CUET UG Chemistry Sample Paper - 12

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. The vapor pressure of pure benzene at a certain temperature is 640 mm Hg. A non-volatile non-electrolyte solid weighing 2.175 g is added to 39 g of benzene. The vapor pressure of the solution is 600 mm Hg. The molecular mass of the solid substance is:

(A) 65.25 g/mol

(B) 130.5 g/mol

(C) 75.3 g/mol

(D) 15.6 g/mol

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

(A) KCl

(B) $C_6H_{12}O_6$ (Glucose)

(C) $Al_2(SO_4)_3$

(D) K_2SO_4

Q3. The cell potential for the cell $Zn|Zn^{2+}(1\text{ M})||Cu^{2+}(1\text{ M})|Cu$ is 1.10 V. If the equilibrium constant for the cell reaction is K_c, then:

(A) $E^\circ_{cell} = \frac{0.059}{2}\log K_c$

(B) $E^{\circ}_{cell} = 0.059 \log K_c$

(C) $\log K_c = \frac{2 \times 1.10}{0.059}$

(D) Both A and C are correct.

Q4. During the electrolysis of aqueous copper sulphate using platinum electrodes, the product obtained at the anode is:

(A) Copper metal

(B) Oxygen gas

(C) Hydrogen gas

(D) Sulphur dioxide

Q5. A reaction is second order with respect to a reactant. If the concentration of the reactant is reduced to half, the rate of the reaction will become:

(A) 1/2 times

(B) 2 times

(C) 1/4 times

(D) 4 times

Q6. The half-life period of a first-order reaction is 69.3 seconds. The rate constant of the reaction is:

(A) 0.01 s^{-1}

(B) 0.1 s^{-1}

(C) 1.0 s^{-1}

(D) 10 s^{-1}

Q7. The correct electronic configuration of Cu^{2+} ion (At. No. 29) is:

(A) $[Ar]3d^9 4s^0$

(B) $[Ar]3d^8 4s^1$

(C) $[Ar]3d^{10} 4s^1$

(D) $[Ar]3d^7 4s^2$

Q8. In the preparation of $KMnO_4$, the pyrolusite ore (MnO_2) is first fused with KOH in the presence of air to form:

(A) K_2MnO_4 (Green)

(B) $KMnO_4$ (Purple)

(C) Mn_2O_7 (Dark oil)

(D) $Mn(OH)_2$ (White)

Q9. The type of isomerism shown by $[Co(NH_3)_5(NO_2)]Cl_2$ and $[Co(NH_3)_5(ONO)]Cl_2$ is:

(A) Coordination isomerism

(B) Linkage isomerism

(C) Ionization isomerism

(D) Solvate isomerism

Q10. The crystal field splitting energy (Δ_o) for the complex $[Co(CN)_6]^{3-}$ is:

(A) Higher than $[Co(NH_3)_6]^{3+}$

(B) Lower than $[Co(NH_3)_6]^{3+}$

(C) Equal to $[Co(NH_3)_6]^{3+}$

(D) Zero

Q11. Among the following, the most reactive towards S_N1 reaction is:

(A) $CH_2 = CH - CH_2Cl$

(B) C_6H_5Cl

(C) CH_3CH_2Cl

(D) $CH_2 = CHCl$

Q12. Which of the following will not form a Grignard reagent upon reaction with Magnesium in dry ether?

(A) C_2H_5Br

(B) C_6H_5Br

(C) $CH_2 = CH - Cl$

(D) $HO - CH_2CH_2Br$

Q13. The conversion of Phenol to Salicylaldehyde using Chloroform and aqueous $NaOH$ is known as:

(A) Kolbe's reaction

(B) Reimer-Tiemann reaction

(C) Etard reaction

(D) Stephen reaction

Q14. The acid catalyzed dehydration of 1-methylcyclohexanol gives the major product:

(A) 1-methylcyclohexene

(B) 3-methylcyclohexene

(C) Methylenecyclohexane

(D) 4-methylcyclohexene

Q15. The most reactive carbonyl compound towards nucleophilic addition among the following is:

(A) $HCHO$

(B) CH_3CHO

(C) CH_3COCH_3

(D) C_6H_5CHO

Q16. Which of the following acids does not undergo Hell-Volhard-Zelinsky (HVZ) reaction?

(A) CH_3COOH

(B) $(CH_3)_2CHCOOH$

(C) $(CH_3)_3CCOOH$

(D) CH_3CH_2COOH

Q17. The order of basic strength of methyl substituted amines in gaseous phase is:

(A) $3^\circ > 2^\circ > 1^\circ > NH_3$

(B) $2^\circ > 1^\circ > 3^\circ > NH_3$

(C) $NH_3 > 1^\circ > 2^\circ > 3^\circ$

(D) $2^\circ > 3^\circ > 1^\circ > NH_3$

Q18. Aniline on reaction with $NaNO_2$ and HCl at 0–5°C followed by treatment with $CuCN/KCN$ gives:

(A) Chlorobenzene

(B) Benzonitrile

(C) Benzylamine

(D) Nitrobenzene

Q19. Which of the following is an example of a globular protein?

(A) Keratin

(B) Myosin

(C) Insulin

(D) Fibroin

Q20. Vitamin B_{12} contains which of the following metal ions?

(A) Fe^{2+}

(B) Zn^{2+}

(C) Co^{3+}

(D) Mg^{2+}

Q21. If the rate of a reaction is $r = k[A]^x[B]^y$, and the volume of the container is suddenly reduced to one-fourth of its original volume, the new rate will be:

(A) $4^{(x+y)}$ times

(B) $(1/4)^{(x+y)}$ times

(C) $4/1$ times

(D) No change

Q22. The catalyst used in the Ziegler-Natta polymerization of ethene is:

(A) $TiCl_4 + (C_2H_5)_3Al$

(B) $Fe + Mo$

(C) V_2O_5

(D) $PdCl_2$

Q23. The geometry and magnetic nature of $[NiCl_4]^{2-}$ are respectively:

(A) Tetrahedral, Paramagnetic

(B) Square Planar, Diamagnetic

(C) Tetrahedral, Diamagnetic

(D) Square Planar, Paramagnetic

Q24. Glucose on prolonged heating with HI gives:

(A) Gluconic acid

(B) n-Hexane

(C) Saccharic acid

(D) Hexanoic acid

Q25. Zwitterion structure is shown by:

(A) Glucose

(B) Urea

(C) Glycine

(D) Aniline

Q26. The values of van't Hoff factor (i) for KCl, $NaCl$, and K_2SO_4 respectively are:

(A) 2, 2, and 2

(B) 2, 2, and 3

(C) 1, 1, and 2

(D) 1, 1, and 1

Q27. A current of 2.0 A is passed for 5 hours through a molten metal salt deposits 22.2 g of metal (At. wt. = 177). The oxidation state of the metal in the metal salt is:

(A) +1

(B) +2

(C) +3

(D) +4

Q28. The electrode potential $E_{(Zn^{2+}/Zn)}$ of a zinc electrode at $25°C$ with $[Zn^{2+}]$ = 0.1 M is ($E° = -0.76$ V):

(A) -0.79 V

(B) -0.73 V

(C) -0.82 V

(D) -0.70 V

Q29. For a first-order reaction, if the initial concentration is $[A]_0$ and the concentration at time t is $[A]_t$, a plot of $\log[A]_t$ vs t gives a slope equal to:

(A) $-k/2.303$

(B) $k/2.303$

(C) $-k$

(D) $2.303/k$

Q30. The temperature coefficient of most reactions lies between:

(A) 1 and 2

(B) 2 and 3

(C) 3 and 4

(D) 1 and 3

Q31. Which of the following oxides of Manganese is amphoteric?

(A) MnO

(B) Mn_2O_3

(C) MnO_2

(D) Mn_2O_7

Q32. The magnetic moment of a divalent ion in aqueous solution with atomic number 25 is:

(A) 2.84 BM

(B) 3.87 BM

(C) 5.92 BM

(D) 4.90 BM

Q33. Which of the following is an example of an ionization isomer?

(A) $[Co(NH_3)_5SO_4]Br$ and $[Co(NH_3)_5Br]SO_4$

(B) $[Cr(H_2O)_6]Cl_3$ and $[Cr(H_2O)_5Cl]Cl_2 \cdot H_2O$

(C) $[Co(NH_3)_6][Cr(CN)_6]$ and $[Cr(NH_3)_6][Co(CN)_6]$

(D) $[Pt(NH_3)_2Cl_2]$ (cis and trans)

Q34. The correct order of ligands in the spectrochemical series is:

(A) $Cl^- < F^- < C_2O_4^{2-} < NO_2^-$

(B) $F^- < Cl^- < NO_2^- < C_2O_4^{2-}$

(C) $C_2O_4^{2-} < F^- < Cl^- < NO_2^-$

(D) $NO_2^- < C_2O_4^{2-} < F^- < Cl^-$

Q35. The reaction of CH_3CH_2I with alcoholic KOH gives:

(A) CH_3CH_2OH

(B) $CH_2 = CH_2$

(C) $CH_3CH_2OCH_2CH_3$

(D) CH_3CH_3

Q36. S_N1 reactions are favored by:

(A) Non-polar solvents

(B) Polar protic solvents

(C) Polar aprotic solvents

(D) High concentration of nucleophile

Q37. Which of the following will react fastest with Lucas reagent?

(A) Butan-1-ol

(B) Butan-2-ol

(C) 2-Methylpropan-2-ol

(D) 2-Methylpropan-1-ol

Q38. Phenol on reaction with concentrated HNO_3 in the presence of concentrated H_2SO_4 gives:

(A) o-Nitrophenol

(B) p-Nitrophenol

(C) 2,4,6-Trinitrophenol

(D) m-Nitrophenol

Q39. The reaction $CH_3COCl \xrightarrow{H_2/Pd-BaSO_4} CH_3CHO$ is:

(A) Stephen reduction

(B) Rosenmund reduction

(C) Cannizzaro reaction

(D) Wolff-Kishner reduction

Q40. Which of the following compounds will undergo the Cannizzaro reaction?

(A) CH_3CHO

(B) CH_3CH_2CHO

(C) $(CH_3)_3CCHO$

(D) $C_6H_5CH_2CHO$

Q41. Arrange the following in decreasing order of basic strength in aqueous solution: (i) NH_3, (ii) CH_3NH_2, (iii) $(CH_3)_2NH$, (iv) $(CH_3)_3N$.

(A) iii > ii > iv > i

(B) iv > iii > ii > i

(C) ii > iii > iv > i

(D) iii > iv > ii > i

Q42. Which amine reacts with HNO_2 to give a yellow oily liquid (nitrosoamine)?

(A) Primary amine

(B) Secondary amine

(C) Tertiary amine

(D) Aniline

Q43. In DNA, the complementary bases are:

(A) Adenine and Thymine; Guanine and Cytosine

(B) Adenine and Guanine; Thymine and Cytosine

(C) Adenine and Cytosine; Guanine and Thymine

(D) Adenine and Uracil; Guanine and Cytosine

Q44. Which of the following is a non-essential amino acid for humans?

(A) Valine

(B) Leucine

(C) Glycine

(D) Phenylalanine

Q45. Two liquids A and B form an ideal solution. At a specified temperature, the vapor pressure of pure A is 200 mm Hg and that of pure B is 300 mm Hg. If the mole fraction of A in the solution is 0.5, the total vapor pressure is:

(A) 250 mm Hg

(B) 500 mm Hg

(C) 100 mm Hg

(D) 400 mm Hg

Q46. The rate of a gaseous reaction is given by $k[A][B]$. If the volume of the reaction vessel is reduced to $1/3$ of its initial volume, the rate of reaction as compared to the original rate will be:

(A) $1/9$

(B) $1/3$

(C) 9 times

(D) 3 times

Q47. Lanthanoid contraction is due to:

(A) Poor shielding of $4f$ electrons

(B) Effective shielding of $4f$ electrons

(C) Increase in nuclear charge

(D) Both A and C

Q48. The IUPAC name of the coordination compound $K_3[Fe(CN)_6]$ is:

(A) Potassium hexacyanoferrate(II)

(B) Potassium hexacyanoferrate(III)

(C) Potassium hexacyanoiron(III)

(D) Tripotassium hexacyanoferrate(II)

Q49. Which of the following is an example of an ambidentate nucleophile?

(A) OH^-

(B) CN^-

(C) H_2O

(D) NH_3

Q50. Secondary structure of protein refers to:

(A) Sequence of amino acids

(B) Fixed configuration of polypeptide backbone (α-helix)

(C) Folding of the polypeptide chain

(D) Combination of two or more polypeptide chains

Detailed Solutions

Q1.

Solution

Concept: Relative Lowering of Vapor Pressure (RLVP)

According to Raoult's Law, when a non-volatile solute is dissolved in a solvent, the vapor pressure of the solvent is lowered. This occurs because the solute particles occupy positions on the liquid surface, decreasing the number of solvent molecules available to escape into the vapor phase. The mathematical expression for the relative lowering of vapor pressure is:

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

Where P° is the vapor pressure of the pure solvent and P_s is the vapor pressure of the solution.

Solution:

- **Step 1: Data Extraction**
  - Vapor pressure of pure benzene (P°) = 640 mm Hg
  - Vapor pressure of solution (P_s) = 600 mm Hg
  - Mass of solute (w_2) = 2.175 g
  - Mass of benzene solvent (w_1) = 39 g
  - Molar mass of benzene (M_1) = C_6H_6 = $(6 \times 12) + (6 \times 1)$ = 78 g/mol
- **Step 2: Calculate Moles of Benzene (n_1)**

$$n_1 = \frac{w_1}{M_1} = \frac{39}{78} = 0.5 \text{ mol}$$

- **Step 3: Solve for Molar Mass of Solute (M_2)** Using the formula: $\frac{P^\circ - P_s}{P_s} = \frac{w_2/M_2}{n_1}$

$$\frac{640 - 600}{600} = \frac{2.175/M_2}{0.5}$$
$$\frac{40}{600} = \frac{4.35}{M_2}$$
$$\frac{1}{15} = \frac{4.35}{M_2}$$
$$M_2 = 4.35 \times 15 = 65.25 \text{ g/mol}$$

Answer: (A)

Q2.

Solution

Concept: Elevation in Boiling Point and van't Hoff Factor

Boiling point elevation (ΔT_b) is a colligative property defined as the increase in the boiling point of a solvent upon the addition of a non-volatile solute. It is mathematically expressed as:

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

Where i is the van't Hoff factor, K_b is the ebullioscopic constant, and m is the molality.

Solution:

Since all solutions have the same concentration (0.1 M), the elevation ΔT_b depends solely on the value of i:

i. **KCl:** $KCl \rightarrow K^+ + Cl^-$ (Produces 2 ions). Therefore, $i = 2$.

ii. **Glucose:** A molecular solid that does not ionize in water. Therefore, $i = 1$.

iii. $Al_2(SO_4)_3$**:** $Al_2(SO_4)_3 \rightarrow 2Al^{3+} + 3SO_4^{2-}$ (Produces 5 ions). Therefore, $i = 5$.

iv. K_2SO_4**:** $K_2SO_4 \rightarrow 2K^+ + SO_4^{2-}$ (Produces 3 ions). Therefore, $i = 3$.

Deep Reasoning:

Colligative properties depend on the **number** of particles. $Al_2(SO_4)_3$ provides the highest number of particles (5 moles of ions per mole of solute), leading to the greatest ΔT_b. Consequently, it will have the highest boiling point among the given options.

Answer: (C)

Q3.

Solution

Concept: Thermodynamics of Galvanic Cells at Equilibrium

In a galvanic cell, the electrical work is derived from the Gibbs free energy of the reaction. As the reaction reaches equilibrium, the potential difference between the electrodes vanishes ($E_{\text{cell}} = 0$).

Solution:

- **The Nernst Equation:**
$$E_{\text{cell}} = E^\circ_{\text{cell}} - \frac{2.303RT}{nF} \log Q$$
- **At Equilibrium:** By definition, $E_{\text{cell}} = 0$ and $Q = K_c$.
$$0 = E^\circ_{\text{cell}} - \frac{0.059}{n} \log K_c$$
$$E^\circ_{\text{cell}} = \frac{0.059}{n} \log K_c \quad \text{— (Eq. 1)}$$
- **Application to the Zn-Cu (Daniell) Cell:** The reaction is $\text{Zn} + \text{Cu}^{2+} \rightleftharpoons \text{Zn}^{2+} + \text{Cu}$. Here, $n = 2$ and $E^\circ_{\text{cell}} = 1.10$ V.
$$\text{From Eq. 1: } E^\circ_{\text{cell}} = \frac{0.059}{2} \log K_c \quad \text{(Matches Option A)}$$
$$\text{Rearranging: } \log K_c = \frac{2 \times E^\circ_{\text{cell}}}{0.059} = \frac{2 \times 1.10}{0.059} \quad \text{(Matches Option C)}$$

Conclusion: Since both A and C are mathematically identical representations of the equilibrium state, the correct choice is D.

Answer: (D)

Q4.

Solution

Concept: Electrolysis and Discharge Potential

Electrolysis involves the movement of ions to electrodes followed by their discharge through gain or loss of electrons. When multiple ions are present in an aqueous solution, the species with the lower discharge potential is preferred.

Solution:

In an aqueous solution of $CuSO_4$, the ions present are Cu^{2+}, SO_4^{2-}, and the ions from water dissociation (H^+ and OH^-).

- **Target Electrode:** The Anode (Positive).
- **Competing Species:** SO_4^{2-} and H_2O.
- **Comparison:** The oxidation potential of H_2O is much higher than that of SO_4^{2-}. Sulphate ions are extremely stable and require a very high potential to oxidize.

Resulting Chemical Reaction: Water is oxidized at the anode surface:

$$2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$$

The liberation of electrons produces oxygen gas (O_2), while the solution near the anode becomes acidic due to H^+ ions.

Answer: (B)

Q5.

Solution

Concept: Rate Laws and Concentration Dependence

The rate of a chemical reaction is defined by the rate law expression. For a reaction that is second-order with respect to a reactant, the rate is proportional to the square of that reactant's concentration.

Solution:

- **Initial Rate (r_1):** Let the initial concentration be $[A]$.

$$r_1 = k[A]^2$$

- **Condition Change:** The concentration is reduced to half, so the new concentration is $[A'] = \frac{[A]}{2}$.
- **New Rate (r_2):** Substitute the new concentration into the rate law:

$$r_2 = k\left(\frac{[A]}{2}\right)^2$$
$$r_2 = k \cdot \frac{[A]^2}{4}$$
$$r_2 = \frac{1}{4}(k[A]^2)$$
$$r_2 = \frac{1}{4}r_1$$

In-Depth Reasoning:

Because the exponent of the concentration in the rate law is 2, any change in concentration results in a "squared" effect on the rate. Thus, halving the concentration $(1/2)$ reduces the speed of the reaction to $(1/2)^2 = 1/4$ of the original velocity.

Answer: (C)

Q6.

Solution

Concept: Kinetics of First-Order Reactions

For a first-order reaction, the rate of reaction is directly proportional to the concentration of one reactant. A key characteristic of these reactions is that the half-life ($t_{1/2}$) is constant and independent of the initial concentration. The mathematical relationship between the rate constant (k) and half-life is derived from the integrated rate law:

$$\ln \frac{[A]_0}{[A]_t} = kt$$

Solution:

- **Step 1: Formula Derivation** At $t = t_{1/2}$, the concentration $[A]_t = \frac{[A]_0}{2}$. Substituting this:

$$\ln(2) = k \cdot t_{1/2} \implies k = \frac{0.693}{t_{1/2}}$$

- **Step 2: Substitution of Given Values** Given $t_{1/2} = 69.3$ seconds.

$$k = \frac{0.693}{69.3}$$
$$k = \frac{6.93 \times 10^{-1}}{6.93 \times 10^{1}}$$
$$k = 10^{-2} = 0.01 \text{ s}^{-1}$$

In-Depth Reasoning:

The unit of the rate constant for a first-order reaction is time^{-1} (e.g., s^{-1}), which confirms our calculation. If the half-life were doubled, the rate constant would be halved, demonstrating their inverse relationship.

Answer: (A)

Q7.

Solution

Concept: Electronic Configuration of Transition Metal Ions

Copper (Z = 29) is a transition metal in the 3d series. Its neutral ground-state configuration is an exception to the Aufbau principle because a completely filled d-subshell (d^{10}) provides extra stability due to symmetrical distribution of electrons and high exchange energy.

Solution:

- **Step 1: Neutral Cu Configuration** Atomic number 25 to 30 usually fill the 4s before the 3d, but for Cu:

$$\text{Cu (Z=29): } [Ar]\, 3d^{10}4s^{1}$$

- **Step 2: Formation of Cu^{2+} Ion** Oxidation involves the removal of electrons. According to the rules: 1. Electrons are removed from the orbital with the highest principal quantum number (n) first. Here, $4s$ ($n = 4$) is higher than $3d$ ($n = 3$). 2. Therefore, 1 electron is removed from $4s$ and 1 electron is removed from $3d$.

- **Step 3: Final Configuration**

$$\text{Cu} \xrightarrow{-1e^-} \text{Cu}^{+}([Ar]\, 3d^{10}4s^{0})$$
$$\text{Cu}^{+} \xrightarrow{-1e^-} \text{Cu}^{2+}([Ar]\, 3d^{9}4s^{0})$$

Conclusion: The resulting configuration is $3d^9$, which makes Cu^{2+} paramagnetic (one unpaired electron) and usually blue in aqueous solution.

Answer: (A)

Q8.

Solution

Concept: Preparation of Potassium Permanganate ($KMnO_4$)

The industrial synthesis of $KMnO_4$ starts from the mineral Pyrolusite (MnO_2). This process involves a two-step oxidation of Manganese from the +4 oxidation state to +7.

Solution:

- **Step 1: Oxidative Fusion** MnO_2 is fused with an alkali hydroxide (like KOH) in the presence of an oxidizing agent such as atmospheric oxygen (O_2) or KNO_3.

$$2MnO_2 + 4KOH + O_2 \rightarrow 2K_2MnO_4 + 2H_2O$$

- **Step 2: Identification of Product** The resulting compound, K_2MnO_4 (Potassium Manganate), contains Mn in the +6 oxidation state. It is characterized by its distinct **dark green** color.

In-Depth Reasoning:

It is important to distinguish between Manganate (MnO_4^{2-}, green) and Permanganate (MnO_4^-, purple). In the second step of the industrial process, the green manganate is acidified or electrolytically oxidized to produce the purple permanganate. Since the question asks for the product of the "fusion" step, the answer is Potassium Manganate.

Answer: (A)

Q9.

Solution

Concept: Linkage Isomerism in Coordination Compounds

Isomerism in coordination chemistry occurs when compounds have the same molecular formula but different arrangements of atoms. Linkage isomerism specifically arises when a coordination complex contains an **ambidentate ligand**.

Solution:

- **Analysis of the Ligand:** The ligand in the given pair is the nitrite ion (NO_2^-). It is ambidentate because it has two different donor atoms: 1. Nitrogen (N): Forming a "nitro" complex ($-NO_2$). 2. Oxygen (O): Forming a "nitrito" complex ($-ONO$).
- **Comparison of the Pair:** - $[Co(NH_3)_5(NO_2)]Cl_2$: The NO_2 group is linked via Nitrogen. - $[Co(NH_3)_5(ONO)]Cl_2$: The NO_2 group is linked via Oxygen.

Conclusion: Because these two compounds differ only in the point of attachment (linkage) of the ligand to the central metal atom, they are classified as linkage isomers.

Answer: (B)

Q10.

Solution

Concept: Crystal Field Theory (CFT) and Ligand Strength

Crystal Field Theory explains the splitting of degenerate d-orbitals into different energy levels (t_{2g} and e_g) when ligands approach the central metal ion. The energy difference between these levels is called the Crystal Field Splitting Energy (Δ_o).

Solution:

- **The Spectrochemical Series:** Ligands are arranged in a series based on their ability to cause d-orbital splitting:

$$I^- < Br^- < Cl^- < F^- < OH^- < \text{ox}^{2-} < H_2O < \text{NH}_3 < \text{en} < \text{NO}_2^- < \text{CN}^- < \text{CO}$$

- **Comparison of Ligands:** In the complexes $[Co(CN)_6]^{3-}$ and $[Co(NH_3)_6]^{3+}$: 1. CN^- is a "Strong Field Ligand" (at the high end of the series). 2. NH_3 is a moderate-to-strong ligand, but it is significantly weaker than CN^-.

Deep Logic:

A stronger ligand creates a stronger electrostatic field, leading to a wider gap between the d-orbitals. Therefore, the Δ_o (splitting energy) for the cyanide complex is much higher than that of the ammine complex. This large Δ_o is also why cyanide complexes are almost always "low spin."

Answer: (A)

Q11.

Solution

Concept: Reactivity of Alkyl Halides in S_N1 Mechanism

The S_N1 (Substitution Nucleophilic Unimolecular) reaction proceeds via the formation of a carbocation intermediate in the rate-determining step. Therefore, the reactivity of a halide is directly proportional to the stability of the carbocation it forms.

Solution:

- **Analysis of Allyl Chloride (A):** Upon ionization, it forms the allyl carbocation: $CH_2 = CH - CH_2^+$. This cation is highly stable due to resonance:

$$[CH_2 = CH - CH_2^+ \leftrightarrow^+ CH_2 - CH = CH_2]$$

- **Analysis of others:** Vinyl ($CH_2 = CHCl$) and Aryl (C_6H_5Cl) halides are extremely unreactive because the C-Cl bond has partial double bond character due to resonance. Ethyl chloride (C) forms a primary carbocation which is much less stable than an allylic one.

Answer: (A)

Q12.

Solution

Concept: Compatibility of Grignard Reagents

Grignard reagents ($R\text{Mg}X$) are powerful nucleophiles and very strong bases. They cannot coexist with "active hydrogen" or acidic protons (like those in $-\text{OH}$, $-\text{NH}_2$, or $-\text{COOH}$ groups).

Solution:

- **Reasoning for Option D:** The molecule $\text{HO} - \text{CH}_2 - \text{CH}_2 - \text{Br}$ contains an alcohol ($-\text{OH}$) group.
- **Reaction:** As soon as the Grignard reagent starts to form at the Br-site, it will immediately react with the acidic hydrogen of the hydroxyl group:

$$\text{HO} - \text{R} - \text{MgBr} \rightarrow \text{BrMg-O} - \text{R} - \text{H}$$

This internal acid-base reaction destroys the reagent.

Answer: (D)

Q13.

Solution

Concept: The Reimer-Tiemann Reaction

The Reimer-Tiemann reaction is used for the ortho-formylation of phenols. When Phenol is treated with chloroform and aqueous sodium hydroxide, a $-CHO$ group is introduced.

Solution:

- **Mechanism:** The reaction involves the generation of dichlorocarbene (: CCl_2) as an intermediate.
- **Product:** The major product is Salicylaldehyde (2-hydroxybenzaldehyde).

$$C_6H_5OH \xrightarrow[NaOH\ (aq)]{CHCl_3} o\text{-}C_6H_4(OH)(CHO)$$

Answer: (B)

Q14.

Solution

Concept: Dehydration of Alcohols and Zaitsev's Rule

Acid-catalyzed dehydration of alcohols follows a carbocation mechanism. The major product is determined by Zaitsev's Rule: the more substituted alkene is the more stable and thus the major product.

Solution:

- **Formation of Carbocation:** 1-methylcyclohexanol loses water to form a tertiary (3°) carbocation at the C1 position.
- **Elimination:** Removal of a proton from the ring (C2) gives **1-methylcyclohexene** (trisubstituted). Removal of a proton from the methyl group gives methylenecyclohexane (disubstituted).
- **Stability:** 1-methylcyclohexene is more stable and is the major product.

Answer: (A)

Q15.

Solution

Concept: Nucleophilic Addition to Carbonyls

The reactivity of aldehydes and ketones towards nucleophilic addition (like adding HCN) depends on steric hindrance and the magnitude of the positive charge on the carbonyl carbon.

Solution:

- **Steric Factors:** Formaldehyde (HCHO) has two small H-atoms, offering the least resistance to an incoming nucleophile.
- **Electronic Factors:** In Acetone and Acetaldehyde, alkyl groups (+I effect) reduce the electrophilicity of the carbonyl carbon.
- **Result:**

Reactivity order: $HCHO > CH_3CHO > CH_3COCH_3$

Answer: (A)

Q16.

Solution

Concept: Hell-Volhard-Zelinsky (HVZ) Reaction

The HVZ reaction is used to halogenate aliphatic carboxylic acids at the α-position. The reaction requires the presence of red phosphorus and a halogen (X_2, where X = Cl or Br).

Solution:

The fundamental mechanism of the HVZ reaction involves the formation of an acid halide intermediate followed by enolization. For this enolization to occur, the carboxylic acid **must possess at least one α-hydrogen** (a hydrogen atom attached to the carbon atom adjacent to the carboxyl group).

Analysis of Options:

- **Acetic acid (CH_3COOH):** Has three α-hydrogens.
- **Propionic acid (CH_3CH_2COOH):** Has two α-hydrogens.
- **Pivalic acid ($(CH_3)_3CCOOH$):** The α-carbon is attached to three methyl groups and the carboxyl group. Therefore, it has **zero α-hydrogens**.

Conclusion: Since Pivalic acid lacks the necessary α-hydrogen atom, it cannot undergo the Hell-Volhard-Zelinsky reaction.

Answer: (C)

Q17.

Solution

Concept: Basicity of Amines in the Gaseous Phase

The basicity of amines is defined by the availability of the lone pair of electrons on the nitrogen atom. In the **gaseous phase**, there are no solvent-solute interactions (like hydration or steric hindrance from water molecules) to complicate the trend.

Solution:

- **Inductive Effect (+I):** Alkyl groups ($-R$) are electron-donating. They push electron density toward the nitrogen atom.
- **Trend Analysis:**

Tertiary (3°): R_3N (Three +I groups)

Secondary (2°): R_2NH (Two +I groups)

Primary (1°): RNH_2 (One +I group)

Ammonia: NH_3 (Zero +I groups)

Conclusion: In the absence of solvent effects, the more alkyl groups attached to the nitrogen, the higher the electron density and the stronger the base. Thus, the order is $3^\circ > 2^\circ > 1^\circ > NH_3$.

Answer: (A)

Q18.

Solution

Concept: Diazotization and Sandmeyer Reaction

This transformation is a two-step process used to convert a primary aromatic amine into a variety of substituted benzene derivatives.

Solution:

- **Step 1: Diazotization** Aniline ($C_6H_5NH_2$) reacts with nitrous acid (generated in situ from $NaNO_2$ + HCl) at low temperature (0–5°C).

  $$C_6H_5NH_2 + NaNO_2 + 2HCl \rightarrow C_6H_5N_2^+Cl^- + NaCl + 2H_2O$$

  The product is Benzene Diazonium Chloride.

- **Step 2: Sandmeyer Reaction** The diazonium salt is treated with Cuprous Cyanide (CuCN) and Potassium Cyanide (KCN). The diazonium group ($-N_2^+$) is an excellent leaving group and is replaced by the cyanide ($-CN$) nucleophile.

  $$C_6H_5N_2^+Cl^- \xrightarrow{CuCN/KCN} C_6H_5CN + N_2 \uparrow$$

Conclusion: The final product formed is Benzonitrile (also known as Phenyl cyanide).

Answer: (B)

Q19.

Solution

Concept: Classification of Proteins (Globular vs. Fibrous)

Proteins are classified based on their molecular shape into two main categories: Fibrous and Globular.

Solution:

- **Fibrous Proteins:** These consist of polypeptide chains that run parallel to each other and are held together by hydrogen and disulfide bonds, forming a thread-like structure. They are **insoluble** in water. Examples include Keratin (hair/nails) and Myosin (muscles).
- **Globular Proteins:** These result from the folding of polypeptide chains into spherical or "globular" shapes. They are generally **soluble** in water.

Specific Example: Insulin is a hormone composed of two polypeptide chains cross-linked by disulfide bonds, folded into a compact, spherical shape. It is highly soluble in water and functions as a biological catalyst/regulator, making it a classic example of a globular protein.

Answer: (C)

Q20.

Solution

Concept: Coordination Compounds in Biology

Many essential biological molecules are actually coordination complexes where a central metal ion is bound to a large organic ligand (a macrocycle).

Solution:

- **Vitamin B_{12} (Cyanocobalamin):** It is a complex of **Cobalt** (Co^{3+}). The cobalt is situated at the center of a corrin ring, which is similar to the porphyrin ring found in heme.
- **Other Comparisons:**
  - **Chlorophyll:** Coordination complex of Magnesium (Mg^{2+}).
  - **Hemoglobin:** Coordination complex of Iron (Fe^{2+}).
  - **Cisplatin:** Coordination complex of Platinum (Pt^{2+}).

Conclusion: Vitamin B_{12} is uniquely characterized by its cobalt metal center.

Answer: (C)

Q21.

Solution

Concept: Concentration and Rate Law Relationships

The rate of a chemical reaction is defined by the concentrations of its reactants raised to their respective orders. For a general reaction $xA + yB \rightarrow$ Product, the rate law is:

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

The molar concentration $[C]$ is defined as moles per unit volume (n/V). Therefore, the concentration is inversely proportional to the volume of the reaction vessel.

Solution:

- **Step 1: Effect of Volume Change** If the volume V is reduced to $1/4$ of its original value $(V' = V/4)$, the new concentration $[C']$ becomes:

$$[C'] = \frac{n}{V/4} = 4 \times \frac{n}{V} = 4[C]$$

  Thus, the concentration of both A and B increases by 4 times.

- **Step 2: Calculate New Rate** (r_2) Initial Rate $(r_1) = k[A]^x[B]^y$. New Rate $(r_2) = k[4A]^x[4B]^y = k \cdot 4^x[A]^x \cdot 4^y[B]^y$.

- **Step 3: Simplify the Expression** Using the laws of exponents:

$$r_2 = 4^{(x+y)} \cdot (k[A]^x[B]^y) = 4^{(x+y)} \cdot r_1$$

Conclusion: The rate of the reaction increases by a factor of $4^{(x+y)}$.

Answer: (A)

Q22.

Solution

Concept: Coordination Polymerization and Catalysis

The Ziegler-Natta catalyst is a groundbreaking discovery in polymer chemistry that allows for the production of high-density polyethylene (HDPE) and stereoregular polymers (like isotactic polypropylene) under relatively mild conditions of temperature and pressure.

Solution:

- **Chemical Composition:** A typical Ziegler-Natta catalyst is a multi-component system consisting of: 1. A transition metal halide (usually **Titanium tetrachloride**, $TiCl_4$). 2. An organometallic co-catalyst (usually **Triethylaluminium**, $(C_2H_5)_3Al$).
- **Function:** The aluminum alkyl acts as a reducing agent and an alkylating agent, creating active sites on the titanium surface where the monomer (like ethene) inserts into the metal-carbon bond to grow the polymer chain.

Conclusion: The combination of $(C_2H_5)_3Al$ and $TiCl_4$ is known as the Ziegler-Natta catalyst.

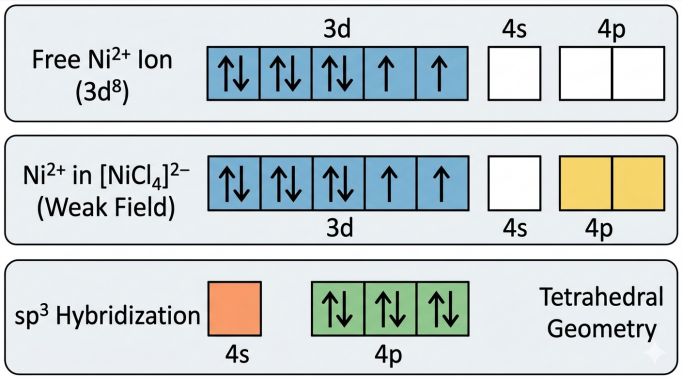
Answer: (A)

Q23.

Solution

Concept: Valence Bond Theory (VBT) and Magnetic Properties

The geometry and magnetic behavior of a coordination complex depend on the oxidation state of the metal, its electronic configuration, and the nature of the ligands (Strong vs. Weak Field).



Solution:

- **Step 1: Oxidation State and Configuration** In $[NiCl_4]^{2-}$, Chlorine has a charge of -1. Let x be the charge on Nickel: $x + 4(-1) = -2 \implies x = +2$. Ni (Z=28): $[Ar]\,3d^8 4s^2 \implies Ni^{2+} : [Ar]\,3d^8 4s^0$.
- **Step 2: Ligand Effect** Cl^- is a **Weak Field Ligand**. According to VBT, it does not have enough energy to force the pairing of the 3d electrons.
- **Step 3: Hybridization and Geometry** To accommodate 4 ligands, the metal uses one $4s$ and three $4p$ orbitals, leading to **sp^3 hybridization** (Tetrahedral geometry).
- **Step 4: Magnetic Character** In the $3d^8$ configuration, there are 2 unpaired electrons ($\uparrow\downarrow \mid \uparrow\downarrow \mid \uparrow\downarrow \mid \uparrow \mid \uparrow$). The presence of unpaired electrons makes the complex **Paramagnetic**.

Answer: (A)

Q24.

Solution

Concept: Structural Elucidation of Carbohydrates (Glucose)

The chemical structure of glucose was determined through a series of classic organic reactions. Each reaction proved a specific feature of the molecule (like the presence of an aldehyde group, six carbons, or five hydroxyl groups).

Solution:

- **Reaction with HI:** When glucose is heated with hydroiodic acid (HI) and red phosphorus for a prolonged period, it undergoes complete reduction.
- **Product Identification:** The reaction yields **n-hexane** ($CH_3 - CH_2 - CH_2 - CH_2 - CH_2 - CH_3$).
- **Significance:** The formation of n-hexane (a straight-chain alkane) serves as definitive proof that all six carbon atoms in the glucose molecule are linked together in a **continuous straight chain**.

Answer: (B)

Q25.

Solution

Concept: Amphoteric Nature of Amino Acids and Zwitterions

Amino acids like Glycine ($H_2N - CH_2 - COOH$) contain both a basic amino group ($-NH_2$) and an acidic carboxyl group ($-COOH$) within the same molecule.

Solution:

- **Formation Mechanism:** In aqueous solution, an internal acid-base reaction occurs. The carboxyl group loses a proton (H^+) and the amino group accepts it.

$$H_2N - CH_2 - COOH \rightleftharpoons H_3N^+ - CH_2 - COO^-$$

- **The Zwitterion:** The resulting dipolar ion is called a **Zwitterion**. It is electrically neutral because it carries both a positive and a negative charge.

Deep Logic: Due to this dipolar nature, amino acids behave like ionic salts; they have high melting points and are soluble in water, despite being organic molecules.

Answer: (C)

Q26.

Solution

Concept: The van't Hoff Factor (i) and Ionic Dissociation

The van't Hoff factor (i) measures the effect of a solute on colligative properties. For ionic compounds that undergo complete dissociation in a dilute solution, i is equal to the total number of moles of ions produced per mole of the solute.

Solution:

- **Potassium Chloride (KCl):** Dissociates into one potassium cation and one chloride anion.

$$KCl \rightarrow K^+ + Cl^- \implies (1 + 1) = 2 \text{ particles.}$$

- **Sodium Chloride (NaCl):** Dissociates into one sodium cation and one chloride anion.

$$NaCl \rightarrow Na^+ + Cl^- \implies (1 + 1) = 2 \text{ particles.}$$

- **Potassium Sulphate (K_2SO_4):** Dissociates into two potassium cations and one sulphate polyatomic anion.

$$K_2SO_4 \rightarrow 2K^+ + SO_4^{2-} \implies (2 + 1) = 3 \text{ particles.}$$

Conclusion: Assuming 100% dissociation (ideal behavior), the values of the van't Hoff factor for KCl, NaCl, and K_2SO_4 are 2, 2, and 3, respectively.

Answer: (B)

Q27.

Solution

Concept: Faraday's First Law of Electrolysis

Faraday's law states that the mass of a substance deposited (w) at an electrode is proportional to the quantity of electricity (Q) passed through the electrolyte. The formula is:

$$w = \frac{E \cdot I \cdot t}{F} = \frac{M \cdot I \cdot t}{n \cdot F}$$

Where M is molar mass, I is current, t is time (seconds), n is the oxidation state (valency), and F is Faraday's constant (≈ 96500 C/mol).

Solution:

- **Step 1: Identify Given Values** $w = 22.2$ g, $M = 177$ g/mol, $I = 2.0$ A. Time $t = 5$ hours $= 5 \times 3600 = 18000$ s.
- **Step 2: Rearrange for** n

$$n = \frac{M \cdot I \cdot t}{w \cdot F}$$

- **Step 3: Solve**

$$n = \frac{177 \times 2 \times 18000}{22.2 \times 96500}$$

$$n = \frac{6372000}{2142300} \approx 2.97$$

Conclusion: Since the number of electrons transferred must be an integer, $n \approx 3$. The oxidation state is +3.

Answer: (C)

Q28.

Solution

Concept: The Nernst Equation for Single Electrode Potential

The electrode potential depends on the concentration of the ions in the electrolyte. For the reduction reaction $M^{n+} + ne^- \rightarrow M(s)$, the Nernst equation is:

$$E = E^\circ - \frac{0.059}{n} \log \frac{1}{[M^{n+}]}$$

Solution:

- **Step 1: Reaction and Data** Reaction: $Zn^{2+} + 2e^- \rightarrow Zn$. $E^\circ = -0.76$ V, $n = 2$, $[Zn^{2+}] = 0.1$ M.
- **Step 2: Calculation**

$$E = -0.76 - \frac{0.059}{2} \log \left(\frac{1}{0.1} \right)$$

$$E = -0.76 - 0.0295 \log(10)$$

$$E = -0.76 - 0.0295(1) = -0.7895 \text{ V}$$

Deep Reasoning: Decreasing the concentration of the cation ($[Zn^{2+}]$) makes the reduction less favorable (according to Le Chatelier's principle), which results in a more negative electrode potential. The calculated value -0.7895 V rounds to -0.79 V.

Answer: (A)

Q29.

Solution

Concept: Linearized First-Order Rate Equation

The integrated rate law for a first-order reaction is $[A]_t = [A]_0 e^{-kt}$. To plot this linearly, we take the logarithm of both sides to fit the equation of a straight line: $y = mx + c$.

Solution:

- **Mathematical Derivation:** Starting with: $2.303 \log \frac{[A]_0}{[A]_t} = kt$

$$\log[A]_0 - \log[A]_t = \frac{kt}{2.303}$$

Rearranging for $\log[A]_t$:

$$\log[A]_t = \left(-\frac{k}{2.303}\right) t + \log[A]_0$$

- **Graph Analysis:** If we plot $\log[A]_t$ (y-axis) vs. t (x-axis), the slope (m) is identified as:

$$\text{Slope} = -\frac{k}{2.303}$$

Conclusion: The slope of the plot for a first-order reaction is $-k/2.303$.

Answer: (A)

Q30.

Solution

Concept: Temperature Coefficient of Reaction Rate

The temperature coefficient (η) of a chemical reaction is defined as the ratio of the rate constants (k) of the reaction at two temperatures differing by 10°C (usually 35°C and 25°C).

$$\text{Temperature Coefficient } (\eta) = \frac{k_{T+10}}{k_T}$$

Solution:

According to the Arrhenius equation, as temperature increases, the fraction of molecules with energy greater than the activation energy increases exponentially. For a large majority of chemical reactions, it has been observed experimentally that for every 10°C rise in temperature, the rate of reaction approximately **doubles or triples**. Therefore, the value of η almost always falls within the range of 2 to 3.

Answer: (B)

Q31.

Solution

Concept: Lanthanoid Contraction and Atomic Radii

Lanthanoid contraction refers to the steady decrease in the size of atoms and ions with increasing atomic number in the Lanthanoid series ($Z = 58$ to 71). This occurs because of the poor shielding effect of $4f$ electrons.

Solution:

- **The Cause:** As we move across the series, the nuclear charge increases. The new electrons enter the $4f$ subshell. Because $4f$ orbitals are very diffused, they do not shield the outer electrons effectively from the increasing nuclear pull.
- **Consequence on 5d Series:** This contraction has a significant impact on the elements following the Lanthanoids. Specifically, the elements of the second transition series ($4d$) and the third transition series ($5d$) end up having almost identical atomic radii.
- **Pair Analysis:** Zirconium (Zr) belongs to the $4d$ series (Group 4), and Hafnium (Hf) belongs to the $5d$ series (Group 4). Normally, Hf should be larger due to an extra shell, but Lanthanoid contraction cancels this increase.

Conclusion: Due to Lanthanoid contraction, the atomic radii of Zr (160 pm) and Hf (159 pm) are nearly the same.

Answer: (A)

Q32.

Solution

Concept: Magnetic Moments and Unpaired Electrons

The magnetic behavior of transition metal ions is determined by the "Spin-only" formula. The magnetic moment (μ) is calculated based on the number of unpaired electrons (n) present in the d-orbitals.

Solution:

- **Step 1: The Formula**

$$\mu = \sqrt{n(n+2)} \text{ Bohr Magnetons (B.M.)}$$

- **Step 2: Configuration of** Ni^{2+} Nickel (Z=28) has the configuration $[Ar]\, 3d^8 4s^2$. For Ni^{2+}, the configuration is $[Ar]\, 3d^8$. In $3d^8$, the electrons are filled as: $\uparrow\downarrow \mid \uparrow\downarrow \mid \uparrow\downarrow \mid \uparrow \mid \uparrow$. Number of unpaired electrons (n) = 2.

- **Step 3: Solve for** μ

$$\mu = \sqrt{2(2+2)} = \sqrt{8}$$
$$\mu \approx 2.83 \text{ B.M.}$$

Deep Reasoning: A magnetic moment of 2.83 B.M. is characteristic of any ion with two unpaired electrons. For example, Ti^{2+} ($3d^2$) would also show a similar value.

Answer: (B)

Q33.

Solution

Concept: IUPAC Nomenclature of Coordination Compounds

IUPAC naming follows a specific order: Cation is named first, followed by the Anion. Within the coordination sphere, ligands are named in alphabetical order, followed by the metal and its oxidation state in Roman numerals.

Solution:

- **Step 1: Identify Ligands** - NH_3 is "ammine" (two 'm's). There are 5: "pentaammine". - CO_3 is "carbonato".
- **Step 2: Calculate Oxidation State of Cobalt (Co)** Let x be the oxidation state: $x + 5(0) + 1(-2) + 1(-1) = 0\, x - 3 = 0 \implies x = +3$.
- **Step 3: Construct the Name** Ligands: Pentaamminecarbonato. Metal: Cobalt(III). Anion: Chloride.

Final Name: Pentaamminecarbonatocobalt(III) chloride. (Note: No space between ligands and metal).

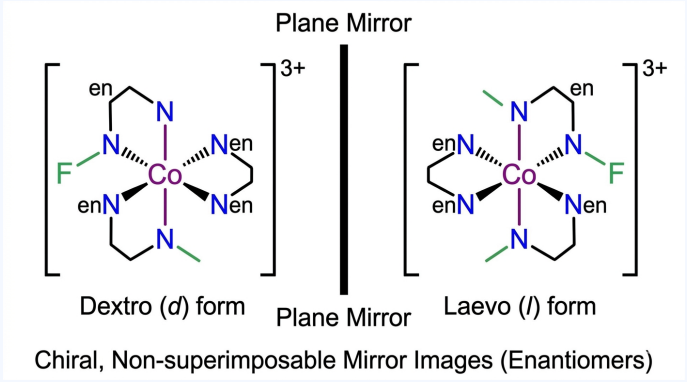
Answer: (A)

Q34.

Solution

Concept: Optical Isomerism in Coordination Compounds

Optical isomerism (enantiomerism) occurs in complexes that lack a plane of symmetry. These molecules are chiral and exist as non-superimposable mirror images (dextro and laevo forms).



Solution:

- **Requirement:** Octahedral complexes with bidentate ligands are the most common candidates for optical activity.
- **Analysis of $[Co(en)_3]^{3+}$:** The ligand "en" (ethylenediamine) is a symmetrical bidentate ligand. In a tris-chelate complex like $[Co(en)_3]^{3+}$, the three rings wrap around the metal in a "propeller" fashion.
- **Symmetry Check:** This arrangement has no plane of symmetry or center of inversion. Consequently, it forms a pair of enantiomers—one that rotates plane-polarized light to the right (d) and one to the left (l).

Conclusion: The tris-ethylenediaminecobalt(III) ion is a classic example of an optically active coordination species.

Answer: (C)

Q35.

Solution

Concept: Lucas Test for Alcohol Classification

The Lucas test uses a reagent consisting of anhydrous $ZnCl_2$ and concentrated HCl to distinguish between primary (1°), secondary (2°), and tertiary (3°) alcohols. The reaction follows an S_N1 mechanism.

Solution:

- **Tertiary Alcohols** (3°)**:** React immediately at room temperature to form an insoluble alkyl chloride, appearing as **instant cloudiness** or "turbidity."
- **Secondary Alcohols** (2°)**:** React within 5–10 minutes at room temperature.
- **Primary Alcohols** (1°)**:** Do not react significantly at room temperature; cloudiness only appears upon heating.

Specific Case (2-methyl-2-propanol): This is a tertiary alcohol (tert-butyl alcohol). Because the 3° carbocation formed is very stable, the reaction with Lucas reagent is nearly instantaneous.

Answer: (A)

Q36.

Solution

Concept: Kolbe's Reaction (Carboxylation of Phenol)

Kolbe's reaction (or Kolbe-Schmitt reaction) is a chemical reaction used to synthesize salicylic acid from phenol. It involves the electrophilic substitution of the phenoxide ion by carbon dioxide.

Solution:

- **Step 1: Formation of Sodium Phenoxide** Phenol reacts with NaOH to form sodium phenoxide. The phenoxide ion is much more reactive than phenol towards electrophilic aromatic substitution because of the high electron density on the ring.
- **Step 2: Reaction with** CO_2 Sodium phenoxide is heated with carbon dioxide (CO_2) under pressure (4–7 atm) at 125°C. CO_2 acts as a weak electrophile and attacks the ortho position.

$$C_6H_5ONa + CO_2 \xrightarrow{\Delta, \text{Pressure}} o\text{-HO-}C_6H_4\text{-COONa}$$

- **Step 3: Acidification** The resulting sodium salicylate is acidified to yield **Salicylic acid** (2-hydroxybenzoic acid).

Conclusion: Kolbe's reaction specifically produces salicylic acid, which is the starting material for making Aspirin.

Answer: (B)

Q37.

Solution

Concept: Acidity of Phenols and Electronic Effects

The acidity of a phenol depends on the stability of the phenoxide ion formed after losing a proton. Substituents on the benzene ring significantly influence this stability through inductive and resonance effects.

Solution:

- **Nitro Group ($-NO_2$):** It is a strong **Electron Withdrawing Group** ($-I$ and $-M$ effects). It withdraws electron density from the ring, effectively delocalizing the negative charge of the phenoxide ion and increasing acidity.
- **Methoxy Group ($-OCH_3$):** It is an **Electron Donating Group** ($+M$ effect). It pushes electron density into the ring, destabilizing the negative charge of the phenoxide ion and decreasing acidity.
- **Methyl Group ($-CH_3$):** It is a weak electron donor ($+I$ and hyperconjugation), which also decreases acidity relative to phenol.

Deep Logic: p-Nitrophenol is significantly more acidic than phenol ($pK_a \approx 7.15$ vs 10), while p-methoxyphenol is less acidic ($pK_a \approx 10.2$). Therefore, the order of increasing acidity is: p-Methoxyphenol < Phenol < p-Nitrophenol.

Answer: (A)

Q38.

Solution

Concept: The Cannizzaro Reaction

The Cannizzaro reaction is a redox (disproportionation) reaction of aldehydes that **lack an α-hydrogen**. In the presence of a concentrated strong base (NaOH or KOH), one molecule of aldehyde is reduced to an alcohol, while another is oxidized to a carboxylic acid salt.

Solution:

- **Formaldehyde (HCHO):** Has no α-carbon, thus no α-hydrogen. It undergoes Cannizzaro reaction.
- **Benzaldehyde (C_6H_5CHO):** The α-carbon is part of the benzene ring and has no hydrogens attached. It undergoes Cannizzaro reaction.
- **Acetaldehyde (CH_3CHO):** Has three α-hydrogens. In concentrated base, it undergoes **Aldol Condensation** and polymerization instead of the Cannizzaro reaction.

Reaction for Benzaldehyde:

$$2C_6H_5CHO + NaOH \rightarrow C_6H_5CH_2OH + C_6H_5COONa$$

(Benzyl alcohol and Sodium benzoate).

Answer: (A)

Q39.

Solution

Concept: Chemical Tests for Carbonyl Compounds

Fehling's solution and Tollen's reagent are mild oxidizing agents used to distinguish between aldehydes and ketones. While both react with most aliphatic aldehydes, they show different selectivity for aromatic aldehydes.

Solution:

- **Aldehydes vs Ketones:** Aldehydes are easily oxidized to carboxylic acids; ketones are not. Thus, aldehydes give a positive test with Fehling's solution (red ppt of Cu_2O).
- **Aliphatic vs Aromatic:** - **Aliphatic aldehydes** (like Acetaldehyde) reduce Fehling's solution. - **Aromatic aldehydes** (like Benzaldehyde) **do not** reduce Fehling's solution because the carbonyl group is stabilized by the resonance with the benzene ring, making it a weaker reducing agent.
- **Acetone:** Being a ketone, it does not react with Fehling's solution.

Conclusion: Benzaldehyde and Acetone both do not react with Fehling's solution, but between a typical aldehyde and ketone, Fehling's solution is the standard reagent for identification.

Answer: (A)

Q40.

Solution

Concept: Esterification Reaction

Esterification is the reaction between a carboxylic acid and an alcohol in the presence of an acid catalyst (usually concentrated H_2SO_4) to form an ester and water.

Solution:

The reaction is a nucleophilic acyl substitution. A key point often tested is the origin of the oxygen atom in the water molecule formed.

$$\text{R-COOH} + \text{R'-OH} \rightleftharpoons \text{R-COOR'} + H_2O$$

- **The Role of Catalyst:** H_2SO_4 protonates the carbonyl oxygen of the acid, making the carbonyl carbon more electrophilic. It also acts as a dehydrating agent to shift the equilibrium to the right (Le Chatelier's Principle).
- **The Products:** - **Ethanoic acid** (CH_3COOH) + **Ethanol** (C_2H_5OH) $\rightarrow$ **Ethyl ethanoate** ($CH_3COOC_2H_5$).

Observation: Esters are characterized by their pleasant, **fruity smell**, which is often used as a laboratory test for the presence of the carboxyl or hydroxyl group.

Answer: (B)

Q41.

Solution

Concept: Basicity of Amines and Steric Hindrance

The basicity of amines in aqueous solution is determined by three competing factors: 1. **Inductive Effect:** Alkyl groups ($+I$) increase electron density on Nitrogen. 2. **Solvation Effect:** Extent of Hydrogen bonding with water ($1^\circ > 2^\circ > 3^\circ$). 3. **Steric Hindrance:** Bulky groups hinder the approach of a proton (H^+).

Solution:

For the methyl-substituted amines (CH_3), the experimental order of basic strength in water is:

$$(CH_3)_2NH > CH_3NH_2 > (CH_3)_3N > NH_3$$

- **Secondary Amine (2°):** Dimethylamine is the strongest because it provides an ideal balance between the $+I$ effect and solvation.
- **Tertiary Amine (3°):** Despite having three $+I$ groups, Trimethylamine is weaker than the 2° and 1° amines because the three methyl groups cause significant steric hindrance, making it difficult for the Nitrogen lone pair to accept a proton.

Conclusion: Due to the "Steric effect" and poor solvation, the tertiary methyl amine drops in the basicity order.

Answer: (B)

Q42.

Solution

Concept: Hoffmann Bromamide Degradation Reaction

The Hoffmann Bromamide reaction is a method used to convert a primary amide into a primary amine with **one less carbon atom** than the starting amide.

Solution:

- **Reagents:** The amide is treated with Bromine (Br_2) and an aqueous or ethanolic solution of Sodium Hydroxide (NaOH).
- **The Transformation:**

$$\text{R-CONH}_2 + \text{Br}_2 + 4\text{NaOH} \rightarrow \text{R-NH}_2 + \text{Na}_2\text{CO}_3 + 2\text{NaBr} + 2\text{H}_2\text{O}$$

- **Application to Benzamide:** Benzamide ($C_6H_5CONH_2$) contains a carbonyl group attached to a phenyl ring. During the reaction, the carbonyl carbon is lost as carbonate (CO_3^{2-}), and the phenyl group migrates to the Nitrogen.

Final Product: The product is **Aniline** ($C_6H_5NH_2$). This reaction is vital for shortening carbon chains in organic synthesis.

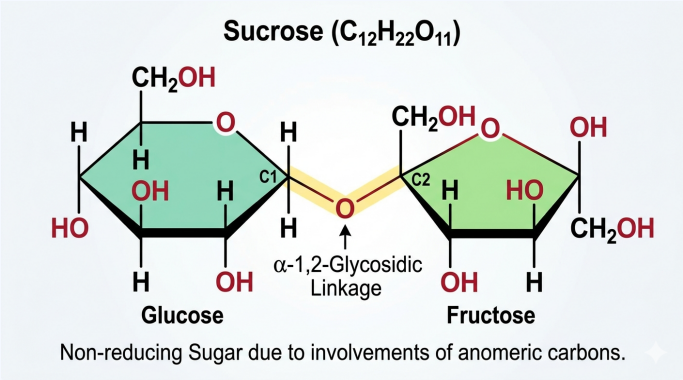
Answer: (A)

Q43.

Solution

Concept: Structure and Linkages in Sucrose

Sucrose ($C_{12}H_{22}O_{11}$) is a disaccharide commonly known as table sugar. It is formed by the condensation of two monosaccharide units.



Solution:

- **Monomer Units:** Sucrose is composed of one molecule of α-D-glucose and one molecule of β-D-fructose.
- **Glycosidic Linkage:** The bond is formed between the $C1$ (anomeric carbon) of the α-glucose and the $C2$ (anomeric carbon) of the β-fructose.

Linkage: C1 (Glucose) — O — C2 (Fructose)

In-Depth Reasoning: Because both anomeric carbons (the aldehyde group of glucose and the keto group of fructose) are involved in the glycosidic bond formation, there are no free aldehyde or ketone groups available. Consequently, sucrose is a **non-reducing sugar** and does not reduce Tollen's or Fehling's reagents.

Answer: (A)

Q44.

Solution

Concept: Deficiency Diseases of Vitamins

Vitamins are essential micronutrients that the body needs in small amounts to function correctly. A deficiency in a specific vitamin leads to distinct clinical symptoms.

Solution:

- **Function:** Vitamin C is crucial for the synthesis of collagen, a structural protein in connective tissues, skin, and blood vessels. It also acts as a potent antioxidant.
- **Deficiency Disease:** Lack of Vitamin C leads to **Scurvy**.
- **Symptoms:** Scurvy is characterized by bleeding gums, delayed wound healing, skin hemorrhages, and extreme fatigue.

Other Comparisons:

- **Rickets:** Caused by deficiency of Vitamin D.
- **Night Blindness:** Caused by deficiency of Vitamin A.
- **Beri-Beri:** Caused by deficiency of Vitamin B1 (Thiamine).

Answer: (B)

Q45.

Solution

Concept: Chemistry of DNA and RNA Bases

Nucleic acids (DNA and RNA) are composed of nucleotides, which include a pentose sugar, a phosphate group, and a nitrogenous base. The nitrogenous bases are divided into Purines and Pyrimidines.

Solution:

- **Common Bases:** Both DNA and RNA contain Adenine (A), Guanine (G), and Cytosine (C).
- **The Differentiating Base:** - **DNA** contains **Thymine (T)**. - **RNA** contains **Uracil (U)** instead of Thymine.

Structural Insight: Thymine is chemically known as 5-methyluracil. The presence of the methyl group in DNA (Thymine) provides greater stability and protection against mutations, which is why DNA is the primary genetic material in higher organisms, while RNA (with Uracil) is used for protein synthesis and message transfer.

Answer: (C)

Q46.

Solution

Concept: Intermolecular Forces in Polymers

Polymers are classified into four categories based on the magnitude of intermolecular forces: Elastomers, Fibers, Thermoplastics, and Thermosetting plastics.

Solution:

- **Definition:** Fibers are thread-forming solids which possess high tensile strength and high modulus.
- **The Force:** These characteristics are due to strong intermolecular forces like **Hydrogen bonding** or strong dipole-dipole interactions.
- **Nylon 6,6:** It is a polyamide. The presence of the carbonyl group (C=O) and the amino group (NH) allows for extensive linear hydrogen bonding between adjacent chains.

$$\cdots \text{C=O} \cdots \text{H-N} \cdots$$

Conclusion: Because of these strong hydrogen bonds, Nylon 6,6 is classified as a "Fiber" and exhibits a high degree of crystallinity.

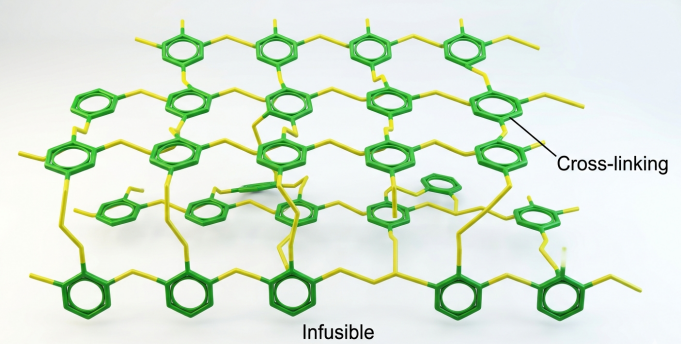
Answer: (B)

Q47.

Solution

Concept: Thermosetting Polymers and Cross-Linking

Thermosetting polymers are those which, on heating, undergo a chemical change to form a three-dimensional network of cross-links. Once "set," they cannot be remelted or reshaped.



Cross-linked network (Thermosetting Polymer)

Solution:

- **Monomers:** Bakelite is prepared by the condensation of **Phenol** and **Formaldehyde**.
- **Structure:** Initially, a linear polymer called Novolac is formed. Upon further heating with formaldehyde, Novolac undergoes extensive cross-linking to form a rigid, infusible solid called Bakelite.
- **Properties:** It is an insulator and highly resistant to heat, making it ideal for electrical switches and handles of utensils.

Other Comparisons:

- **Polythene/PVC:** These are thermoplastics (linear/branched, no cross-links).
- **Buna-S:** An elastomer (synthetic rubber).

Answer: (A)

Q48.

Solution

Concept: Natural Rubber and Vulcanization

Natural rubber is a linear polymer of **Isoprene** (2-methyl-1,3-butadiene). In its natural state, it is soft, sticky, and has low tensile strength.

Solution:

- **Geometric Isomerism:** Natural rubber consists of isoprene units linked together in a **cis-configuration** at every double bond. This is why it is technically called **cis-1,4-polyisoprene**.
- **Coiled Structure:** The cis-geometry prevents the chains from packing closely together. The chains are held by weak van der Waals forces and have a coiled structure, giving the material its elastic properties.

Note: The trans-isomer of polyisoprene is known as **Gutta-percha**, which is non-elastic and crystalline.

Answer: (C)

Q49.

Solution

Concept: Condensation Polymerization (Step-Growth)

Condensation polymerization involves the repetitive condensation reaction between two different bi-functional or tri-functional monomeric units, usually with the loss of small molecules like water or alcohol.

Solution:

- **Monomers:** 1. Ethylene glycol (HO-CH_2-CH_2-OH) 2. Terephthalic acid (p-HOOC-C_6H_4-COOH)
- **The Reaction:** The alcohol group of the glycol reacts with the carboxyl group of the acid to form an **ester linkage**.

$$n(\text{Acid}) + n(\text{Alcohol}) \rightarrow [\text{Polyester}]_n + (2n-1)H_2O$$

Conclusion: Since a water molecule is eliminated during the formation of each ester bond, Terylene is a classic example of a condensation polymer.

Answer: (B)

Q50.

Solution

Concept: Biodegradable Polymers

Most synthetic polymers are non-biodegradable, leading to environmental pollution. To solve this, chemists developed biodegradable polymers that can be broken down by enzymatic or chemical hydrolysis in the environment.

Solution:PHBV

- **Full Name:** Poly-β-hydroxybutyrate-co-β-hydroxyvalerate.
- **Monomers:** 1. 3-hydroxybutanoic acid 2. 3-hydroxypentanoic acid
- **Properties:** It is an aliphatic polyester. It is biodegradable and is used in specialty packaging, orthopedic devices, and controlled release of drugs.

Other Comparisons:

- **Nylon 6,6 / Terylene:** Non-biodegradable.
- **Nylon 2-nylon 6:** Another biodegradable polymer (polyamide).

Answer: (A)

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	A	2	C	3	D	4	B	5	C
6	A	7	A	8	A	9	B	10	A
11	A	12	D	13	B	14	A	15	A
16	C	17	A	18	B	19	C	20	C
21	A	22	A	23	A	24	B	25	C
26	B	27	C	28	A	29	A	30	B
31	A	32	B	33	A	34	C	35	A
36	B	37	A	38	A	39	A	40	B
41	B	42	A	43	A	44	B	45	C
46	B	47	A	48	C	49	B	50	A