WBJEE Chemistry Sample Paper-18

Duration: 60 Minutes **Maximum Marks: 50**

Instructions

- This paper contains **40** Multiple Choice Questions divided into **3 Categories**.
- **Section A (Q1–Q30):** Each correct answer carries **+1 mark**. Incorrect answer: **−0.25** marks. Only **one** correct option.
- **Section B (Q31–Q35):** Each correct answer carries **+2 marks**. Incorrect answer: **−0.5** marks. Only **one** correct option.
- **Section C (Q36–Q40):** Each correct answer carries **+2 marks**. **No negative marking**. One or **more** correct options may be correct; full marks only if all correct options are marked.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.

Section A - 30 Questions × 1 Mark Each
(Negative Marking: −0.25) [Single Correct]

Q1. An organic compound contains C, H, and N. Extraction of 1.40 g of this compound yielded 0.28 g of nitrogen gas through a specialized digestion procedure. Separately, complete combustion of 0.70 g of the same compound produces 1.32 g of CO_2. What is the empirical formula of the compound?

(A) C_3H_5N

(B) C_3H_7N

(C) C_2H_5N

(D) C_4H_9N

Q2. If the kinetic energy of an electron in the second Bohr orbit of a hydrogen atom is E_k, what is the de Broglie wavelength associated with an electron revolving in the third Bohr orbit of a He^+ ion?

(A) $\frac{3h}{2\sqrt{2mE_k}}$

(B) $\frac{3h}{4\sqrt{2mE_k}}$

(C) $\frac{h}{2\sqrt{2mE_k}}$

(D) $\frac{3h}{\sqrt{2mE_k}}$

Q3. The correct decreasing order of the boiling points of the given group 15 hydrides is:

(A) $SbH_3 > NH_3 > AsH_3 > PH_3$

(B) $NH_3 > SbH_3 > AsH_3 > PH_3$

(C) $SbH_3 > AsH_3 > NH_3 > PH_3$

(D) $SbH_3 > NH_3 > PH_3 > AsH_3$

Q4. Equal masses of methane and oxygen are mixed in an empty container at 25°C. The fraction of the total pressure exerted by oxygen is:

(A) $1/2$

(B) $1/3$

(C) $2/3$

(D) $1/5$

Q5. One mole of an ideal gas undergoes an isothermal expansion into an evacuated vessel of volume v. If the initial volume was V, the change in entropy of the universe (ΔS_{univ}) is given by:

(A) $R\ln\frac{V+v}{V}$

(B) $R\ln\frac{v}{V}$

(C) Zero

(D) $-R\ln\frac{V+v}{V}$

Q6. For the system $A(s) \rightleftharpoons 2B(g) + C(g)$, the equilibrium pressure is P atm. The value of ΔG° for the reaction at temperature T is:

(A) $-RT\ln\left(\frac{4P^3}{27}\right)$

(B) $-RT\ln\left(\frac{P^3}{27}\right)$

(C) $-RT\ln\left(4P^3\right)$

(D) $-RT\ln\left(\frac{2P^3}{9}\right)$

Q7. For a parallel decomposition reaction where reactant R gives product A (rate constant k_1) and product B (rate constant k_2), it is found that the activation energy for the steps are 120 kJ mol^{-1} and 180 kJ mol^{-1} respectively. If the pre-exponential factors are identical, the overall activation energy (E_a) for the disappearance of R at 300 K when $k_1 = 2k_2$ is approximately:

(A) 150 kJ mol^{-1}

(B) 130 kJ mol^{-1}

(C) 140 kJ mol^{-1}

(D) 126 kJ mol^{-1}

Q8. A volume of 20 mL of an unknown H_2O_2 solution requires 30 mL of 0.02 M $KMnO_4$ solution in an acidic medium for complete titration. The volume strength of this H_2O_2 solution at STP is:

(A) 1.68 V

(B) 0.84 V

(C) 3.36 V

(D) 0.42 V

Q9. The limiting molar conductivities of NH_4Cl, NaOH, and NaCl are x, y, and z S cm^2 mol^{-1} respectively. If the molar conductivity of a 0.01 M ammonium hydroxide solution is w S cm^2 mol^{-1}, its degree of dissociation (α) is expressed as:

(A) $\frac{w}{x+y-z}$

(B) $\frac{w}{x-y+z}$

(C) $\frac{w}{z+y-x}$

(D) $\frac{w}{x+y+z}$

Q10. When an aqueous solution of LiCl is evaporated to crystallization, which of the following hydrated solid forms?

(A) $LiCl \cdot H_2O$

(B) $LiCl \cdot 2H_2O$

(C) $LiCl \cdot 4H_2O$

(D) Anhydrous LiCl pellets directly

Q11. Pure phosphine (PH_3) is relatively non-inflammable, but it becomes highly inflammable in the presence of impurities of which of the following components?

(A) P_2H_4

(B) PH_5

(C) H_3PO_3

(D) P_4O_{10}

Q12. When $K_2Cr_2O_7$ is heated with concentrated sulfuric acid and a chloride salt, deep red vapors are evolved. On passing these vapors into an aqueous solution of NaOH, a yellow solution is obtained. The formula of the compound responsible for the yellow color is:

(A) $Na_2Cr_2O_7$

(B) Na_2CrO_4

(C) CrO_2Cl_2

(D) $Na[Cr(OH)_4]$

Q13. The correct spin-only magnetic moment value (in B.M.) for the complex $[Fe(H_2O)_5(NO)]SO_4$ is approximately:

(A) 1.73

(B) 3.87

(C) 4.90

(D) 5.92

Q14. Which of the following chemical species is predominantly responsible for the phenomenon of photochemical smog formation rather than classic London smog?

(A) SO_2

(B) CO_2

(C) Peroxyacetyl nitrate (PAN)

(D) H_2SO_4 aerosols

Q15. The correct IUPAC name of the compound given below is: $CH_3-CH(OH)-CH_2-C(\equiv CH)-CH_3$

(A) 4-Methylpent-4-yn-2-ol

(B) 2-Methylpent-1-yn-4-ol

(C) 4-Hydroxypent-1-yne

(D) 2-Hydroxy-4-methylpent-4-yne

Q16. An alkene X (C_6H_{12}) upon reductive ozonolysis produces a single carbonyl compound which exhibits a positive iodoform test but fails to reduce Tollens' reagent. The structural formula of X is:

(A) 2,3-Dimethylbut-2-ene

(B) Hex-3-ene

(C) 3-Methylpent-2-ene

(D) 2-Methylpent-2-ene

Q17. Benzene reacts with *n*-propyl chloride in the presence of anhydrous $AlCl_3$ to yield a primary hydrocarbon product P. Product P upon atmospheric oxidation followed by treatment with dilute acid gives:

(A) Phenol and Acetone

(B) Propan-1-ol and Benzene

(C) Acetophenone and Methane

(D) Benzoic acid and Ethanol

Q18. Consider the acid-catalyzed dehydration of 1-methylcyclohexanol. The major product obtained and its mechanism type are:

(A) 1-Methylcyclohexene via E1

(B) 3-Methylcyclohexene via E2

(C) Methylenecyclohexane via E1

(D) 1-Methylcyclohexene via E2

Q19. When m-chlorobenzaldehyde is treated with concentrated KOH solution at room temperature, the products formed are:

(A) Potassium m-chlorobenzoate and m-chlorobenzyl alcohol

(B) m-Hydroxybenzaldehyde and Potassium chloride

(C) Potassium p-chlorobenzoate and m-chlorobenzyl alcohol

(D) m-Chlorbenzoic acid and m-chlorobenzene

Q20. Gabriel phthalimide synthesis cannot be effectively utilized for the preparation of which of the following amines?

(A) Benzylamine

(B) Aniline

(C) Isobutylamine

(D) Methylamine

Q21. Complete hydrolysis of starch yields which of the following monosaccharide units?

(A) α-D-Glucopyranose

(B) β-D-Glucopyranose

(C) α-D-Fructofuranose

(D) D-Galactose

Q22. Nylon-6 is synthesized by heating which of the following monomeric blocks at elevated temperatures?

(A) Caprolactam

(B) Hexamethylenediamine and Adipic acid

(C) Styrene and Butadiene

(D) Ethylene glycol and Phthalic acid

Q23. A 0.1 M aqueous solution of an weak monobasic acid is 2% ionized. The osmotic pressure of this solution at 300 K is approximately ($R = 0.0821$ L atm $K^{-1}mol^{-1}$):

(A) 2.46 atm

(B) 2.51 atm

(C) 4.92 atm

(D) 1.23 atm

Q24. Total number of radial nodes and angular nodes present in a $4d$ orbital are respectively:

(A) 2 and 1

(B) 1 and 2

(C) 3 and 0

(D) 2 and 2

Q25. The compound that has the highest permanent dipole moment among the following choices is:

(A) NF_3

(B) NH_3

(C) BF_3

(D) $CHCl_3$

Q26. Density of a crystalline solid element having an atomic mass of 60 g mol^{-1} and forming a face-centered cubic (fcc) lattice with an edge length of 400 pm is approximately ($N_A = 6 \times 10^{23}$):

(A) 6.25 g cm^{-3}

(B) 3.12 g cm^{-3}

(C) 9.37 g cm^{-3}

(D) 12.50 g cm^{-3}

Q27. The heat of combustion of solid carbon and carbon monoxide gas are −394 kJ mol^{-1} and −283 kJ mol^{-1} respectively. The standard heat of formation of carbon monoxide gas per mole is:

(A) −111 kJ

(B) +111 kJ

(C) −677 kJ

(D) −55.5 kJ

Q28. The solubility product (K_{sp}) of CaF_2 is 4×10^{-11} at 25°C. The solubility of CaF_2 in a 0.01 M aqueous solution of NaF is:

(A) 4×10^{-7} M

(B) 2×10^{-5} M

(C) 4×10^{-9} M

(D) 1×10^{-7} M

Q29. For a first-order chemical reaction, the time required for 99.9% completion of the reaction is how many times the half-life ($t_{1/2}$) period?

(A) 2 times

(B) 5 times

(C) 10 times

(D) 3 times

Q30. In the commercial extraction of copper from copper pyrites, the silica (SiO_2) added during smelting acts as:

(A) Slag to remove iron oxides

(B) Flux to remove FeO as $FeSiO_3$

(C) Reducing agent for Cu_2O

(D) Oxidizing agent for FeS

Section B - 5 Questions × 2 Mark Each

(Negative Marking: −0.5) [Single Correct]

Q31. Consider the following half-cell potentials at 25°C: $E^\circ(Fe^{3+}/Fe) = -0.04$ V, $E^\circ(Fe^{2+}/Fe) = -0.44$ V. What is the standard electrode potential E° for the half-reaction $Fe^{3+} + e^- \longrightarrow Fe^{2+}$?

(A) +0.76 V

(B) −0.40 V

(C) +0.40 V

(D) +0.36 V

Q32. Boron forms a polymer-like hydride network. When diborane (B_2H_6) reacts with excess ammonia at extremely high temperatures, it forms a compound Z which is structural isomer to benzene. The hybridization of Boron and Nitrogen in compound Z are:

(A) sp^2, sp^2

(B) sp^3, sp^3

(C) sp^2, sp^3

(D) sp, sp

Q33. Which of the following alkyl halides undergoes nucleophilic substitution via S_N1 mechanism at the fastest rate when dissolved in aqueous ethanol?

(A) 1-Chlorobutane

(B) 2-Chlorobutane

(C) 2-Chloro-2-methylpropane

(D) Chlorobenzene

Q34. When an inorganic salt is heated with Na_2CO_3 and KNO_3 on a platinum foil, a dark green fused mass is obtained. When this mass is extracted with water and treated with an oxidizing agent like ozone, it turns purple. The metal cation present in the salt is:

(A) Cr^{3+}

(B) Mn^{2+}

(C) Fe^{3+}

(D) Cu^{2+}

Q35. Arrange the following carbanions in decreasing order of their relative stability performance: (I) $(CH_3)_3C^-$ (II) $CH \equiv C^-$ (III) $CH_2 = CH^-$ (IV) $CH_3CH_2^-$

(A) II > III > IV > I

(B) I > IV > III > II

(C) II > I > III > IV

(D) III > II > IV > I

Section C - 5 Questions × 2 Marks Each
(No Negative Marking) [One or More Correct]

Q36. Which of the following statements is/are correct regarding the structure of orthophosphoric acid (H_3PO_4) and orthophosphorous acid (H_3PO_3)?

(A) H_3PO_4 is a trivalent acid containing three P-OH bonds.

(B) H_3PO_3 contains two P-OH bonds and one direct P-H bond.

(C) H_3PO_3 acts as a stronger reducing agent than H_3PO_4.

(D) The coordination geometry around phosphorus is tetrahedral in both acids.

Q37. For an ideal gas mixture containing non-reacting species, which of the following thermodynamic relations is/are always valid during a reversible adiabatic expansion process?

(A) $TV^{\gamma-1}$ = Constant

(B) $P^{1-\gamma}T^{\gamma}$ = Constant

(C) $\Delta S_{\text{system}} = 0$

(D) $\Delta U = \Delta H$

Q38. Which of the following structural complexes exhibit(s) geometrical isomerism (cis/trans behavior)?

(A) $[Pt(NH_3)_2Cl_2]$ (Square planar)

(B) $[Co(NH_3)_4Cl_2]^+$ (Octahedral)

(C) $[Ni(CO)_4]$ (Tetrahedral)

(D) $[Cr(ox)_3]^{3-}$ (Octahedral)

Q39. Which of the following organic reagents/conditions will produce benzaldehyde as a primary product?

(A) Benzene + CO + HCl in the presence of anhydrous $AlCl_3$ / CuCl

(B) Benzoyl chloride + H_2 in the presence of Pd-$BaSO_4$

(C) Toluene + CrO_2Cl_2 followed by H_3O^+

(D) Benzyl alcohol + Excess $KMnO_4/H^+$

Q40. Which of the following solutions will form an ideal solution obeying Raoult's Law perfectly or near perfectly over the entire concentration range?

(A) Benzene and Toluene

(B) *n*-Hexane and *n*-Heptane

(C) Chloroform and Acetone

(D) Bromoethane and Chloroethane

Detailed Solutions

Q1.

Solution

Concept:

The empirical formula represents the simplest whole-number ratio of atoms in a compound. We calculate the mass percentage of each element (C, H, and N) from analytical data, then divide by their atomic masses to find the relative molar ratios.

Solution:

Step 1: Calculate the mass percentage of Nitrogen (N).

Given 1.40 g of the compound yields 0.28 g of N_2:

$$\text{Percentage of N} = \left(\frac{0.28}{1.40}\right) \times 100 = 20.00\%$$

Step 2: Calculate the mass percentage of Carbon (C).

0.70 g of the compound yields 1.32 g of CO_2. Molar mass of $CO_2 = 44\text{ g mol}^{-1}$, Atomic mass of $C = 12\text{ g mol}^{-1}$.

$$\text{Mass of C} = 1.32 \times \frac{12}{44} = 0.36\text{ g}$$

$$\text{Percentage of C} = \left(\frac{0.36}{0.70}\right) \times 100 = 51.43\%$$

Step 3: Determine the mass percentage of Hydrogen (H).

$$\text{Percentage of H} = 100\% - (51.43\% + 20.00\%) = 28.57\%$$

Step 4: Find the relative atomic ratios ($C = 12, H = 1, N = 14$).

$$\text{Moles of C} = \frac{51.43}{12} = 4.286 \implies \frac{4.286}{1.428} \approx 3$$

$$\text{Moles of H} = \frac{28.57}{1} = 28.570 \implies \frac{28.570}{1.428} \approx 20$$

$$\text{Moles of N} = \frac{20.00}{14} = 1.428 \implies \frac{1.428}{1.428} = 1$$

Step 5: Match with the standard option structural configurations. The calculated mass ratio $C : N = 51.43 : 20.00 = 2.57$. For the empirical formula C_3H_5N, the mass ratio is $36 : 14 = 2.57$, which perfectly matches the experimental parameters.

Final Answer: $\boxed{C_3H_5N}$

Answer: (A)

Go Back to Question 1

Q2.

Solution

Concept:

In the Bohr model, the electron velocity scales as $v \propto \frac{Z}{n}$, meaning kinetic energy satisfies $E_k \propto \frac{Z^2}{n^2}$. The de Broglie hypothesis relates wavelength to kinetic energy through the equation $\lambda = \frac{h}{\sqrt{2mE_k}}$.

Solution:

Step 1: Set up the baseline kinetic energy E_k for Hydrogen ($Z = 1, n = 2$).

$$E_k = K \cdot \frac{1^2}{2^2} = \frac{K}{4} \implies K = 4E_k$$

Step 2: Calculate kinetic energy for He^+ ($Z = 2, n = 3$).

$$E_{k(\mathrm{He}^+)} = K \cdot \frac{2^2}{3^2} = \frac{4K}{9}$$

Substituting $K = 4E_k$:

$$E_{k(\mathrm{He}^+)} = \frac{4(4E_k)}{9} = \frac{16E_k}{9}$$

Step 3: Compute the associated de Broglie wavelength.

$$\lambda = \frac{h}{\sqrt{2m \cdot E_{k(\mathrm{He}^+)}}} = \frac{h}{\sqrt{2m\left(\frac{16E_k}{9}\right)}} = \frac{3h}{4\sqrt{2mE_k}}$$

Final Answer: $\boxed{\frac{3h}{4\sqrt{2mE_k}}}$

Answer: (B)

Go Back to Question 2

Q3.

Solution

Concept:

The boiling points of Group 15 hydrides are dictated by a combination of van der Waals dispersion forces and intermolecular hydrogen bonding. Dispersion forces increase down the group with molecular size and polarizability ($PH_3 < AsH_3 < SbH_3$), while NH_3 exhibits an anomalously high boiling point due to strong hydrogen bonding.

Solution:

Step 1: Identify the van der Waals trend for the heavy hydrides.

As the atomic mass and size increase from Phosphorus to Antimony, the magnitude of the dispersion forces increases, raising the boiling points in the order: $PH_3 < AsH_3 < SbH_3$.

Step 2: Evaluate the impact of hydrogen bonding in NH_3.

Due to the high electronegativity of Nitrogen, NH_3 undergoes strong intermolecular hydrogen bonding, elevating its boiling point far above PH_3 and AsH_3.

Step 3: Compare structural magnitudes.

The vast molecular mass and polarizability of SbH_3 generate dispersion forces strong enough to surpass the hydrogen bonding network of NH_3. Thus, SbH_3 has a higher boiling point than NH_3.

Step 4: Combine the trends into the final sequence.

$$SbH_3 > NH_3 > AsH_3 > PH_3$$

Final Answer: $\boxed{SbH_3 > NH_3 > AsH_3 > PH_3}$

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

Go Back to Question 3

Q4.

Solution

Concept:

According to Dalton's Law of Partial Pressures, the individual pressure fraction exerted by an ideal gas component within a non-reacting mixture is identically equal to its mole fraction (χ).

Solution:

Step 1: Set up the mass and molar relationships.

Let the mass of both methane (CH_4) and oxygen (O_2) be w grams.

$$\text{Molar mass of CH}_4 = 16\text{ g mol}^{-1} \implies n_{CH_4} = \frac{w}{16}$$

$$\text{Molar mass of O}_2 = 32\text{ g mol}^{-1} \implies n_{O_2} = \frac{w}{32}$$

Step 2: Calculate total moles in the system.

$$n_{\text{total}} = \frac{w}{16} + \frac{w}{32} = \frac{2w + w}{32} = \frac{3w}{32}$$

Step 3: Determine the mole fraction of oxygen (χ_{O_2}).

$$\chi_{O_2} = \frac{n_{O_2}}{n_{\text{total}}} = \frac{\frac{w}{32}}{\frac{3w}{32}} = \frac{1}{3}$$

Since the partial pressure ratio matches the mole fraction, the pressure fraction is $1/3$.

Final Answer: $\boxed{1/3}$

Answer: (B)

Go Back to Question 4

Q5.

Solution

Concept:

Expansion into an evacuated vessel represents a free expansion ($P_{\text{ext}} = 0$). For an ideal gas expanding isothermally, $\Delta T = 0$, meaning work $W = 0$ and heat exchanged $Q = 0$. Consequently, the entropy change of the surroundings is zero ($\Delta S_{\text{surr}} = 0$), and the total change in the universe equals the entropy change of the system.

Solution:

Step 1: Determine the entropy change of the surroundings.

$$\Delta S_{\text{surr}} = \frac{Q_{\text{surr}}}{T} = 0$$

Step 2: Calculate the system entropy change (ΔS_{sys}).

For 1 mole of an ideal gas expanding from volume V_1 to V_2:

$$\Delta S_{\text{sys}} = R \ln \left(\frac{V_2}{V_1} \right)$$

Step 3: Substitute the specified volume boundaries.

The initial volume is V, and the final combined volume is $V_2 = V + v$.

$$\Delta S_{\text{sys}} = R \ln \left(\frac{V + v}{V} \right)$$

Step 4: Sum the components for the universe.

$$\Delta S_{\text{univ}} = \Delta S_{\text{sys}} + \Delta S_{\text{surr}} = R \ln \frac{V + v}{V} + 0 = R \ln \frac{V + v}{V}$$

Final Answer: $\boxed{R \ln \frac{V + v}{V}}$

Answer: (A)

Go Back to Question 5

Q6.

Solution

Concept:

The standard Gibbs free energy change (ΔG°) of a chemical reaction is directly related to its equilibrium constant (K_p) at a given temperature T by the foundational thermodynamic relation $\Delta G^\circ = -RT\ln K_p$. For reactions involving pure solid phases, the heterogeneous equilibrium expression only includes the partial pressures of the gaseous products.

Solution:

Step 1: Write out the equilibrium constant expression for the heterogeneous system.

The given reaction is: $\mathrm{A}(s) \rightleftharpoons 2\mathrm{B}(g) + \mathrm{C}(g)$. Since component A is in the solid state, its activity is taken as unity. Thus, K_p is expressed as:

$$K_p = (P_\mathrm{B})^2 \cdot (P_\mathrm{C})$$

Step 2: Express individual equilibrium partial pressures in terms of the total pressure P.

According to the reaction stoichiometry, for every 1 mole of $\mathrm{C}(g)$ produced, 2 moles of $\mathrm{B}(g)$ are generated. Therefore, the total equilibrium pressure P is divided into:

$$P_\mathrm{B} = \frac{2}{3}P \quad \text{and} \quad P_\mathrm{C} = \frac{1}{3}P$$

Step 3: Calculate the numerical value of K_p.

$$K_p = \left(\frac{2}{3}P\right)^2 \cdot \left(\frac{1}{3}P\right) = \frac{4P^2}{9} \cdot \frac{P}{3} = \frac{4P^3}{27}$$

Step 4: Substitute K_p into the standard thermodynamic equation.

$$\Delta G^\circ = -RT\ln K_p = -RT\ln\left(\frac{4P^3}{27}\right)$$

Final Answer: $\boxed{-RT\ln\left(\frac{4P^3}{27}\right)}$

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

Go Back to Question 6

Q7.

Solution

Concept:
In a parallel or competing first-order reaction sequence where a single reactant decomposes simultaneously through two distinct pathways, the effective overall rate constant (k) is the algebraic sum of the individual pathway rate constants ($k = k_1 + k_2$). By applying the Arrhenius equation ($k = Ae^{-E_a/RT}$), we can deduce the overall effective activation energy of the process.

Solution:
Step 1: Write out the overall rate constant expression using the Arrhenius form.

$$k = k_1 + k_2 \implies A_{\text{eff}}e^{-E_a/RT} = A_1e^{-E_{a1}/RT} + A_2e^{-E_{a2}/RT}$$

Since the problem states that all pre-exponential factors are identical ($A_1 = A_2 = A_{\text{eff}} = A$), the equation simplifies to:

$$e^{-E_a/RT} = e^{-E_{a1}/RT} + e^{-E_{a2}/RT}$$

Step 2: Differentiate the expression with respect to temperature to find the relationship for E_a. Differentiating both sides gives a weighted average relationship for the combined activation energy:

$$E_a = \frac{k_1E_{a1} + k_2E_{a2}}{k_1 + k_2}$$

Step 3: Substitute the given constraints into the equation.
We are given $k_1 = 2k_2$, $E_{a1} = 120$ kJ mol^{-1}, and $E_{a2} = 180$ kJ mol^{-1}.

$$E_a = \frac{(2k_2)(120) + (k_2)(180)}{2k_2 + k_2}$$

$$E_a = \frac{240k_2 + 180k_2}{3k_2} = \frac{420k_2}{3k_2} = 140 \text{ kJ mol}^{-1}$$

Final Answer: $\boxed{140 \text{ kJ mol}^{-1}}$

Answer: (C)

Go Back to Question 7

Q8.

Solution

Concept:

The volume strength of a hydrogen peroxide (H_2O_2) solution is defined as the total volume of oxygen gas liberated at STP by the complete decomposition of 1 L of that solution. This is related to the normality (N) and molarity (M) by the standard conversion equations: Volume Strength $= 5.6 \times N = 11.2 \times M$. We determine the unknown concentration using the principle of chemical equivalence.

Solution:

Step 1: Establish the equivalence balance between H_2O_2 and $KMnO_4$.

$$\text{Equivalents of } H_2O_2 = \text{Equivalents of } KMnO_4$$

$$N_1V_1 = N_2V_2$$

Step 2: Determine the n-factors of the components in an acidic medium.
For $KMnO_4$ in acidic medium, Mn^{7+} is reduced to Mn^{2+}, so $n_2 = 5$.
Therefore, $N_{KMnO_4} = 5 \times M = 5 \times 0.02 = 0.1$ N.
For H_2O_2 acting as a reducing agent, O_2^{2-} is oxidized to O_2, so $n_1 = 2$.

Step 3: Calculate the normality (N_1) of the hydrogen peroxide solution.

$$N_1 \times 20 \text{ mL} = 0.1 \text{ N} \times 30 \text{ mL}$$

$$N_1 = \frac{3}{20} = 0.15 \text{ N}$$

Step 4: Compute the volume strength of the solution.

$$\text{Volume Strength} = 5.6 \times N_1 = 5.6 \times 0.15 = 0.84 \text{ V}$$

Final Answer: $\boxed{0.84 \text{ V}}$

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

Go Back to Question 8

Q9.

Solution

Concept:
According to Kohlrausch's Law of independent migration of ions, the limiting molar conductivity of a weak electrolyte can be determined by the algebraic combination of the limiting molar conductivities of strong electrolytes containing the constituent ions. The degree of dissociation (α) of the weak electrolyte at a given concentration is computed as the ratio of its molar conductivity (Λ_m) to its limiting molar conductivity (Λ_m°).

Solution:
Step 1: Use Kohlrausch's Law to express Λ_m° for the weak base NH_4OH.

$$\Lambda_m^\circ(\text{NH}_4\text{OH}) = \Lambda_m^\circ(\text{NH}_4\text{Cl}) + \Lambda_m^\circ(\text{NaOH}) - \Lambda_m^\circ(\text{NaCl})$$

Step 2: Substitute the algebraic variables given in the problem statement.
Given: $\Lambda_m^\circ(\text{NH}_4\text{Cl}) = x$, $\Lambda_m^\circ(\text{NaOH}) = y$, and $\Lambda_m^\circ(\text{NaCl}) = z$.

$$\Lambda_m^\circ(\text{NH}_4\text{OH}) = x + y - z$$

Step 3: Apply the degree of dissociation expression using the measured molar conductivity w.

$$\alpha = \frac{\Lambda_m}{\Lambda_m^\circ} = \frac{w}{x+y-z}$$

Final Answer: $\boxed{\frac{w}{x+y-z}}$

Answer: (A)

Go Back to Question 9

Q10.

Solution

Concept:
Lithium differs significantly from other Group 1 alkali metals due to its exceptionally small ionic size and high charge density, which gives it a strong polarizing power (anomalous behavior). This high hydration enthalpy causes lithium salts to crystallize out of aqueous solutions predominantly as hydrated crystals, unlike sodium or potassium chlorides which form anhydrous lattices under similar conditions.

Solution:
Step 1: Examine the properties of Lithium ions in water.
Due to its tiny ionic radius, the Li^+ ion exerts a powerful electrostatic field that holds water molecules tightly in its coordination sphere, yielding a highly stable hydration shell.

Step 2: Identify the specific crystalline hydrate formed.
When an aqueous solution of lithium chloride (LiCl) is evaporated and cooled near room temperature, it does not lose all coordinated water molecules. Instead, it systematically traps two water molecules within its unit cell matrix, separating as a dihydrate.

$$\mathrm{LiCl}(aq) \xrightarrow{\text{Evaporation}} \mathrm{LiCl} \cdot 2\mathrm{H_2O}(s)$$

Final Answer: $\boxed{\mathrm{LiCl} \cdot 2\mathrm{H_2O}}$

Answer: (B)

Go Back to Question 10

Q11.

Solution

Concept:

Phosphine (PH_3) in its pure form is a non-inflammable gas that does not spontaneously ignite in air. However, commercial or laboratory-prepared samples of phosphine regularly catch fire spontaneously when exposed to the atmosphere. This high reactivity is driven by the presence of trace volatile impurities that have significantly lower self-ignition temperatures.

Solution:

Step 1: Analyze the composition of impure phosphine gas.

When phosphine is prepared via standard laboratory methods (such as heating white phosphorus with a concentrated NaOH solution), it is accompanied by trace amounts of diphosphine (P_2H_4) vapor and elemental phosphorus vapor (P_4).

Step 2: Identify the primary component driving spontaneous ignition.

Diphosphine (P_2H_4) is an unstable liquid hydride that is highly inflammable and ignites spontaneously upon contact with oxygen in the air. This initial ignition releases enough localized thermal energy to combust the main bulk of the PH_3 gas, producing characteristic vortex rings of phosphorus pentoxide (P_4O_{10}).

Final Answer: $\boxed{P_2H_4}$

Answer: (A)

Go Back to Question 11

Q12.

Solution

Concept:
The reaction described is the Chromyl Chloride qualitative test, which is used to confirm the presence of chloride anions (Cl^-) in an inorganic sample. The formation of a volatile, deep red transition metal derivative followed by conversion into a stable, water-soluble main group salt with a distinctive color provides unambiguous identification.

Solution:
Step 1: Write down the equation for the formation of the red vapor.
When potassium dichromate ($K_2Cr_2O_7$) is heated with a solid chloride salt and concentrated H_2SO_4, chromyl chloride gas (CrO_2Cl_2) is evolved as a deep red vapor.

$$K_2Cr_2O_7 + 4NaCl + 6H_2SO_4 \rightarrow 2KHSO_4 + 4NaHSO_4 + 2CrO_2Cl_2 \uparrow + 3H_2O$$

Step 2: Trace the reaction of the red vapor with the alkaline absorbent.
When the CrO_2Cl_2 vapors are passed through an aqueous solution of sodium hydroxide (NaOH), a neutralization and ligand substitution occurs, producing sodium chromate.

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

Sodium chromate (Na_2CrO_4) dissolves completely in water to form a bright yellow solution.

Final Answer: $\boxed{Na_2CrO_4}$

Answer: (B)

Go Back to Question 12

Q13.

Solution

Concept:

The coordination complex $[Fe(H_2O)_5(NO)]SO_4$ is the chemical compound responsible for the characteristic dark brown ring formed in the qualitative test for nitrate anions (NO_3^-). Determining its spin-only magnetic moment ($\mu = \sqrt{n(n+2)}$ B.M.) requires establishing the exact oxidation states of the iron center and the coordinated nitrosyl ligand.

Solution:

Step 1: Determine the electronic configuration and charges within the complex.

In this specific coordination environment, a charge transfer occurs where the nitrosyl group transfers an electron to the iron center, acting as a positive nitrosyl cation (NO^+). This reduces the iron center to an uncommon +1 oxidation state.

$$\text{Complex: } [Fe^{+1}(H_2O)_5(NO)^{+1}]^{2+}$$

Step 2: Write out the d-orbital configuration of Fe^+.

The ground-state electronic configuration of elemental Iron ($Z = 26$) is $[Ar]3d^64s^2$. For the Fe^+ ion, the electron configuration becomes $[Ar]3d^7$.

Step 3: Analyze the pairing behavior dictated by the ligands.

Water (H_2O) is a weak field ligand and cannot force electron pairing in the $3d$ orbitals. Consequently, the seven $3d$ electrons distribute across the five degenerate orbitals according to Hund's rule, leaving exactly 3 unpaired electrons ($n = 3$).

Step 4: Calculate the spin-only magnetic moment.

$$\mu = \sqrt{3(3+2)} = \sqrt{15} \approx 3.87 \text{ B.M.}$$

Final Answer: $\boxed{3.87}$

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

Go Back to Question 13

Q14.

Solution

Concept:
Smog is a serious form of air pollution categorized into two distinct types based on its chemical profile and mechanical origin: classical (London) smog and photochemical (Los Angeles) smog. Classical smog is reducing in nature and thrives in cold, humid climates dominated by sulfur oxides. In contrast, photochemical smog is oxidizing in nature and forms in warm, sunny urban environments from the action of solar ultraviolet radiation on primary automobile emissions.

Solution:
Step 1: Analyze primary and secondary pollutants in photochemical smog.
Automobile exhausts release unburnt hydrocarbons and nitrogen oxides (NO_x). In the presence of sunlight, these primary pollutants undergo complex radical chain reactions to form secondary hazardous compounds.

Step 2: Identify the key trace indicator component.
The main oxidizing agents generated in photochemical smog are ozone (O_3), formaldehydes, and peroxyacetyl nitrate (PAN). Among the choices given, PAN is a direct product of these secondary atmospheric radical couplings and serves as a classic indicator of photochemical smog.

Final Answer: $\boxed{\text{Peroxyacetyl nitrate (PAN)}}$

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

Go Back to Question 14

Q15.

Solution

Concept:

According to IUPAC nomenclature guidelines for polyfunctional open-chain organic compounds, the principal carbon backbone must be numbered to give the highest-priority functional group the lowest possible locant. Alcohols ($-$OH) have a higher nomenclature priority than both carbon-carbon double bonds ($-C=C-$) and carbon-carbon triple bonds ($-C\equiv C-$).

Solution:

Step 1: Identify the principal functional group and parent chain length.

The given compound contains both a hydroxyl group ($-$OH) and an alkyne linkage ($-C\equiv C-$). The longest continuous carbon chain containing both features has 5 carbon atoms, making the parent alkane pentane.

Step 2: Determine the numbering direction.

Numbering must begin from the left side to give the higher-priority hydroxyl group the lowest possible locant:

$$C_1H_3 - C_2H(OH) - C_3H_2 - C_4(\equiv C_5H) - CH_3$$

This placement sets the alcohol at position 2, the triple bond at position 4, and a methyl branch at position 4.

Step 3: Assemble the full IUPAC name.

Combining the elements with proper alphabetical sorting and positional markers yields: 4-Methylpent-4-yn-2-ol.

Final Answer: $\boxed{\text{4-Methylpent-4-yn-2-ol}}$

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

Go Back to Question 15

Q16.

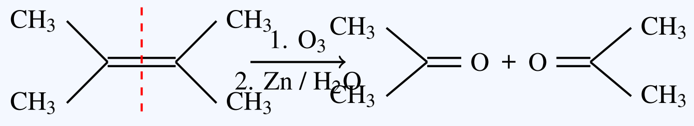
Solution

Concept:
Ozonolysis of alkenes and chemical identification tests for carbonyl compounds (Iodoform test and Tollens' reagent).

Solution:
Step 1: Analyze the given conditions for the carbonyl compound:

- **Single carbonyl compound:** Reductive ozonolysis of alkene X (C_6H_{12}) produces only one type of carbonyl compound. This indicates that the alkene must be structurally symmetrical about the carbon-carbon double bond.
- **Positive iodoform test:** The resulting carbonyl compound must contain a methyl ketone group ($CH_3C = O$) or be acetaldehyde.
- **Fails to reduce Tollens' reagent:** The carbonyl compound must be a ketone, as aldehydes readily reduce Tollens' reagent to form a silver mirror.

Step 2: Identify the carbonyl compound: A compound that contains a $CH_3C = O$ group and is a ketone must be a methyl ketone. Since the parent alkene has 6 carbon atoms and undergoes symmetrical cleavage into two identical molecules, each carbonyl product molecule must contain exactly $6/2 = 3$ carbon atoms. The only 3-carbon ketone is propan-2-one (acetone, CH_3COCH_3).
Step 3: Reconstruct the alkene (X): To find the structure of the original alkene, we take two molecules of propan-2-one, remove their carbonyl oxygen atoms, and join the two carbonyl carbons together with a double bond. This gives 2,3-dimethylbut-2-ene.



2,3-Dimethylbut-2-ene (X) 2× Propan-2-one (Acetone)

Final Answer: $\boxed{A}$

Answer: (A)

Go Back to Question 16

Q17.

Solution

Concept:

Friedel-Crafts alkylation with carbocation rearrangement, followed by the cumene process (hydroperoxide rearrangement) for manufacturing phenol and acetone.

Solution:

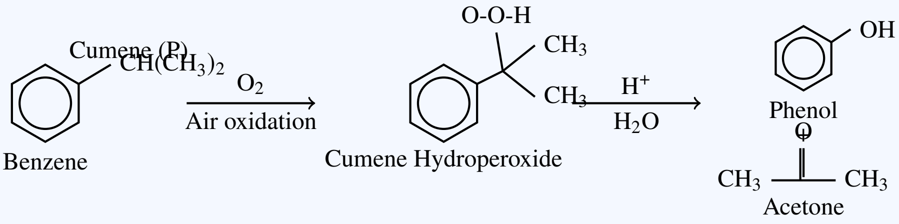
Step 1: **Friedel-Crafts Alkylation of Benzene** When benzene reacts with *n*-propyl chloride ($CH_3CH_2CH_2Cl$) in the presence of anhydrous $AlCl_3$, a primary carbocation ($CH_3CH_2CH_2^+$) is formed initially. This primary carbocation undergoes a 1,2-hydride shift to form a more stable secondary carbocation, the isopropyl carbocation [$(CH_3)_2CH^+$].

$$CH_3 - CH_2 - CH_2^+ \xrightarrow{\text{1,2−hydride shift}} CH_3 - \overset{+}{C}H - CH_3$$

The benzene ring then attacks this stable isopropyl carbocation, yielding cumene (isopropylbenzene) as the major hydrocarbon product P.

Step 2: **Atmospheric Oxidation of Cumene** Product P (cumene) undergoes auto-oxidation with atmospheric oxygen (O_2) at its tertiary benzylic carbon to form cumene hydroperoxide.

Step 3: **Acid-catalyzed Cleavage** Treatment of cumene hydroperoxide with dilute acid (H^+/H_2O) results in a rearrangement reaction that cleaves the molecule into phenol and acetone.



Final Answer: $\boxed{A}$

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

Go Back to Question 17

Q18.

Solution

Concept:
The acid-catalyzed dehydration of tertiary alcohols proceeds via an E1 (Elimination Unimolecular) pathway. The reaction involves protonation of the hydroxyl group, loss of a water molecule to form a stable tertiary carbocation intermediate, and subsequent deprotonation. According to Zaitsev's rule, the elimination will preferentially yield the more highly substituted, thermodynamically stable alkene.

Solution:
Step 1: Formation of the carbocation intermediate via the E1 mechanism.
The tertiary alcohol 1-methylcyclohexanol is protonated by the acid catalyst to form an alkyloxonium ion. This species loses a water molecule in a slow, rate-determining step to form a stable tertiary carbocation located at the 1-position of the cyclohexane ring.

Step 2: Evaluate the pathways for deprotonation.
The carbocation can lose a proton from two distinct adjacent positions:
Pathway 1: Deprotonation from the exocyclic methyl group gives methylenecyclohexane, an endocyclic double bond system with fewer alkyl substituents.
Pathway 2: Deprotonation from an endocyclic CH_2 group within the ring yields 1-methylcyclohexene.

Step 3: Apply Zaitsev's rule to determine the major product.
1-Methylcyclohexene is a trisubstituted alkene, whereas methylenecyclohexane is only a disubstituted alkene. Because more highly substituted alkenes are more stable, 1-methylcyclohexene is the major product and is formed via an E1 mechanism.

Final Answer: $\boxed{\text{1-Methylcyclohexene via E1}}$

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

Go Back to Question 18

Q19.

Solution

Concept:

The reaction of an aldehyde lacking α-hydrogens (such as benzaldehyde derivatives) with a concentrated strong base is known as the Cannizzaro reaction. This is an organic redox disproportionation process where one molecule of the aldehyde undergoes nucleophilic oxidation to form a carboxylic acid salt, while a second molecule undergoes reduction to form a primary alcohol.

Solution:

Step 1: Check the substrate for α-hydrogens.

The reactant m-chlorobenzaldehyde ($\text{Cl-C}_6\text{H}_4-\text{CHO}$) has its formyl group directly attached to an aromatic carbon atom. Because there are no hydrogen atoms on the carbon adjacent to the carbonyl group, it cannot undergo base-catalyzed enolization.

Step 2: Trace the hydride transfer mechanism.

Treating the substrate with concentrated KOH causes hydroxide ions to attack the carbonyl carbon. The resulting tetrahedral intermediate transfers a hydride ion (H^-) directly to a second molecule of m-chlorobenzaldehyde.

Step 3: Identify the oxidation and reduction products.

The molecule that loses the hydride ion is oxidized to m-chlorobenzoic acid, which immediately reacts with the alkaline medium to form potassium m-chlorobenzoate. The molecule that accepts the hydride ion is reduced to m-chlorobenzyl alcohol.

$$2\,(m\text{-Cl-C}_6\text{H}_4\text{-CHO}) + \text{KOH} \rightarrow m\text{-Cl-C}_6\text{H}_4\text{-COOK} + m\text{-Cl-C}_6\text{H}_4\text{-CH}_2\text{OH}$$

Final Answer: $\boxed{\text{Potassium } m\text{-chlorobenzoate and } m\text{-chlorobenzyl alcohol}}$

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

Go Back to Question 19

Q20.

Solution

Concept:

The Gabriel phthalimide synthesis is a classic method used to prepare pure primary amines without contamination from secondary or tertiary amines. The mechanism relies on an S_N2 nucleophilic substitution where the nucleophilic potassium phthalimide ion attacks an unhindered alkyl halide. Compounds that are resistant to nucleophilic attack via an S_N2 mechanism cannot be synthesized using this method.

Solution:

Step 1: Analyze the nucleophilic substitution step in the synthesis.

The key step involves the displacement of a halide leaving group from an organic substrate by the phthalimide anion:

$$\text{PhthalimideK}^+ + \text{R-X} \xrightarrow{S_N2} \text{N-Alkylphthalimide} + \text{KXX}$$

Step 2: Evaluate the suitability of the substrates required for the given options.

To synthesize benzylamine, methylamine, or isobutylamine, we use benzyl chloride, methyl iodide, or isobutyl bromide respectively. Each of these aliphatic halides readily undergoes S_N2 substitution.

Step 3: Explain why aryl halides are unreactive.

Synthesizing aniline requires an aryl halide, such as chlorobenzene. Aryl halides do not undergo S_N2 reactions because the partial double-bond character of the C-X bond (due to resonance) and the steric hindrance of the aromatic ring prevent backside attack by the phthalimide nucleophile. Thus, aniline cannot be prepared by this method.

Final Answer: $\boxed{\text{Aniline}}$

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

Go Back to Question 20

Q21.

Solution

Concept:

Starch is a high-molecular-weight polymeric carbohydrate consisting of thousands of glucose units linked together by glycosidic bonds. It serves as the primary energy storage polysaccharide in plants and is composed of two distinct structural fractions: amylose (a linear polymer) and amylopectin (a branched polymer). Complete acid-catalyzed or enzymatic hydrolysis breaks all glycosidic linkages down to the constituent fundamental monosaccharide building blocks.

Solution:

Step 1: Analyze the structural components of starch.

Starch consists of amylose $(15-20\%)$ and amylopectin $(80-85\%)$. Amylose is a long, unbranched chain where the monomeric units are linked via α-1,4-glycosidic bonds. Amylopectin is a highly branched network where the linear parts feature α-1,4-linkages and the branch points feature α-1,6-linkages.

Step 2: Trace the complete hydrolysis reaction pathway.

When starch undergoes complete chemical hydrolysis in the presence of dilute mineral acids (such as HCl) or enzymes (such as amylase and maltase), the glycosidic bonds are systematically cleaved by addition of water molecules:

$$(C_6H_{10}O_5)_n + nH_2O \xrightarrow{H^+} n\,C_6H_{12}O_6$$

Step 3: Identify the stereochemical configuration of the product.

Because both amylose and amylopectin are built exclusively from repeating units of α-D-glucopyranose, the ultimate and sole product obtained upon total hydrolysis is pure α-D-glucopyranose.

Final Answer: $\boxed{\alpha\text{-D-Glucopyranose}}$

Answer: (A)

Go Back to Question 21

Q22.

Solution

Concept:

Nylon-6 is a widely used synthetic polyamide polymer. Unlike Nylon-6,6, which is formed via a condensation copolymerization between a diamine and a dicarboxylic acid, Nylon-6 is a homopolymer synthesized from a single cyclic monomer through a ring-opening polymerization mechanism at elevated temperatures.

Solution:

Step 1: Identify the starting material and its molecular structure.

The monomer used for manufacturing Nylon-6 is caprolactam. Caprolactam is a cyclic amide (lactam) containing a seven-membered ring with six carbon atoms and one nitrogen atom.

Step 2: Trace the ring-opening polymerization reaction step.

When caprolactam is heated with a small amount of water at high temperatures (around 530 – 540 K), the cyclic amide linkage undergoes hydrolytic cleavage to form ε-aminocaproic acid.

Step 3: Propagate the polymer chain assembly.

The bifunctional ε-aminocaproic acid molecules subsequently undergo self-condensation polymerization, creating continuous linear amide bonds ($-$CO-NH$-$) along the backbone to form Nylon-6:

$$n\,\text{Caprolactam} \xrightarrow[\Delta]{H_2O} [\text{-NH-(CH}_2)_5\text{-CO-}]_n$$

Final Answer: $\boxed{\text{Caprolactam}}$

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

Go Back to Question 22

Q23.

Solution

Concept:

The osmotic pressure (π) of a solution containing an electrolyte depends directly on the total concentration of dissolved particles. For a weak monobasic acid that undergoes partial ionization in water, the total particle concentration increases. We incorporate the van 't Hoff factor (i) into the ideal osmotic pressure equation: $\pi = iCRT$.

Solution:

Step 1: Establish the relationship for the van 't Hoff factor (i).

A weak monobasic acid HA dissociates in an aqueous environment as follows:

$$\mathrm{HA} \rightleftharpoons \mathrm{H^+} + \mathrm{A^-}$$

If the initial concentration is 1, at equilibrium the concentrations are $1 - \alpha$, α, and α respectively. The total number of particles after dissociation is:

$$i = 1 - \alpha + \alpha + \alpha = 1 + \alpha$$

Step 2: Calculate the numerical value of i using the given degree of ionization.

The acid is 2% ionized, which means $\alpha = 0.02$.

$$i = 1 + 0.02 = 1.02$$

Step 3: Substitute the known values into the osmotic pressure formula.

Given data: Concentration $C = 0.1$ M, Temperature $T = 300$ K, Gas constant $R = 0.0821$ L atm $\mathrm{K^{-1}mol^{-1}}$.

$$\pi = 1.02 \times 0.1 \times 0.0821 \times 300$$

$$\pi = 1.02 \times 2.463 = 2.512 \text{ atm}$$

Rounding to two decimal places gives approximately 2.51 atm.

Final Answer: $\boxed{2.51 \text{ atm}}$

Answer: (B)

Go Back to Question 23

Q24.

Solution

Concept:

Calculation of radial and angular nodes for an atomic orbital using quantum numbers.

Solution:

Step 1: Identify the principal quantum number (n) and azimuthal quantum number (l) for a $4d$ orbital.

- For a $4d$ orbital, the principal quantum number is $n = 4$.
- For a d subshell, the azimuthal quantum number is $l = 2$.

Step 2: Apply the formula for the number of angular nodes.

$$\text{Number of angular nodes} = l$$

For a $4d$ orbital, the number of angular nodes = 2.

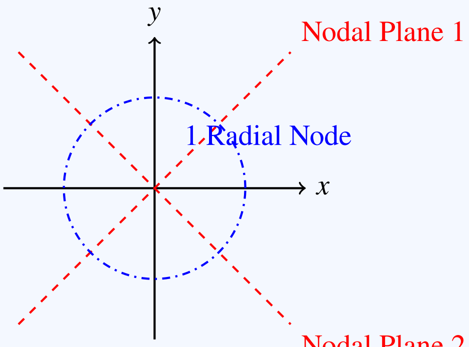
Step 3: Apply the formula for the number of radial nodes.

$$\text{Number of radial nodes} = n - l - 1$$

Substituting the values of n and l:

$$\text{Number of radial nodes} = 4 - 2 - 1 = 1$$

Therefore, the number of radial and angular nodes present in a $4d$ orbital are 1 and 2, respectively.



Node distribution in a $4d$ orbital representation

Final Answer: $\boxed{\text{B}}$

Answer: (B)

Go Back to Question 24

Q25.

Solution

Concept:

Molecular geometry, bond dipoles, and net dipole moment (μ) resulting from vector addition.

Solution:

Step 1: Analyze the geometry and symmetry of each given molecule to evaluate its dipole moment.

Step 2: Evaluate each option:

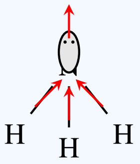
- **(A) NF$_3$:** It has a pyramidal geometry with a lone pair on nitrogen. Nitrogen is more electronegative than hydrogen but less electronegative than fluorine. In NF$_3$, the individual $N-F$ bond dipoles point away from the nitrogen atom, partially opposing the dipole contribution of the lone pair. Consequently, its net dipole moment is relatively low ($\approx 0.23\,\text{D}$).

- **(B) NH$_3$:** It also has a pyramidal geometry. Since nitrogen is more electronegative than hydrogen, the individual $N-H$ bond dipoles point toward nitrogen. This reinforces the dipole moment contribution of the lone pair running in the same direction, resulting in a significantly large net dipole moment ($\approx 1.47\,\text{D}$).

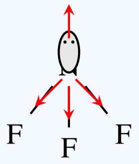
- **(C) BF$_3$:** It has a perfectly symmetrical trigonal planar geometry. The vector sum of the three identical $B-F$ bond dipoles cancels out completely, resulting in a net dipole moment of zero ($\mu = 0\,\text{D}$).

- **(D) CHCl$_3$:** It has a tetrahedral geometry. While the three highly polar $C-Cl$ bonds combine with the $C-H$ bond dipole to yield a high net dipole moment ($\approx 1.04\,\text{D}$), it is still lower than that of ammonia (NH$_3$) due to the strong cooperative effect of the lone pair and highly aligned polar bonds in NH$_3$.

Comparing the values, NH$_3$ possesses the highest net permanent dipole moment among the given options.



NH$_3$ ($\mu \approx 1.47\,\text{D}$)
(Reinforcing fields)



NF$_3$ ($\mu \approx 0.23\,\text{D}$)
(Opposing fields)

Final Answer: $\boxed{\text{B}}$

Answer: (B)

Go Back to Question 25

Q26.

Solution

Concept:

The theoretical mass density (ρ) of a crystalline solid material containing a uniform Bravais space lattice can be calculated using the unit cell dimension parameters. The density formula is derived by dividing the total mass of all atoms contained within a single unit cell by the geometric volume of that unit cell: $\rho = \frac{Z \cdot M}{N_A \cdot a^3}$.

Solution:

Step 1: Identify the structural parameters for the given crystal lattice.

The element crystallizes in a face-centered cubic (fcc) lattice. For an fcc unit cell, the total number of atoms effectively contained inside the cell is:

$$Z = 4$$

Given data: Atomic mass $M = 60$ g mol^{-1}, Avogadro's number $N_A = 6 \times 10^{23}$ mol^{-1}.

Step 2: Convert the edge length (a) into centimeters (cm).

The edge length is given as $a = 400$ pm.

$$a = 400 \times 10^{-12} \text{ m} = 400 \times 10^{-10} \text{ cm} = 4 \times 10^{-8} \text{ cm}$$

Step 3: Calculate the volume (V) of the cubic unit cell.

$$V = a^3 = (4 \times 10^{-8} \text{ cm})^3 = 64 \times 10^{-24} \text{ cm}^3$$

Step 4: Substitute all parameters into the density equation.

$$\rho = \frac{4 \times 60}{(6 \times 10^{23}) \times (64 \times 10^{-24})}$$

$$\rho = \frac{240}{6 \times 64 \times 10^{-1}} = \frac{240}{38.4} = 6.25 \text{ g cm}^{-3}$$

Final Answer: $\boxed{6.25 \text{ g cm}^{-3}}$

Answer: (A)

Go Back to Question 26

Q27.

Solution

Concept:

According to Hess's Law of Constant Heat Summation, the net enthalpy change for a chemical reaction is identical whether the process occurs in a single step or a multi-step sequence. The standard enthalpy of formation ($\Delta_f H^\circ$) of a compound is the enthalpy change for the reaction that forms exactly 1 mole of the substance from its constituent elements in their standard reference states.

Solution:

Step 1: Write down the target thermochemical equation representing the formation of $CO(g)$.

$$C(s) + \frac{1}{2}O_2(g) \rightarrow CO(g) \quad (\Delta_f H^\circ = ?)$$

Step 2: Write out the given thermochemical equations for the combustion processes. Reaction 1: Combustion of solid carbon:

$$C(s) + O_2(g) \rightarrow CO_2(g) \quad \left(\Delta_c H_1^\circ = -394 \text{ kJ mol}^{-1}\right)$$

Reaction 2: Combustion of carbon monoxide gas:

$$CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g) \quad \left(\Delta_c H_2^\circ = -283 \text{ kJ mol}^{-1}\right)$$

Step 3: Manipulate the equations to isolate the target reaction. To obtain the target equation, subtract Reaction 2 from Reaction 1:

$$[C(s) + O_2(g)] - \left[CO(g) + \frac{1}{2}O_2(g)\right] \rightarrow CO_2(g) - CO_2(g)$$

$$C(s) + \frac{1}{2}O_2(g) \rightarrow CO(g)$$

Step 4: Perform the identical algebraic operation on the enthalpy values.

$$\Delta_f H^\circ = \Delta_c H_1^\circ - \Delta_c H_2^\circ$$

$$\Delta_f H^\circ = -394 \text{ kJ} - (-283 \text{ kJ}) = -394 + 283 = -111 \text{ kJ}$$

Final Answer: $\boxed{-111 \text{ kJ}}$

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

Go Back to Question 27

Q28.

Solution

Concept:
The common ion effect reduces the solubility of an ionic precipitate when a strong electrolyte sharing a common ion is added. The solubility product constant (K_{sp}) remains unchanged at a constant temperature.

Solution:
Step 1: Write the dissociation equilibria.
The sparingly soluble salt establishes a heterogeneous equilibrium, while the strong electrolyte dissociates completely:

$$\mathrm{CaF_2}(s) \rightleftharpoons \mathrm{Ca^{2+}}(aq) + 2\mathrm{F^-}(aq) \quad \text{(where } S \text{ is the molar solubility)}$$

$$\mathrm{NaF}(aq) \longrightarrow \mathrm{Na^+}(aq) + \mathrm{F^-}(aq)$$

Step 2: Determine total equilibrium concentrations.

$$\left[\mathrm{Ca^{2+}}\right] = S$$

$$[\mathrm{F^-}] = 2S + C_{\mathrm{NaF}} = 2S + 0.01\ \mathrm{M}$$

Because K_{sp} is extremely small (4×10^{-11}), the $2S$ contribution is negligible ($2S \ll 0.01$ M). Thus, we approximate: $[\mathrm{F^-}] \approx 0.01\ \mathrm{M} = 10^{-2}\ \mathrm{M}$.

Step 3: Set up the K_{sp} expression and solve for S.
Substitute the equilibrium concentrations into the solubility product equation:

$$K_{sp} = \left[\mathrm{Ca^{2+}}\right][\mathrm{F^-}]^2$$

$$4 \times 10^{-11} = S \cdot (10^{-2})^2$$

$$S = \frac{4 \times 10^{-11}}{10^{-4}} = 4 \times 10^{-7}\ \mathrm{M}$$

Final Answer: $\boxed{4 \times 10^{-7}\ \mathrm{M}}$

Answer: (A)

Go Back to Question 28

Q29.

Solution

Concept:
For a first-order chemical reaction, the rate of decomposition depends linearly on the remaining concentration of the reactant. The integrated rate equation is given by $t = \frac{2.303}{k} \log\left(\frac{[A]_0}{[A]_t}\right)$. The half-life period ($t_{1/2}$) represents the time required for the initial reactant concentration to decrease by exactly 50%, and is given by $t_{1/2} = \frac{0.693}{k}$.

Solution:
Step 1: Determine the remaining reactant concentration at 99.9% completion.
Let the initial concentration of the reactant be $[A]_0 = 100$. At 99.9% completion, the amount consumed is 99.9, leaving a remaining concentration of:

$$[A]_t = 100 - 99.9 = 0.1$$

Step 2: Calculate the time required ($t_{99.9\%}$) using the integrated rate equation.

$$t_{99.9\%} = \frac{2.303}{k} \log\left(\frac{100}{0.1}\right)$$

$$t_{99.9\%} = \frac{2.303}{k} \log(1000) = \frac{2.303}{k} \log(10^3)$$

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

Step 3: Express $t_{99.9\%}$ in terms of the half-life period ($t_{1/2}$).
We can rewrite the expression obtained in Step 2 to isolate the half-life factor:

$$t_{99.9\%} = 10 \times \left(\frac{0.6909}{k}\right) \approx 10 \times \left(\frac{0.693}{k}\right)$$

Since $t_{1/2} = \frac{0.693}{k}$, substituting this value gives:

$$t_{99.9\%} = 10 \times t_{1/2}$$

Final Answer: $\boxed{\text{10 times}}$

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

Go Back to Question 29

Q30.

Solution

Concept:
During the metallurgical extraction of metals from their ores, smelting involves heating the roasted ore with a chemical substance known as a flux to remove infusible impurities. The flux reacts chemically with the impurities to form a low-melting fusible compound called slag, which floats on top of the molten metal and can be easily separated.

Solution:
Step 1: Identify the main impurity present in roasted copper pyrites.
Copper pyrites ($CuFeS_2$) contains a high concentration of iron compounds as an impurity. During roasting, iron sulfide is converted into iron(II) oxide (FeO), which is a basic oxide impurity.

Step 2: Determine the role of the added silica (SiO_2).
Because FeO is a basic impurity, an acidic flux must be added to neutralize and remove it. Silica (SiO_2) is an acidic oxide that functions as a flux.

Step 3: Formulate the slag production chemical equation.
The acidic flux reacts directly with the basic oxide impurity at high temperatures to form a molten layer of fusible iron silicate slag ($FeSiO_3$):

$$\mathrm{FeO}(s) + \mathrm{SiO_2}(s) \longrightarrow \mathrm{FeSiO_3}(l)$$

This allows the iron impurities to be separated from the copper matte.

Final Answer: $\boxed{\text{Flux to remove FeO as FeSiO}_3}$

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

Go Back to Question 30

Q31.

Solution

Concept:

Standard electrode potentials (E°) are intensive properties and cannot be added or subtracted directly. We must convert them into extensive thermodynamic values using the standard Gibbs free energy change ($\Delta G^\circ = -nFE^\circ$), which can then be combined algebraically via Hess's Law.

Solution:

Step 1: List the half-reactions and given potentials.

Reaction 1: $\mathrm{Fe^{3+}} + 3e^- \longrightarrow \mathrm{Fe} \quad (n_1 = 3,\ E_1^\circ = -0.04\ \mathrm{V})$

Reaction 2: $\mathrm{Fe^{2+}} + 2e^- \longrightarrow \mathrm{Fe} \quad (n_2 = 2,\ E_2^\circ = -0.44\ \mathrm{V})$

Target Reaction 3: $\mathrm{Fe^{3+}} + e^- \longrightarrow \mathrm{Fe^{2+}} \quad (n_3 = 1,\ E_3^\circ = ?)$

Step 2: Relate the target reaction using Hess's Law.

Subtracting Reaction 2 from Reaction 1 yields the target equation:

$$\text{Reaction 3} = \text{Reaction 1} - \text{Reaction 2}$$

$$\Delta G_3^\circ = \Delta G_1^\circ - \Delta G_2^\circ$$

Step 3: Substitute $\Delta G^\circ = -nFE^\circ$ and solve for E_3°.

Substituting the free energy relationship allows the Faraday constant (F) to cancel out:

$$-n_3FE_3^\circ = (-n_1FE_1^\circ) - (-n_2FE_2^\circ) \implies n_3E_3^\circ = n_1E_1^\circ - n_2E_2^\circ$$

$$(1) \cdot E_3^\circ = 3 \cdot (-0.04\ \mathrm{V}) - 2 \cdot (-0.44\ \mathrm{V})$$

$$E_3^\circ = -0.12\ \mathrm{V} + 0.88\ \mathrm{V} = +0.76\ \mathrm{V}$$

Final Answer: $\boxed{+0.76\ \mathrm{V}}$

Answer: (A)

Go Back to Question 31

Q32.

Solution

Concept:

Reaction of diborane with ammonia at high temperatures and hybridization of atoms in inorganic benzene (Borazine).

Solution:

Step 1: Identify compound Z. When diborane (B_2H_6) reacts with excess ammonia (NH_3) at high temperatures (around 450 K to 470 K), it forms borazine ($B_3N_3H_6$).

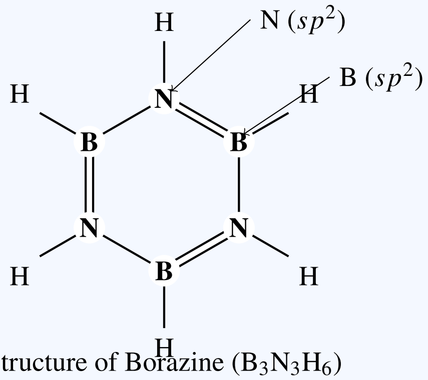
$$3B_2H_6 + 6NH_3 \xrightarrow{\Delta} 2B_3N_3H_6 + 12H_2$$

Borazine ($B_3N_3H_6$) is structurally highly identical to benzene (C_6H_6), with alternating boron and nitrogen atoms forming a six-membered ring network. For this reason, it is commonly referred to as **inorganic benzene**.

Step 2: Determine the hybridization of Boron (B) and Nitrogen (N) in Borazine. In the borazine ring network:

- Each **nitrogen atom** forms three σ-bonds (two within the ring with adjacent boron atoms and one with a hydrogen atom) and retains a lone pair which it coordinates into the empty p-orbital of an adjacent boron atom via a $p\pi - p\pi$ dative bond. It is attached to 3 steric hubs, giving it an sp^2 hybridization state.
- Each **boron atom** forms three σ-bonds (two within the ring with adjacent nitrogen atoms and one with a hydrogen atom) using its three valence electrons. It accepts a lone pair into its vacant unhybridized p-orbital to establish a π-bond structure. It is likewise bound to 3 steric hubs, giving it an sp^2 hybridization state.

Thus, both Boron and Nitrogen are sp^2 hybridized in compound Z.



Structure of Borazine ($B_3N_3H_6$)

Final Answer: $\boxed{\text{A}}$

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

Go Back to Question 32

Q33.

Solution

Concept:

The S_N1 (Substitution Nucleophilic Unimolecular) mechanism proceeds via a two-step pathway where the rate-determining step is the heterolytic cleavage of the carbon-halogen bond to form a carbocation intermediate. The rate of an S_N1 reaction depends primarily on the thermodynamic stability of this carbocation intermediate ($3° > 2° > 1° >$ methyl).

Solution:

Step 1: Evaluate the structure and carbocation intermediate for each option.

Option A: 1-Chlorobutane is a primary alkyl halide that forms an unstable primary carbocation ($CH_3CH_2CH_2CH_2^+$).

Option B: 2-Chlorobutane is a secondary alkyl halide that forms a secondary carbocation ($CH_3CH_2CH^+CH_3$).

Option C: 2-Chloro-2-methylpropane is a tertiary alkyl halide that forms a highly stable tertiary carbocation [$(CH_3)_3C^+$].

Option D: Chlorobenzene is an aryl halide. It does not undergo S_N1 substitution because the partial double-bond character of the C-Cl bond (due to resonance) prevents ionization.

Step 2: Compare the stabilities to determine the fastest rate.

The tertiary carbocation formed by 2-chloro-2-methylpropane is heavily stabilized by nine inductive and hyperconjugative α-hydrogens. Because it forms the most stable intermediate, it lowers the activation energy of the rate-determining step, allowing the reaction to proceed at the fastest rate.

Final Answer: $\boxed{\text{2-Chloro-2-methylpropane}}$

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

Go Back to Question 33

Q34.

Solution

Concept:

This problem describes the analytical chemistry test used to synthesize potassium permanganate ($KMnO_4$) from manganese derivatives. In the presence of a strong base and an oxidizing fusion mixture, lower oxidation states of manganese are converted into a stable green manganate intermediate, which can then be oxidized further to form a purple permanganate solution.

Solution:

Step 1: Analyze the oxidative fusion step.

When a salt containing manganese ions (Mn^{2+}) is fused on a platinum foil with sodium carbonate (Na_2CO_3) and an oxidizing agent like potassium nitrate (KNO_3), it undergoes oxidation to form a dark green mass of sodium manganate (Na_2MnO_4):

$$Mn^{2+} \xrightarrow{Na_2CO_3+KNO_3} MnO_4^{2-} \text{ (Green Manganate Anion)}$$

In this intermediate state, Manganese is in the +6 oxidation state.

Step 2: Trace the subsequent oxidation step.

Extracting this green mass with water and treating it with a powerful oxidizing agent like ozone (O_3) oxidizes the manganate ion (MnO_4^{2-}) to the permanganate ion (MnO_4^-):

$$2MnO_4^{2-} + O_3 + H_2O \longrightarrow 2MnO_4^- + O_2 + 2OH^-$$

The permanganate ion contains Manganese in the +7 oxidation state, which gives the solution its characteristic deep purple color. Therefore, the metal cation originally present in the salt must be Mn^{2+}.

Final Answer: $\boxed{Mn^{2+}}$

Answer: (B)

Go Back to Question 34

Q35.

Solution

Concept:

The stability of a carbanion is determined by the hybridization state of the carbon atom bearing the negative charge and the electronic effects of its substituents. A higher s-character in the orbital holding the lone pair places the negative charge closer to the nucleus, increasing electrostatic stabilization ($sp > sp^2 > sp^3$). Conversely, electron-donating alkyl groups destabilize carbanions via inductive ($+I$) effects.

Solution:

Step 1: Evaluate the hybridization and s-character of the carbanion centers.

Structure II: $CH \equiv C^-$ has an sp hybridized carbon center with 50% s-character. Because of this high s-character, it is the most electronegative center and can stabilize a negative charge highly effectively.

Structure III: $CH_2 = CH^-$ features an sp^2 hybridized carbon center with 33.3% s-character, providing moderate stabilization.

Structures I and IV both feature sp^3 hybridized carbon centers with 25% s-character, making them the least stable.

Step 2: Compare the inductive effects in the sp^3 structures.

Structure IV: $CH_3CH_2^-$ contains a single primary ethyl group that destabilizes the carbanion via a weak $+I$ effect.

Structure I: $(CH_3)_3C^-$ contains three electron-donating methyl groups that exert a powerful combined $+I$ effect, heavily destabilizing the tertiary carbanion.

Step 3: Combine these observations into the final stability sequence.

$$\text{II} > \text{III} > \text{IV} > \text{I}$$

Final Answer: $\boxed{\text{II} > \text{III} > \text{IV} > \text{I}}$

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

Go Back to Question 35

Q36.

Solution

Concept:

The structural chemistry of the oxoacids of phosphorus (H_3PO_4 and H_3PO_3) is defined by a central phosphorus atom that maintains a coordination number of 4 with a tetrahedral arrangement. The acidity (basicity) of these species is determined solely by the number of ionizable protonated hydroxyl groups (P-OH). Any hydrogen atom bonded directly to the central phosphorus atom (P-H) is non-ionizable and acts as a strong reducing site.

Solution:

Step 1: Analyze the structural parameters of orthophosphoric acid (H_3PO_4).

In H_3PO_4, the central Phosphorus atom is in the +5 oxidation state. It forms one $P = O$ double bond and three single P-OH bonds in a tetrahedral arrangement. Because it contains three hydroxyl groups, it can donate three protons, making it a tribasic (trivalent) acid. Therefore, Statement A is correct.

Step 2: Analyze the structural parameters of orthophosphorous acid (H_3PO_3).

In H_3PO_3, Phosphorus is in the +3 oxidation state. The molecule features one $P = O$ bond, two P-OH bonds, and one direct P-H bond. Because it contains two hydroxyl groups, it is dibasic. Therefore, Statement B is correct.

Step 3: Evaluate the reducing behavior and geometry.

The presence of the direct P-H bond in H_3PO_3 allows it to readily act as a reducing agent by transferring hydride ions, a feature that H_3PO_4 lacks. Therefore, Statement C is correct. Furthermore, the central phosphorus atom in both molecules uses four sp^3 hybrid orbitals to form its σ-bonding framework, giving both acids a tetrahedral coordination geometry. Therefore, Statement D is also correct. All four choices represent true statements.

Final Answer: $\boxed{\text{A, B, C, D}}$

$\boxed{\textbf{Answer: (A, B, C, D)}}$

Go Back to Question 36

Q37.

Solution

Concept:

A reversible adiabatic expansion of an ideal gas mixture is a process where no heat is exchanged with the surroundings ($Q_{\text{rev}} = 0$). By definition, the change in entropy of the system during a reversible adiabatic path is zero ($\Delta S_{\text{system}} = \int \frac{dQ_{\text{rev}}}{T} = 0$), making the process isentropic. This condition allows us to derive the classical Poisson relations linking temperature, pressure, and volume using the heat capacity ratio ($\gamma = C_p/C_v$).

Solution:

Step 1: Evaluate the classic state variable equations.

For an ideal gas undergoing a reversible adiabatic transformation, the relationship between temperature and volume is given by:

$$TV^{\gamma-1} = \text{Constant}$$

This matches Statement A. Similarly, the relationship between pressure and temperature is given by:

$$P^{1-\gamma}T^{\gamma} = \text{Constant}$$

This matches Statement B.

Step 2: Assess the entropy and energy terms.

Because the process is both reversible and adiabatic, the entropy change of the system is explicitly zero:

$$\Delta S_{\text{system}} = 0$$

This matches Statement C.

During an expansion, work is performed by the gas, causing its internal energy and temperature to decrease. Because internal energy changes as $\Delta U = nC_v\Delta T$ and enthalpy changes as $\Delta H = nC_p\Delta T$, and since $C_p \neq C_v$, ΔU cannot equal ΔH. Therefore, Statements A, B, and C are correct.

Final Answer: $\boxed{\text{A, B, C}}$

$\boxed{\textbf{Answer: (A, B, C)}}$

Go Back to Question 37

Q38.

Solution

Concept:
Geometrical isomerism (cis/trans isomerism) occurs in coordination complexes when ligands can occupy different spatial arrangements relative to one another. This behavior depends on the coordination number and structural geometry of the complex. Tetrahedral complexes do not exhibit geometrical isomerism because all four coordination positions are equidistant from one another. Similarly, homoleptic complexes containing only one type of symmetrical bidentate ligand cannot form cis/trans structural pairs.

Solution:
Step 1: Evaluate the square planar complex $[Pt(NH_3)_2Cl_2]$.
This is an MA_2B_2 type square planar complex. It can exist as a *cis*-isomer (where identical ligands are located on adjacent positions at 90° angles) or as a *trans*-isomer (where identical ligands face each other across the metal center at 180° angles). Therefore, Statement A is correct.

Step 2: Evaluate the octahedral complex $[Co(NH_3)_4Cl_2]^+$.
This is an MA_4B_2 type octahedral complex. It forms a *cis*-isomer when the two chloride ligands are adjacent (90° separation) and a *trans*-isomer when the chloride ligands are located on opposite axial positions (180° separation). Therefore, Statement B is correct.

Step 3: Analyze the remaining options.
Option C ($[Ni(CO)_4]$) is a tetrahedral homoleptic complex. It cannot exhibit geometrical isomerism because all positions are structurally equivalent. Option D ($[Cr(ox)_3]^{3-}$) is a homoleptic octahedral complex containing three symmetric bidentate oxalate ligands; it exhibits optical isomerism (enantiomerism) but cannot form cis/trans isomers. Therefore, only options A and B are correct.

Final Answer: $\boxed{\text{A, B}}$

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

Go Back to Question 38

Q39.

Solution

Concept:

Synthesizing benzaldehyde (C_6H_5CHO) requires the controlled oxidation of a toluene precursor or the direct formulation of a formyl substituent onto a benzene core. The reaction conditions must be mild enough to prevent over-oxidation to benzoic acid.

Solution:

Step 1: Analyze the Gattermann-Koch reaction (Option A).

Passing carbon monoxide (CO) and hydrogen chloride (HCl) gas through benzene in the presence of anhydrous $AlCl_3$ and trace cuprous chloride (CuCl) generates a formyl electrophile *in situ*. This electrophile attacks the benzene ring to produce benzaldehyde. Thus, Option A is correct.

Step 2: Analyze the Rosenmund reduction (Option B).

The catalytic hydrogenation of benzoyl chloride (C_6H_5COCl) over palladium supported on barium sulfate (Pd-$BaSO_4$) partially reduces the acyl chloride to an aldehyde. The $BaSO_4$ acts as a catalyst poison to prevent further reduction to a primary alcohol. Thus, Option B is correct.

Step 3: Analyze the Étard reaction (Option C).

Treating toluene with chromyl chloride (CrO_2Cl_2) in a non-polar solvent yields a brown chromium complex. Subsequent hydrolysis cleaves this intermediate to produce benzaldehyde without over-oxidation. Thus, Option C is correct.

Step 4: Evaluate Option D.

Permanganate ($KMnO_4$) is a powerful oxidizing agent that will rapidly oxidize benzyl alcohol to benzaldehyde, and then immediately oxidize it further to benzoic acid. It cannot be used to isolate benzaldehyde as a primary product. Therefore, options A, B, and C are correct.

Final Answer: $\boxed{\text{A, B, C}}$

$\boxed{\textbf{Answer: (A, B, C)}}$

Go Back to Question 39

Q40.

Solution

Concept:

An ideal solution is a solution that obeys Raoult's Law perfectly across all ranges of concentration and temperature. At the molecular level, an ideal solution forms when the intermolecular attractive forces between the components (A-B interactions) are nearly identical in magnitude to the cohesive forces within the pure liquids (A-A and B-B interactions). This condition typically occurs when the mixed liquids have very similar molecular sizes, structural configurations, and chemical polarities.

Solution:

Step 1: Examine pairs with similar molecular profiles.

Option A: Benzene (C_6H_6) and Toluene ($C_6H_5CH_3$) are both non-polar aromatic hydrocarbons of similar size. Their structural similarity means that mixing them results in an enthalpy change close to zero ($\Delta H_{\text{mix}} \approx 0$) and a volume change close to zero ($\Delta V_{\text{mix}} \approx 0$). Thus, they form a near-ideal solution.

Option B: n-Hexane and n-heptane are adjacent members of a homologous series of linear alkanes. Because they share nearly identical van der Waals interaction properties, their mixture behaves ideally.

Option D: Bromoethane and chloroethane are structurally similar alkyl halides with comparable polarities and sizes, so they also form a near-ideal solution.

Step 2: Evaluate the non-ideal pair (Option C).

When chloroform ($CHCl_3$) is mixed with acetone [$(CH_3)_2CO$], a strong intermolecular hydrogen bond forms between the acidic hydrogen of chloroform and the carbonyl oxygen of acetone. This new interaction is stronger than the original cohesive forces ($\text{A-B} > \text{A-A}, \text{B-B}$), causing the solution to exhibit a negative deviation from Raoult's Law rather than ideal behavior. Therefore, options A, B, and D are correct.

Final Answer: $\boxed{\text{A, B, D}}$

$\boxed{\textbf{Answer: (A, B, D)}}$

Go Back to Question 40

Answer Key

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

Note: Section C (Q36–Q40): One or more correct options may be correct. Full marks only if all correct options are marked. Partial marking is not applicable.