\circ(\text{NaBr}) = 126 + 152 - 150$$

$$\Lambda_m^\circ(\text{NaBr}) = 278 - 150 = 128 \text{ S cm}^2 \text{ mol}^{-1}$$

Answer: (A)

Q34.

Solution

Concept: Charging a lead storage battery is the reverse of the discharge process. Electrolysis occurs to regenerate the original reactants.

Solution: During charging:

- **At the Cathode:** $PbSO_4(s) + 2e^- \longrightarrow Pb(s) + SO_4^{2-}(aq)$ (Reduction of $PbSO_4$ to Pb).
- **At the Anode:** $PbSO_4(s) + 2H_2O(l) \longrightarrow PbO_2(s) + SO_4^{2-}(aq) + 4H^+(aq) + 2e^-$ (Oxidation of $PbSO_4$ to PbO_2).
- **Electrolyte:** Sulfuric acid (H_2SO_4) is produced/regenerated, so its specific gravity increases.

All given statements are correct.

Answer: (D)

Q35.

Solution

Concept: The cell constant (G^*) of a conductivity cell is defined as the ratio of the distance between the electrodes (l) to their cross-sectional area (A).

$$G^* = \frac{l}{A}$$

Solution: Since the distance between electrodes and their area are fixed physical dimensions for a specific cell, the cell constant remains constant regardless of the electrolyte type, its concentration, or the temperature.

Answer: (C)

Q36.

Solution

Concept: The rate law expresses the relationship between the reaction rate and the concentrations of reactants.

$$\text{Rate} = k[A]^x[B]^y$$

Solution: Doubling $[A]$ quadruples the rate: $(2)^x = 4 \Rightarrow x = 2$. The reaction is second order with respect to A.Doubling $[B]$ has no effect: $(2)^y = 1 \Rightarrow y = 0$. The reaction is zero order with respect to B.Combining these, the rate law is:

$$\text{Rate} = k[A]^2[B]^0 = k[A]^2$$

Answer: (B)

Q37.

Solution

Concept: Decomposition reactions on a metal surface (heterogeneous catalysis) follow Langmuir adsorption kinetics.

Solution: At low pressure, the amount of gas adsorbed (surface coverage) is directly proportional to the pressure. Since the rate of a surface reaction is proportional to the surface coverage (θ), at low pressure the rate is proportional to pressure (or concentration), making it a first-order reaction.

$$\text{Rate} \propto \theta \propto P$$

Answer: (A)

Q38.

Solution

Concept: For a first-order reaction, the time required for a change in concentration is:

$$t = \frac{2.303}{k} \log \frac{[A]_0}{[A]_t}$$

Solution: Given:$k = 1.6 \times 10^{-3}$ s^{-1}, $[A]_0 = 5$ g, $[A]_t = 1.25$ gCalculate the ratio: $\frac{[A]_0}{[A]_t} = \frac{5}{1.25} = 4$.Note that 4 is 2^2, which means two half-lives have passed.

$$t_{1/2} = \frac{0.693}{1.6 \times 10^{-3}} = 433.125 \text{ s}$$

Total time $t = 2 \times t_{1/2} = 2 \times 433.125 = 866.25$ s.Using the formula:

$$t = \frac{2.303}{1.6 \times 10^{-3}} \log 4 = \frac{2.303 \times 0.602}{1.6 \times 10^{-3}} \approx 866 \text{ s}$$

Answer: (B)

Q39.

Solution

Concept: Ionic radii generally decrease across the lanthanoid series ($La \to Lu$) due to lanthanoid contraction. Y^{3+} (Yttrium, period 5) has a radius ($\sim$ 90 pm) similar to heavy lanthanoids (near Ho and Er).

Solution: Following the decrease in the series:La^{3+} (largest, 103 pm) > Eu^{3+} (95 pm) > Lu^{3+} (86 pm).Yttrium (Y^{3+}) is significantly smaller than the early lanthanoids because it has fewer shells, and its size is comparable to the very end of the lanthanoid series.The increasing order of radii is:

$$Y^{3+} < Lu^{3+} < Eu^{3+} < La^{3+}$$

Answer: (A)

Q40.

Solution

Concept: A primary standard in volumetric analysis must be stable, non-hygroscopic, and easy to weigh accurately.

Solution: Sodium dichromate ($Na_2Cr_2O_7$) is hygroscopic (absorbs moisture from the air) and deliquescent, making it difficult to maintain a constant weight for standard solutions. Potassium dichromate ($K_2Cr_2O_7$) is not hygroscopic and is therefore preferred as a primary standard.

Answer: (B)

Q41.

Solution

Concept: Interstitial compounds are formed when small atoms occupy the "voids" or "interstices" in the metal lattice.

Solution: Characteristics of interstitial compounds:

- Very high melting points (higher than pure metals).
- Very hard (some approach diamond hardness).
- Retain metallic conductivity.
- They are **chemically inert** (not reactive).

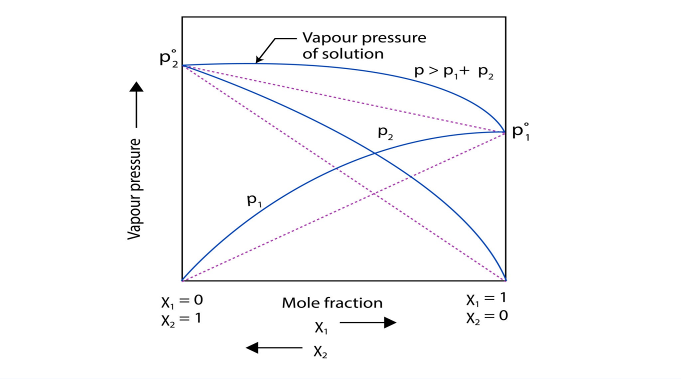
Therefore, statement D is not a property.

Answer: (D)

Q42.

Solution

Concept: For a complex to absorb visible light and appear colored, it must typically have partially filled d-orbitals to allow for $d-d$ transitions.



Solution:

- $[Sc(H_2O)_6]^{3+}$: Sc^{3+} is d^0. (Colorless)
- $[Ti(en)_2(NH_3)_2]^{4+}$: Ti^{4+} is d^0. (Colorless)
- $[Cr(NH_3)_6]^{3+}$: Cr^{3+} is d^3. (Colored/Absorbs light)
- $[Zn(NH_3)_6]^{2+}$: Zn^{2+} is d^{10}. (Colorless)

The chromium complex has unpaired electrons and will show $d-d$ transitions.

Answer: (C)

Q43.

Solution

Concept: The spin-only magnetic moment is $\mu = \sqrt{n(n+2)}$. A value of 4.90 BM corresponds to $n = 4$ unpaired electrons.

Solution: Cobalt in $[CoF_6]^{3-}$ is in the +3 oxidation state ($3d^6$).If $n = 4$, the electrons are distributed as $t_{2g}^4 e_g^2$. This happens when the ligand is weak and electrons do not pair up (High Spin).High spin octahedral complexes use the outer d-orbitals ($4d$) for hybridization, resulting in sp^3d^2.

Answer: (A)

Q44.

Solution

Concept: In aqueous solution, coordination complexes dissociate into their coordination sphere (complex ion) and counter ions.

Solution: The complex $[Pt(NH_3)_4Cl_2]Cl_2$ dissociates as:

$$[Pt(NH_3)_4Cl_2]Cl_2 \rightarrow [Pt(NH_3)_4Cl_2]^{2+} + 2Cl^-$$

Total ions = 1 complex cation + 2 chloride anions = 3 ions.

$\boxed{\textbf{Answer: (B)}}$

Q45.

Solution

Concept: Facial (*fac*) and Meridional (*mer*) isomerism is a form of geometrical isomerism in octahedral complexes.

Solution: This occurs in complexes of the type $[MA_3B_3]$.

- **fac-isomer:** The three identical ligands occupy one face of the octahedron.
- **mer-isomer:** The three identical ligands occupy a "meridian" (a plane passing through the center).

$\boxed{\textbf{Answer: (A)}}$

Q46.

Solution

Concept: The S_N2 reaction mechanism involves a back-side attack of the nucleophile on the carbon, leading to a complete inversion of configuration at the chiral center, known as Walden Inversion.

Solution: The starting material is (S)-2-bromooctane. During the S_N2 attack by OH^-, the stereochemistry is inverted.(S)-reactant $\xrightarrow{S_N2}$ (R)-productThe product formed is (R)-octan-2-ol.

$\boxed{\textbf{Answer: (A)}}$

Q47.

Solution

Concept: Haloarenes like chlorobenzene are less reactive toward nucleophilic substitution due to several factors including resonance, hybridization, and steric/electronic effects.

Solution:

(a) **Resonance:** C-Cl bond acquires partial double bond character.

(b) **Hybridization:** The carbon is sp^2 hybridized, which is more electronegative and holds the bond more tightly than sp^3 carbon in haloalkanes.

(c) **Instability of Phenyl Cation:** If the bond breaks, the resulting phenyl cation is not stabilized by resonance and is very unstable.

Thus, all the mentioned factors contribute.

Answer: (D)

Q48.

Solution

Concept: For haloalkanes with the same halogen atom, the boiling point increases with the number of halogen atoms due to the increase in molecular mass and surface area, which leads to stronger van der Waals forces.

Solution: Comparing the series:$CH_3Cl < CH_2Cl_2 < CHCl_3 < CCl_4$$CCl_4$ has the highest molecular mass and greatest surface area, resulting in the highest boiling point.

Answer: (D)

Q49.

Solution

Concept: Reaction with alcoholic KOH causes dehydrohalogenation (β-elimination), where a hydrogen atom from the β-carbon and the halogen from the α-carbon are removed to form an alkene.

Solution: The reactant is $CH_3CH_2CH_2Br$ (1-bromopropane).

$$CH_3CH_2CH_2Br + \text{alc. KOH} \rightarrow CH_3CH = CH_2 + KBr + H_2O$$

The product is propene.

Answer: (A)

Q50.

Solution

Concept: Silver cyanide ($AgCN$) is primarily covalent. When it reacts with an alkyl halide, the nucleophilic attack occurs through the nitrogen atom because the carbon atom is bonded to silver.

Solution:

$$R - X + \mathrm{AgCN} \longrightarrow R - \mathrm{NC} + \mathrm{AgX}$$

This yields an alkyl isocyanide. In contrast, KCN (ionic) allows the attack through carbon to form an alkyl cyanide ($R - CN$).

Answer: (B)

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	D	3	D	4	C	5	B
6	B	7	A	8	C	9	A	10	A
11	A	12	C	13	C	15	A	16	B
17	D	18	A	19	A	20	A	21	A
22	B	23	B	24	B	25	C	26	A
27	C	29	A	30	A	31	A	32	C
33	A	34	D	35	C	36	B	37	A
38	B	39	A	40	B	41	D	43	A
44	B	45	A	46	A	47	D	48	D
49	A	50	B						