JCECE Chemistry Sample Paper-11

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

Instructions

- This paper contains **50** Multiple Choice Questions (Single Correct Answer), modelled on the Physics portion of JCECE entrance.
- Each correct answer carries **+1** mark. Incorrect answer: **−0.25** marks.unattempted questions get 0.
- Only one option is correct. Choose carefully.
- Syllabus level: **Class 11 and Class 12 NCERT Physics (Jharkhand JAC / CBSE aligned)**
- Use of mobile phones, calculators, or electronic gadgets is strictly prohibited.

Q1. An organic compound with the molecular formula $C_4H_{10}O_3$ reacts with excess acetic anhydride to form a product with a molecular mass of 234 g mol^{-1}. The number of hydroxyl groups present in the initial organic compound is:

(A) 1

(B) 2

(C) 3

(D) 4

Q2. For a certain first-order reaction A $\rightarrow$ B, the time required for 20% completion is t_1 and the time required for 60% completion is t_2. The ratio t_2/t_1 is closest to:

(A) 3.00

(B) 4.11

(C) 2.32

(D) 1.86

Q3. Which of the following statements regarding the dynamic structures of Xe compounds is correct?

(A) XeF_6 has a completely regular octahedral geometry in the gas phase.

(B) In XeO_3, the lone pair on central atom occupies an equatorial position in a trigonal bipyramid arrangement.

(C) Partial hydrolysis of XeF_6 yields a bright yellow liquid $XeOF_4$.

(D) XeF_5^- has a pentagonal planar geometry with two lone pairs positioned axially.

Q4. In a face-centered cubic lattice of an oxide, if $1/8$th of the tetrahedral voids are occupied by divalent cations B^{2+} and $1/2$ of the octahedral voids are occupied by trivalent cations A^{3+}, the empirical formula of the oxide is:

(A) AB_2O_4

(B) A_2BO_4

(C) ABO_2

(D) $A_2B_3O_4$

Q5. Identify the major product formed when bromobenzene is treated with $NaNH_2$ in liquid ammonia at low temperature:

(A) Aniline

(B) Benzylamine

(C) *m*-Bromoaniline

(D) *o*-Phenylene diamine

Q6. The correct order of ionic radii for the following isoelectronic species is:

(A) $S^{2-} > Cl^- > K^+ > Ca^{2+}$

(B) $Ca^{2+} > K^+ > Cl^- > S^{2-}$

(C) $Cl^- > S^{2-} > Ca^{2+} > K^+$

(D) $K^+ > Ca^{2+} > S^{2-} > Cl^-$

Q7. Consider the following reaction at 298 K:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

If $\Delta H^\circ = -198\ \text{kJ mol}^{-1}$, which of the following changes will increase the equilibrium yield of SO_3?

(A) Increasing the volume of the reaction vessel

(B) Adding an inert gas at constant volume

(C) Increasing the temperature of the system

(D) Adding more O_2 gas to the system

Q8. Which of the following pairs of coordination complexes represents a case of linkage isomerism?

(A) $[Co(NH_3)_5(SO_4)]Br$ 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) $[Co(NH_3)_5(NO_2)]Cl_2$ and $[Co(NH_3)_5(ONO)]Cl_2$

(D) $[Pt(NH_3)_4][PtCl_4]$ and $[Pt(NH_3)_3Cl][PtCl_3(NH_3)]$

Q9. 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) 1/9

Q10. An alkene C_6H_{12} on reductive ozonolysis gives two different isomers of a carbonyl compound with the formula C_3H_6O. The structure of the alkene is:

(A) Hex-3-ene

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

(C) 4-Methylpent-2-ene

(D) 2-Methylpent-2-ene

Q11. The extraction of gold by leaching with a dilute solution of NaCN in the presence of atmospheric oxygen involves the formation of a soluble complex X. Complex X on treatment with zinc yields gold. The formula of complex X is:

(A) $[Au(CN)_4]^{3-}$

(B) $[Au(CN)_2]^{-}$

(C) $[Au(CN)_4]^{-}$

(D) $[Au(CN)_2]^{2-}$

Q12. The specific conductance of a 0.01 M solution of an electrolyte is 0.0002 S cm^{-1}. If the resistance of this solution measured in a conductivity cell is 100 Ω, the cell constant of the cell is:

(A) 0.02 cm^{-1}

(B) 0.20 cm^{-1}

(C) 2.00 cm^{-1}

(D) 0.01 cm^{-1}

Q13. In the reaction sequences below:

$$\text{Toluene} \xrightarrow{KMnO_4/OH^-, \Delta} A \xrightarrow{SOCl_2} B \xrightarrow{H_2, \text{Pd-BaSO}_4} C$$

The final product C is:

(A) Benzyl alcohol

(B) Benzoyl chloride

(C) Benzaldehyde

(D) Benzoic acid

Q14. The standard reduction potentials of three metallic elements X, Y, and Z are +0.52 V, −2.87 V, and −0.44 V respectively. The correct order of their reducing power is:

(A) X > Z > Y

(B) Y > X > Z

(C) Y > Z > X

(D) Z > Y > X

Q15. The correct order of increasing thermal stability for the alkaline earth metal carbonates is:

(A) $BaCO_3 < SrCO_3 < CaCO_3 < MgCO_3$

(B) $MgCO_3 < CaCO_3 < SrCO_3 < BaCO_3$

(C) $MgCO_3 < SrCO_3 < CaCO_3 < BaCO_3$

(D) $BaCO_3 < CaCO_3 < SrCO_3 < MgCO_3$

Q16. Glucose on prolonged heating with concentrated hydriodic acid (HI) gives:

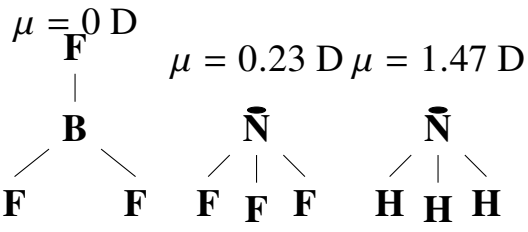
(A) *n*-Hexane

(B) Gluconic acid

(C) Saccharic acid

(D) Hexanoic acid

Q17. The arrangement of molecular species that represents the correct order of increasing dipole moment is:



(A) $NF_3 < NH_3 < BF_3$

(B) $BF_3 < NF_3 < NH_3$

(C) $BF_3 < NH_3 < NF_3$

(D) $NH_3 < NF_3 < BF_3$

Q18. The freezing point of a 0.05 m aqueous solution of a non-electrolyte solute is -0.093°C. The cryoscopic constant (K_f) of water is closest to:

(A) 1.86 K kg mol^{-1}

(B) 0.52 K kg mol^{-1}

(C) 3.72 K kg mol^{-1}

(D) 0.93 K kg mol^{-1}

Q19. When aniline is treated with nitrous acid ($NaNO_2$ + HCl) at 0 – 5°C, followed by warming with cuprous chloride (Cu_2Cl_2) in HCl, the reaction is known as:

(A) Gattermann reaction

(B) Sandmeyer reaction

(C) Finkelstein reaction

(D) Wurtz-Fittig reaction

Q20. In the qualitative analysis of Group II cations, H_2S gas is passed in the presence of dilute HCl. The role of HCl is to:

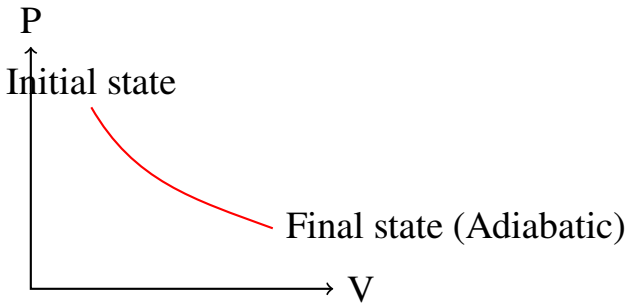
(A) Increase the solubility of H_2S gas

(B) Decrease the concentration of sulfide ions by common ion effect

(C) Maintain an alkaline medium for fast precipitation

(D) Oxidize the cations to higher oxidation states

Q21. For the ideal gas expansion process under adiabatic conditions as illustrated below, which of the following sets of criteria is correct?



(A) $q = 0, \Delta W < 0, \Delta T < 0$

(B) $q < 0, \Delta W = 0, \Delta T = 0$

(C) $q = 0, \Delta W > 0, \Delta T > 0$

(D) $q > 0, \Delta W < 0, \Delta T = 0$

Q22. Arrange the following carbonyl compounds in order of decreasing reactivity towards nucleophilic addition reactions:

(i) CH_3CHO (ii) $(CH_3)_2CO$ (iii) $HCHO$ (iv) $(t\text{-Bu})_2CO$

(A) (iii) > (i) > (ii) > (iv)

(B) (i) > (iii) > (ii) > (iv)

(C) (iv) > (ii) > (i) > (iii)

(D) (iii) > (ii) > (i) > (iv)

Q23. Which of the following oxoacids of phosphorus contains a direct P – P bond along with a +4 oxidation state for phosphorus atoms?

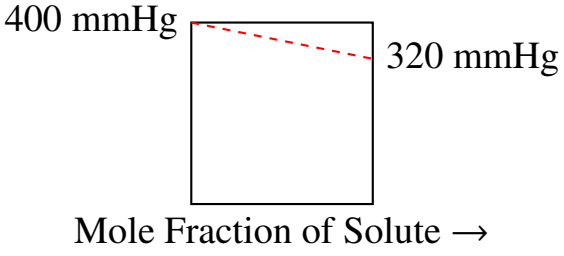
(A) Pyrophosphoric acid

(B) Hypophosphoric acid

(C) Orthophosphoric acid

(D) Pyrophosphorous acid

Q24. Vapor pressure of pure liquid A at a certain temperature is 400 mm Hg. When a non-volatile solute B is added, the vapor pressure drops to 320 mm Hg as per the lowering behavior shown. The mole fraction of solute B in the solution is:



(A) 0.8

(B) 0.2

(C) 0.5

(D) 0.25

Q25. Which of the following intermediate species possesses a planar geometry with an sp^2 hybridized carbon atom?

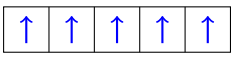
(A) Methyl radical

(B) Methyl carbanion

(C) Methyl carbocation

(D) Triethyl amine oxide

Q26. The spin-only magnetic moment of a divalent transition metal ion with atomic number 25 (Mn^{2+}) in an aqueous solution is:



Five unpaired $3d$ electrons

(A) 4.90 BM

(B) 5.92 BM

(C) 3.87 BM

(D) 1.73 BM

Q27. The entropy change (ΔS) for the isothermal reversible expansion of 2 moles of an ideal gas from a volume of 10 L to 100 L at 300 K is:

(A) 38.29 J K^{-1}

(B) 19.15 J K^{-1}

(C) 76.58 J K^{-1}

(D) 0 J K^{-1}

Q28. The principal organic product obtained from the reaction of sodium phenoxide with carbon dioxide at 400 K under high pressure, followed by acidification is:

(A) Salicylaldehyde

(B) Salicylic acid

(C) Phenolphthalein

(D) Aspirin

Q29. Which of the following standard statements concerning lanthanoid contraction is false?

(A) Atomic radii of $4d$ and $5d$ transition elements become very similar.

(B) It is a consequence of the poor shielding effect of $4f$ electrons.

(C) Basic strength of lanthanoid hydroxides increases from $La(OH)_3$ to $Lu(OH)_3$.

(D) Separation of lanthanoid elements in pure form becomes exceptionally difficult.

Q30. The solubility product (K_{sp}) of Ag_2CrO_4 is 3.2×10^{-11} at 25°C. The solubility of this salt in pure water is:

(A) 2.0×10^{-4} mol L^{-1}

(B) 4.0×10^{-4} mol L^{-1}

(C) 1.6×10^{-4} mol L^{-1}

(D) 8.0×10^{-5} mol L^{-1}

Q31. Heating an alkaline solution of a primary amine with chloroform ($CHCl_3$) produces an intolerable foul-smelling compound via the carbylamine pathway. The structural class of the foul-smelling compound is:

(A) Alkyl cyanide

(B) Alkyl isocyanide

(C) Alkyl isocyanate

(D) Nitroalkane

Q32. In the extraction of iron from hematite ore in the blast furnace, the compound acting as the principal slag is formed by the reaction shown below:

(A) $FeSiO_3$

(B) $CaSiO_3$

(C) $MgSiO_3$

(D) Al_2O_3

Q33. A 0.1 M solution of a weak monobasic acid shows a pH of 4.0. The value of its ionization constant (K_a) is:

(A) 1.0×10^{-4}

(B) 1.0×10^{-7}

(C) 1.0×10^{-8}

(D) 1.0×10^{-5}

Q34. The major product obtained when 2-bromobutane reacts with hot alcoholic potassium hydroxide is:

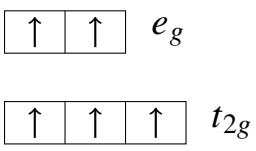
(A) But-1-ene

(B) trans-But-2-ene

(C) cis-But-2-ene

(D) Butan-2-ol

Q35. The configuration of the complex ion $[CoF_6]^{3-}$ according to Crystal Field Theory splits the d-orbitals into two sub-levels as shown. Its state is best described as:



(A) $t_{2g}^4 e_g^2$, paramagnetic with high spin

(B) $t_{2g}^6 e_g^0$, diamagnetic with low spin

(C) $t_{2g}^3 e_g^3$, paramagnetic with high spin

(D) $t_{2g}^5 e_g^1$, paramagnetic with low spin

Q36. The total number of atoms in 4.25 g of NH_3 gas is approximately:

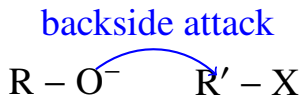
(A) 6.022×10^{23}

(B) 1.505×10^{23}

(C) 3.011×10^{23}

(D) 1.204×10^{24}

Q37. Williamson synthesis of ethers involving the reaction of an alkyl halide with a sodium alkoxide proceeds through which of the following mechanisms?



(A) S_N1

(B) S_N2

(C) E1

(D) E2

Q38. Which of the following elements does not show a variable oxidation state in its chemical compounds?

(A) Fe

(B) Cu

(C) Sc

(D) Mn

Q39. The rate constant of a chemical reaction increases by a factor of 4 when the temperature is raised from 300 K to 320 K. The activation energy (E_a) for the reaction is given by (Take $R = 8.314$ J mol^{-1} K^{-1}):

(A) 55.33 kJ mol^{-1}

(B) 27.66 kJ mol^{-1}

(C) 110.66 kJ mol^{-1}

(D) 44.21 kJ mol^{-1}

Q40. Among the following compounds, which one will fail to undergo Cannizzaro reaction when treated with a concentrated alkali solution?

(A) Formaldehyde

(B) Benzaldehyde

(C) Trimethylacetaldehyde

(D) Acetaldehyde

Q41. Which statement describes the hybridization and spatial geometry of the central nitrogen atom in the azide ion (N_3^-) as given by its resonance layout?

$$\overline{N} = \overset{+}{N} = \overline{N}$$

(A) sp^2, bent

(B) sp, linear

(C) sp^3, pyramidal

(D) dsp^2, square planar

Q42. How many coulombs of electricity are required to completely reduce 1 mole of $Cr_2O_7^{2-}$ ions to Cr^{3+} ions in an acidic medium according to the half-cell reaction?

$$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$$

(A) 289, 500 C

(B) 579, 000 C

(C) 96, 500 C

(D) 193, 000 C

Q43. Which of the following biological polymers contains chemically linked β-D-glucose monomeric units through β-1,4-glycosidic linkages?

(A) Amylose

(B) Amylopectin

(C) Cellulose

(D) Glycogen

Q44. Which of the following p-block elements has the highest negative electron gain enthalpy value?

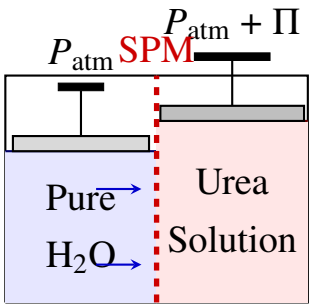
(A) Fluorine

(B) Chlorine

(C) Bromine

(D) Iodine

Q45. The osmotic pressure setup below contains a solution of 6.0 g of urea (molecular mass = 60 g mol^{-1}) in 1 L of water at 300 K. Its pressure value is (Given R = 0.0821 L atm K^{-1} mol^{-1}):



(A) 2.46 atm

(B) 24.6 atm

(C) 1.23 atm

(D) 4.92 atm

Q46. The structural conversion of phenol into p-hydroxyazobenzene by reacting it with benzenediazonium chloride in a weakly basic medium is classified as:

(A) Electrophilic substitution reaction

(B) Nucleophilic substitution reaction

(C) Free radical addition reaction

(D) Electrophilic addition reaction

Q47. The gas that turns lime water milky and simultaneously decolorizes an acidified potassium permanganate solution is:

(A) CO_2

(B) SO_2

(C) NO_2

(D) O_3

Q48. The standard enthalpy of formation ($\Delta_f H^\circ$) of $CO_2(g)$, $H_2O(l)$, and $C_2H_4(g)$ are -393.5, -285.8, and $+52.3$ kJ mol^{-1} respectively. The standard enthalpy of combustion of $C_2H_4(g)$ is:

(A) -1410.9 kJ mol^{-1}

(B) -1306.3 kJ mol^{-1}

(C) $+1410.9$ kJ mol^{-1}

(D) -1126.7 kJ mol^{-1}

Q49. The major organic product formed when ethyl chloride is heated with dry silver oxide (Ag_2O) is:

(A) Diethyl ether

(B) Ethanol

(C) Ethyl acetate

(D) Ethene

Q50. Boric acid (H_3BO_3) behaves as a monobasic acid in aqueous solution primarily because:

(A) It contains a replaceable hydrogen ion from its own structural backbone.

(B) It acts as a Lewis acid by accepting a hydroxyl ion (OH^-) from water, releasing a proton.

(C) It undergoes self-ionization to yield hydronium ions.

(D) It acts as a strong proton donor in the presence of strong mineral acids.

Detailed Solutions

Q1.

Solution

Concept: When an organic compound containing hydroxyl (−OH) groups is treated with excess acetic anhydride, each −OH group undergoes an acetylation reaction where a hydrogen atom (H, atomic mass = 1 g mol^{-1}) is replaced by an acetyl group (−$COCH_3$, formula mass = 43 g mol^{-1}). This substitution results in a net mass increase of 42 g mol^{-1} per hydroxyl group converted into an acetate ester.

Solution: Step 1: Calculate the molecular mass of the initial organic compound with formula $C_4H_{10}O_3$.

$$\text{Mass} = (4 \times 12) + (10 \times 1) + (3 \times 16) = 48 + 10 + 48 = 106 \text{ g mol}^{-1}$$

Step 2: Determine the total mass change that occurred during the full acetylation reaction.

$$\Delta M = M_{\text{product}} - M_{\text{reactant}} = 234 \text{ g mol}^{-1} - 106 \text{ g mol}^{-1} = 128 \text{ g mol}^{-1}$$

Step 3: Establish the formula for the net mass increase per acetylated position. Each substitution replaces one H with −$COCH_3$, leading to a net gain of:

$$\Delta m = 43 - 1 = 42 \text{ g mol}^{-1}$$

Step 4: Find the total number of hydroxyl groups (n) by dividing the total observed mass change by the net mass gain per individual group.

$$n = \frac{\Delta M}{42} = \frac{128}{42} \approx 3.05$$

Since the number of groups must be an integer, the compound contains exactly 3 hydroxyl groups.

Final Answer: 3

Answer: (C)

Go Back to Question 1

Q2.

Solution

Concept: For a first-order chemical reaction, the integrated rate equation relates the time elapsed to the initial concentration and the remaining concentration of the reactant. The rate constant k remains invariant at a constant temperature, allowing us to build a ratio between two distinct time periods of completion.

Solution: Step 1: Write down the general integrated rate expression for a first-order reaction.

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

Step 2: Set up the equation for t_1, which corresponds to 20% completion. This means 20% of the initial reactant has been consumed, leaving 80% remaining behind.

$$t_1 = \frac{2.303}{k} \log\left(\frac{100}{100-20}\right) = \frac{2.303}{k} \log\left(\frac{100}{80}\right) = \frac{2.303}{k} \log(1.25)$$

Step 3: Set up the equation for t_2, which corresponds to 60% completion. This signifies that 60% of the reactant is consumed, leaving 40% intact.

$$t_2 = \frac{2.303}{k} \log\left(\frac{100}{100-60}\right) = \frac{2.303}{k} \log\left(\frac{100}{40}\right) = \frac{2.303}{k} \log(2.5)$$

Step 4: Take the ratio of t_2 to t_1 to eliminate the common constants.

$$\frac{t_2}{t_1} = \frac{\log(2.5)}{\log(1.25)} = \frac{0.3979}{0.0969} \approx 4.106$$

Evaluating this logarithmic ratio gives a value of approximately 4.11.

Final Answer: 4.11

Answer: (B)

Go Back to Question 2

Q3.

Solution

Concept: The structural features of noble gas compounds are interpreted through valence shell electron pair repulsion (VSEPR) theory. In the case of anionic or neutral xenon halides, the total number of valence electrons dictates the hybrid state, coordinate architecture, and position of bond pairs and stereochemically active or inactive lone pairs.

Solution: Step 1: Evaluate the geometry of XeF_5^-. The central Xenon atom possesses 8 valence electrons. Adding 5 electrons from the fluorine atoms and 1 electron from the negative charge gives 14 total electrons, or 7 electron pairs around the central atom.

Step 2: Assign the steric number. A steric number of 7 implies a pentagonal bipyramidal electronic geometry. Among these 7 pairs, 5 are bonding pairs directed towards the fluorine atoms, and 2 are lone pairs.

Step 3: Position the lone pairs to minimize repulsion. To achieve the lowest possible steric strain, the two lone pairs occupy the axial positions opposite to one another. This directs the 5 fluorine atoms to sit perfectly within a single horizontal plane, forming a highly symmetric pentagonal planar molecular shape.

Step 4: Contrast with other choices: XeF_6 has a distorted octahedral shape due to a stereochemically active lone pair; XeO_3 is pyramidal; partial hydrolysis of XeF_6 gives colorless $XeOF_4$.

Final Answer: XeF_5^- has a pentagonal planar geometry with two lone pairs positioned axially.

Answer: (D)

Go Back to Question 3

Q4.

Solution

Concept: In a close-packed crystalline framework containing N oxide ions, the number of octahedral voids generated is exactly N, whereas the number of tetrahedral voids generated is equal to $2N$. The empirical formula is established by multiplying these ratios by the fractional occupancy values given for each type of cation.

Solution: Step 1: Let the number of oxide ions (O^{2-}) forming the face-centered cubic lattice be $N = 4$ per unit cell.

Step 2: Calculate the total available tetrahedral and octahedral voids based on the oxide packing.

$$\text{Tetrahedral Voids} = 2N = 2 \times 4 = 8$$

$$\text{Octahedral Voids} = N = 4$$

Step 3: Compute the actual number of divalent B^{2+} ions present based on its fractional occupancy.

$$\text{Number of } B^{2+} = \frac{1}{8} \times \text{Tetrahedral Voids} = \frac{1}{8} \times 8 = 1$$

Step 4: Compute the actual number of trivalent A^{3+} ions present based on its fractional occupancy.

$$\text{Number of } A^{3+} = \frac{1}{2} \times \text{Octahedral Voids} = \frac{1}{2} \times 4 = 2$$

Step 5: Write down the structural ratio of the constituents A : B : O, which gives 2 : 1 : 4. Therefore, the simplest whole-number empirical formula is A_2BO_4.

Final Answer: A_2BO_4

Answer: (B)

Go Back to Question 4

Q5.

Solution

Concept: The reaction of an unactivated aryl halide such as bromobenzene with an exceptionally strong base like sodamide ($NaNH_2$) in liquid ammonia proceeds via an elimination-addition pathway called the benzyne mechanism. This process is distinct from standard nucleophilic substitution because it goes through a highly reactive neutral aromatic intermediate.

Solution: Step 1: The strong amide ion (NH_2^-) abstracts an ortho-proton relative to the bromine atom on the benzene ring.

Step 2: The departure of the bromide ion (Br^-) coupled with the elimination of the proton creates a transient, highly strained triple bond within the ring framework, yielding the reactive benzyne intermediate.

Step 3: The nucleophilic amide ion (NH_2^-) attacks one of the triply-bonded carbon atoms in the benzyne intermediate, breaking the temporary weak bond.

Step 4: Protonation of the resulting aryl carbanion by the solvent ammonia finishes the addition step. Because bromobenzene is completely symmetrical, the addition leads directly to the formation of aniline as the sole primary product.

Final Answer: Aniline

Answer: (A)

Go Back to Question 5

Q6.

Solution

Concept: For an isoelectronic series (species possessing the identical number of electrons), the size of the ionic radius is governed by the effective nuclear charge (Z_{eff}). As the number of protons in the nucleus increases, the inward electrostatic pull on the shared electron cloud intensifies, causing a contraction in size.

Solution: Step 1: Identify the electron count for each given ion: S^{2-}, Cl^{-}, K^{+}, and Ca^{2+} each contain exactly 18 electrons.

Step 2: Determine the nuclear charge (Z, number of protons) for each element:

$$S = 16,\ Cl = 17,\ K = 19,\ Ca = 20$$

Step 3: Analyze the relationship between nuclear charge and ionic size. A lower nuclear charge means fewer protons are holding the 18 electrons, allowing the electron cloud to expand. Conversely, a higher positive nuclear charge pulls the electrons closer.

Step 4: Arrange the ions by decreasing size based on increasing atomic numbers. The ion with the lowest positive charge (S^{2-}) is the largest, while the ion with the highest positive charge (Ca^{2+}) is the smallest:

$$S^{2-} > Cl^{-} > K^{+} > Ca^{2+}$$

Final Answer: $S^{2-} > Cl^{-} > K^{+} > Ca^{2+}$

Answer: (A)

Go Back to Question 6

Q7.

Solution

Concept: Le Chatelier's principle states that if a dynamic equilibrium system is subjected to a change in concentration, temperature, or pressure, the position of the equilibrium shifts in a direction that counteracts the imposed change. For a gas-phase reaction, increasing the concentration of a reactant drives the system forward.

Solution: Step 1: Examine the chemical equation and physical states:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

Step 2: Evaluate the impact of changing the concentration of the reactants. Adding extra O_2 gas increases the collision frequency between reactants. To reduce this disturbance, the forward reaction accelerates, converting reactants into SO_3 and increasing its yield.

Step 3: Analyze the alternative options: Increasing the volume shifts the equilibrium toward the side with more moles of gas (the reverse direction). Adding an inert gas at constant volume does not change the partial pressures, so it has no effect. Since the reaction is exothermic ($\Delta H^\circ < 0$), raising the temperature shifts the equilibrium backward.

Final Answer: Adding more O_2 gas to the system

Answer: (D)

Go Back to Question 7

Q8.

Solution

Concept: Linkage isomerism occurs in coordination chemistry when a complex contains an ambidentate ligand. An ambidentate ligand possesses two or more distinct donor atoms through which it can coordinate to the central metal ion, leading to separate structural combinations.

Solution: Step 1: Identify the ambidentate ligand among the choices. The nitro/nitrito group (NO_2^-) can bind to a metal ion either through its nitrogen atom ($-NO_2$, nitro) or through an oxygen atom ($-ONO$, nitrito).

Step 2: Analyze the pair in option (C):

$$[Co(NH_3)_5(NO_2)]Cl_2 \quad \text{and} \quad [Co(NH_3)_5(ONO)]Cl_2$$

In the first complex, the cobalt ion bonds to the nitrogen atom of the ligand. In the second complex, it bonds to an oxygen atom.

Step 3: Verify the other choices: Option (A) represents ionization isomerism, option (B) represents hydrate isomerism, and option (D) represents coordination isomerism. This confirms option (C) as the correct choice.

Final Answer: $[Co(NH_3)_5(NO_2)]Cl_2$ and $[Co(NH_3)_5(ONO)]Cl_2$

Answer: (C)

Go Back to Question 8

Q9.

Solution

Concept: According to Dalton's law of partial pressures, the partial pressure exerted by an individual gas in a non-reactive gas mixture is equal to the product of the total pressure and the mole fraction of that specific gas. The mole fraction is calculated from the masses and molecular weights of the component gases.

Solution: Step 1: Let the mass of both methane (CH_4) and oxygen (O_2) gas in the mixture be equal to w grams.

Step 2: Determine the molar masses of the gases:

$$\text{Molar mass of } CH_4 = 12 + (4 \times 1) = 16 \text{ g mol}^{-1}$$

$$\text{Molar mass of } O_2 = 2 \times 16 = 32 \text{ g mol}^{-1}$$

Step 3: Calculate the number of moles (n) of each gas present in the system.

$$n_{CH_4} = \frac{w}{16}, \quad n_{O_2} = \frac{w}{32}$$

Step 4: Find the total number of moles in the container.

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

Step 5: Compute the mole fraction of oxygen (X_{O_2}), which corresponds directly to its fraction of the total pressure.

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

Final Answer: 1/3

Answer: (B)

Go Back to Question 9

Q10.

Solution

Concept: Reductive ozonolysis (O_3 followed by Zn/H_2O) oxidatively cleaves the carbon-carbon double bond of an alkene, transforming each alkene carbon into a carbonyl (C = O) group. Analyzing the structures of the resulting fragments allows us to reconstruct the original alkene skeleton.

Solution: Step 1: The prompt states that the carbonyl products are two different structural isomers with the formula C_3H_6O.

Step 2: Identify the possible three-carbon carbonyl isomers. The two options are propanal (an aldehyde, CH_3CH_2CHO) and propanone (a ketone, CH_3COCH_3).

Step 3: Combine these two fragments by removing the oxygen atoms and connecting the carbonyl carbons with a double bond to reconstruct the reactant alkene:

$$CH_3CH_2CH = C(CH_3)_2$$

Step 4: Determine the IUPAC name of this combined molecule. Numbering from the right side gives the lowest locants for the double bond and the substituent, identifying the compound as 2-methylpent-2-ene.

Final Answer: 2-Methylpent-2-ene

Answer: (D)

Go Back to Question 10

Q11.

Solution

Concept: The Macarthur-Forrest cyanide process for the extraction of gold utilizes hydrometallurgy. Gold is dissolved via an oxidation-leaching reaction in a dilute aqueous solution of sodium cyanide in the presence of air, yielding a highly stable anionic coordination complex.

Solution: Step 1: Write out the balanced leaching chemical reaction for gold in an alkaline cyanide solution containing dissolved oxygen:

$$4Au(s) + 8CN^{-}(aq) + O_2(g) + 2H_2O(l) \rightarrow 4[Au(CN)_2]^{-}(aq) + 4OH^{-}(aq)$$

Step 2: Identify the oxidation state of gold within this soluble intermediate complex. Gold is oxidized from its elemental state (0) to a stable linear univalent coordinated state (+1).

Step 3: Conclude the molecular identity of complex X. The formula corresponds to the dicyanoaurate(I) ion, which is written as $[Au(CN)_2]^{-}$.

Step 4: This complex is subsequently treated with scrap zinc metal, where zinc acts as a reducing agent to displace and precipitate pure metallic gold.

Final Answer: $\boxed{[Au(CN)_2]^{-}}$

Answer: (B)

Go Back to Question 11

Q12.

Solution

Concept: The cell constant (G^*) of a conductivity cell is a geometric parameter defined as the ratio of the distance between the electrodes (l) to their cross-sectional area (A). It relates the measured resistance (R) of an electrolytic solution to its specific conductance (κ).

Solution: Step 1: State the mathematical equation connecting specific conductance (κ), resistance (R), and the cell constant (G^*).

$$\kappa = \frac{1}{R} \times \left(\frac{l}{A}\right) = \frac{G^*}{R}$$

Step 2: Rearrange this relationship to solve directly for the cell constant (G^*).

$$G^* = \kappa \times R$$

Step 3: Substitute the values provided in the problem into the rearranged equation:

$$\kappa = 0.0002 \text{ S cm}^{-1}, \quad R = 100\ \Omega$$

$$G^* = 0.0002 \text{ S cm}^{-1} \times 100\ \Omega = 0.02 \text{ cm}^{-1}$$

Note that the concentration value (0.01 M) is extra information not needed for this calculation.

Final Answer: $\boxed{0.02 \text{ cm}^{-1}}$

Answer: (A)

Go Back to Question 12

Q13.

Solution

Concept: Alkyl side chains on an aromatic ring are oxidized to carboxylic acid groups by strong oxidizing agents. Carboxylic acids then convert to acyl chlorides when treated with thionyl chloride, which can undergo selective partial reduction to aldehydes via the Rosenmund reduction.

Solution: Step 1: Toluene is treated with alkaline $KMnO_4$ under heat. This oxidizes the methyl side chain completely, converting toluene into benzoic acid (Intermediate A, C_6H_5COOH).

Step 2: Benzoic acid reacts with thionyl chloride ($SOCl_2$). This replaces the hydroxyl group with a chlorine atom, forming benzoyl chloride (Intermediate B, C_6H_5COCl).

Step 3: Benzoyl chloride undergoes hydrogenative reduction using a palladium catalyst poisoned with barium sulfate (H_2, Pd-$BaSO_4$). This Rosenmund reduction selectively reduces the acyl chloride to an aldehyde while preventing further reduction to an alcohol, yielding benzaldehyde (C) as the final product.

Final Answer: Benzaldehyde

Answer: (C)

Go Back to Question 13

Q14.

Solution

Concept: The reducing power of a metal represents its ability to act as a reducing agent by losing electrons and undergoing oxidation. Quantitatively, reducing power is inversely proportional to the standard reduction potential (E°). A lower or more negative reduction potential indicates a stronger reducing power.

Solution: Step 1: Collect the standard reduction potentials (E°) given for each element:

$$E^\circ(\text{X}) = +0.52\ \text{V}, \quad E^\circ(\text{Y}) = -2.87\ \text{V}, \quad E^\circ(\text{Z}) = -0.44\ \text{V}$$

Step 2: Compare these reduction potentials. A more negative value means the element releases electrons more readily, making it a more powerful reducing agent.

Step 3: Order the potentials from most negative to most positive:

$$-2.87\ \text{V (Y)} < -0.44\ \text{V (Z)} < +0.52\ \text{V (X)}$$

Step 4: Convert this order into reducing power. Since lower potentials correspond to greater reducing capacity, the correct sequence is:

$$\text{Y} > \text{Z} > \text{X}$$

Final Answer: $\boxed{\text{Y} > \text{Z} > \text{X}}$

Answer: (C)

Go Back to Question 14

Q15.

Solution

Concept: The thermal stability of alkaline earth metal carbonates increases down the group. This trend is explained by the ionic size of the cation and its polarizing power, which affects how easily it can deform the large, polarizable carbonate anion (CO_3^{2-}).

Solution: Step 1: Identify the order of the alkaline earth metal cations down Group 2: Mg^{2+}, Ca^{2+}, Sr^{2+}, and Ba^{2+}.

Step 2: Apply Fajan's rules. Smaller cations have a higher charge density and greater polarizing power. Mg^{2+} strongly polarizes the carbonate ion, distorting its electron cloud and facilitating its decomposition into an oxide and CO_2 at relatively low temperatures.

Step 3: Analyze the trend down the group. As the cation size increases from Mg^{2+} to Ba^{2+}, its polarizing power decreases. This stabilizes the carbonate lattice, requiring higher temperatures to induce thermal decomposition.

Step 4: Conclude the correct order of increasing stability:

$$MgCO_3 < CaCO_3 < SrCO_3 < BaCO_3$$

Final Answer: $MgCO_3 < CaCO_3 < SrCO_3 < BaCO_3$

Answer: (B)

Go Back to Question 15

Q16.

Solution

Concept: The chemical structure of monosaccharides can be verified through reductive cleavage reactions. Heating an aldohexose like glucose with a powerful reducing agent like concentrated hydriodic acid (HI) removes all oxygen-containing functional groups, converting the carbon skeleton into its corresponding alkane.

Solution: Step 1: Glucose is a six-carbon polyhydroxy aldehyde. Its structure consists of a continuous chain of six carbon atoms with an aldehyde group at one end and five hydroxyl groups along the chain.

Step 2: Concentrated hydriodic acid (HI) in combination with red phosphorus is a vigorous reducing agent capable of cleaving both C − O single bonds and C = O double bonds.

Step 3: Prolonged heating with HI reduces all the carbonyl and hydroxyl groups of the glucose molecule into hydrocarbon segments ($-CH_2-$ and $-CH_3$).

Step 4: This complete reduction yields an unbranched six-carbon alkane, confirming that the six carbon atoms in glucose are arranged in a straight, continuous chain. This product is *n*-hexane.

Final Answer: *n*-Hexane

Answer: (A)

Go Back to Question 16

Q17.

Solution

Concept: The net dipole moment (μ) of a polyatomic molecule is the vector sum of its individual bond dipoles. It depends on both the electronegativity differences between the bonded atoms and the spatial geometry of the molecule, including the orientation of lone pairs.

Solution: Step 1: Analyze BF_3. Boron trifluoride has a symmetrical trigonal planar geometry (sp^2 hybridized). The three polar B – F bond dipoles point in opposite directions at 120° angles, canceling each other out completely to give a net dipole moment of zero ($\mu = 0$ D).

Step 2: Analyze NF_3. Nitrogen trifluoride has a trigonal pyramidal shape. Fluorine is more electronegative than nitrogen, so the N – F bond dipoles point away from the nitrogen atom. However, the lone pair dipole on the nitrogen points in the opposite direction, partially canceling the bond dipoles and resulting in a small net dipole moment ($\mu \approx 0.23$ D).

Step 3: Analyze NH_3. Ammonia also has a trigonal pyramidal shape. Nitrogen is more electronegative than hydrogen, so the N – H bond dipoles point toward the nitrogen atom. This matches the direction of the lone pair dipole, reinforcing each other to produce a larger net dipole moment ($\mu \approx 1.47$ D).

Step 4: Arrange the molecules in order of increasing dipole moment: $BF_3 < NF_3 < NH_3$.

Final Answer: $BF_3 < NF_3 < NH_3$

Answer: (B)

Go Back to Question 17

Q18.

Solution

Concept: The depression of freezing point (ΔT_f) is a colligative property that depends on the total number of solute particles in a solution. For a non-electrolyte solute, the van 't Hoff factor (i) is exactly 1, meaning the molecule does not dissociate or associate in solution.

Solution: Step 1: Write down the formula for the depression of freezing point:

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

Step 2: Identify the given values from the problem statement:

$$T_{f,\text{pure}} = 0^\circ\text{C}, \quad T_{f,\text{solution}} = -0.093^\circ\text{C}$$

$$\Delta T_f = 0 - (-0.093) = 0.093^\circ\text{C} = 0.093\ \text{K}$$

$$\text{Molality } (m) = 0.05\ \text{m}, \quad i = 1 \text{ (non-electrolyte)}$$

Step 3: Rearrange the equation to isolate the cryoscopic constant (K_f):

$$K_f = \frac{\Delta T_f}{m}$$

Step 4: Substitute the values into the rearranged equation to calculate K_f:

$$K_f = \frac{0.093\ \text{K}}{0.05\ \text{mol kg}^{-1}} = 1.86\ \text{K kg mol}^{-1}$$

Final Answer: $1.86\ \text{K kg mol}^{-1}$

Answer: (A)

Go Back to Question 18

Q19.

Solution

Concept: Primary aromatic amines react with nitrous acid at low temperatures to form diazonium salts. Replacing the diazonium group with a halide using copper(I) salts is a classic synthetic method in organic chemistry.

Solution: Step 1: Aniline ($C_6H_5NH_2$) is treated with a mixture of sodium nitrite and hydrochloric acid ($NaNO_2$ + HCl) at a cold temperature ($0 - 5^\circ C$). This diazotization reaction converts aniline into benzenediazonium chloride ($C_6H_5N_2^+Cl^-$).

Step 2: The stable diazonium salt solution is then treated with cuprous chloride (Cu_2Cl_2) dissolved in hydrochloric acid.

Step 3: The copper(I) ion acts as a catalyst, facilitating the release of nitrogen gas (N_2) and introducing a chlorine atom onto the aromatic ring to form chlorobenzene.

Step 4: This sequence—where a diazonium group is replaced by a halogen using a cuprous halide catalyst—is called the Sandmeyer reaction.

Final Answer: Sandmeyer reaction

Answer: (B)

Go Back to Question 19

Q20.

Solution

Concept: The separation of cations in qualitative inorganic analysis relies on controlling solubility products (K_{sp}). Group II cations precipitate as sulfides under a lower concentration of sulfide ions, which is achieved by utilizing the common ion effect in an acidic medium.

Solution: Step 1: Hydrogen sulfide (H_2S) is a weak diprotic electrolyte that dissociates reversibly in water:

$$H_2S(aq) \rightleftharpoons 2H^+(aq) + S^{2-}(aq)$$

Step 2: Hydrochloric acid (HCl) is a strong mineral acid that dissociates completely, releasing a high concentration of hydrogen ions (H^+).

Step 3: The high concentration of H^+ ions from HCl shifts the H_2S dissociation equilibrium to the left, according to Le Chatelier's principle. This common ion effect reduces the concentration of sulfide ions (S^{2-}) in the solution.

Step 4: The reduced sulfide concentration remains high enough to exceed the very low K_{sp} values of Group II sulfides (e.g., CuS, PbS), but prevents the premature precipitation of Group IV sulfides, which require a higher sulfide concentration.

Final Answer: Decrease the concentration of sulfide ions by common ion effect

Answer: (B)

Go Back to Question 20

Q21.

Solution

Concept: An adiabatic process is defined as a thermodynamic operation where no heat is exchanged between the system and its surroundings ($q = 0$). For an expanding gas, the mechanical work performed comes at the expense of its internal energy, affecting the temperature of the system.

Solution: Step 1: Establish the primary definition of an adiabatic boundary condition. By definition, there is no thermal exchange with the surroundings, so $q = 0$.

Step 2: Apply the first law of thermodynamics:

$$\Delta U = q + W$$

Since $q = 0$, this simplifies to $\Delta U = W$.

Step 3: Analyze the expansion component. In an expansion process, the gas performs work on its surroundings, meaning the work done W is negative ($W < 0$).

Step 4: Relate the work performed to the internal energy and temperature. Since $\Delta U = W$ and $W < 0$, the internal energy must decrease ($\Delta U < 0$). For an ideal gas, internal energy depends directly on temperature ($\Delta U = nC_v\Delta T$), meaning a drop in internal energy causes a corresponding drop in temperature ($\Delta T < 0$). This results in a cooling effect during expansion.

Final Answer: $q = 0, \Delta W < 0, \Delta T < 0$

Answer: (A)

Go Back to Question 21

Q22.

Solution

Concept: The reactivity of carbonyl compounds toward nucleophilic addition reactions is governed by electronic and steric factors. Nucleophiles attack the electrophilic carbonyl carbon atom, so lower steric hindrance and a higher partial positive charge on this carbon increase the reaction rate.

Solution: Step 1: Analyze the steric factors. Bulky alkyl groups around the carbonyl carbon hinder the approach of the incoming nucleophile, slowing down the reaction.

Step 2: Analyze the electronic factors. Alkyl groups are electron-donating via inductive effects ($+I$). This density reduces the partial positive charge ($\delta+$) on the carbonyl carbon, making it less attractive to a nucleophile.

Step 3: Compare the given structures:
- (iii) Formaldehyde (HCHO) has no alkyl groups, offering the lowest steric hindrance and the highest partial positive charge. It is the most reactive.
- (i) Acetaldehyde (CH_3CHO) has one methyl group.
- (ii) Acetone ($(CH_3)_2CO$) has two methyl groups.
- (iv) Di-tert-butyl ketone has two bulky tert-butyl groups, making it the least reactive due to severe steric hindrance.

Step 4: Combine these factors into the final reactivity sequence: (iii) > (i) > (ii) > (iv).

Final Answer: (iii) > (i) > (ii) > (iv)

Answer: (A)

Go Back to Question 22

Q23.

Solution

Concept: The oxoacids of phosphorus are categorized by the oxidation state of the central phosphorus atoms and the presence of specific structural bonds, such as P – H, P – OH, P = O, or direct catenated P – P linkages.

Solution: Step 1: Write down the chemical formula for hypophosphoric acid: $H_4P_2O_6$.

Step 2: Determine the oxidation state of the phosphorus atoms in this molecule. Let the oxidation state of P be x.

$$4(+1) + 2(x) + 6(-2) = 0 \implies 4 + 2x - 12 = 0 \implies 2x = 8 \implies x = +4$$

Step 3: Examine the structural connectivity of $H_4P_2O_6$. Its geometry consists of two symmetric $-PO(OH)_2$ units joined directly by a covalent phosphorus-phosphorus (P – P) bond.

Step 4: Verify the other choices: Pyrophosphoric acid ($H_4P_2O_7$) contains a P – O – P bridge with phosphorus in a +5 oxidation state. Orthophosphoric acid (H_3PO_4) is a monomeric acid with a +5 oxidation state. This confirms hypophosphoric acid as the correct answer.

Final Answer: Hypophosphoric acid

Answer: (B)

Go Back to Question 23

Q24.

Solution

Concept: According to Raoult's law, the relative lowering of vapor pressure for a dilute solution containing a non-volatile solute is equal to the mole fraction of the solute in that solution. This principle relates physical pressure measurements directly to solution composition.

Solution: Step 1: Write down the mathematical expression for Raoult's law:

$$\frac{P_A^\circ - P_A}{P_A^\circ} = X_B$$

Step 2: Identify the given values from the problem statement:
- Vapor pressure of pure solvent (P_A°) = 400 mm Hg
- Vapor pressure of the solution (P_A) = 320 mm Hg

Step 3: Calculate the absolute lowering of the vapor pressure (ΔP):

$$\Delta P = P_A^\circ - P_A = 400 - 320 = 80 \text{ mm Hg}$$

Step 4: Divide the absolute lowering by the pure solvent vapor pressure to find the mole fraction of the solute (X_B):

$$X_B = \frac{80}{400} = \frac{1}{5} = 0.20$$

Final Answer: 0.2

Answer: (B)

Go Back to Question 24

Q25.

Solution

Concept: The geometry and hybridization of carbon-based intermediates depend on the number of bonding pairs and lone pairs surrounding the central carbon atom. A trivalent carbon atom with an empty valence orbital adopts a flat geometry to minimize electron-pair repulsion.

Solution: Step 1: Analyze the methyl carbocation (CH_3^+). The central carbon atom shares three pairs of electrons with three hydrogen atoms and holds a positive charge, meaning its valence shell contains no lone pairs.

Step 2: Apply VSEPR theory. The three bonding pairs position themselves as far apart as possible, which corresponds to a trigonal planar arrangement with bond angles of 120°.

Step 3: Determine the hybridization. A trigonal planar arrangement of three bonding pairs requires sp^2 hybridization of the carbon atom. The unhybridized p_z orbital remains entirely empty and projects perpendicularly above and below the molecular plane.

Step 4: Evaluate the alternatives: The methyl radical is typically considered planar but contains an unpaired electron; the methyl carbanion has three bonding pairs and one lone pair, giving it an sp^3 hybridized pyramidal geometry. This confirms the methyl carbocation is the correct answer.

Final Answer: Methyl carbocation

Answer: (C)

Go Back to Question 25

Q26.

Solution

Concept: The magnetic properties of transition metal complexes depend on the number of unpaired electrons in their d-orbitals. The spin-only magnetic moment (μ_s) can be calculated directly using a formula based on the number of unpaired electrons (n).

Solution: Step 1: Write down the ground-state electron configuration of a neutral manganese atom ($Z = 25$):

$$\text{Mn} = [\text{Ar}]3d^5 4s^2$$

Step 2: Determine the configuration of the divalent manganese ion (Mn^{2+}) by removing the two valence electrons from the outermost $4s$ subshell:

$$\text{Mn}^{2+} = [\text{Ar}]3d^5$$

Step 3: Count the number of unpaired electrons (n) in the $3d$ subshell. According to Hund's rule, the five electrons occupy the five available $3d$ orbitals individually, meaning there are $n = 5$ unpaired electrons.

Step 4: Use the spin-only magnetic moment formula to calculate μ_s:

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

$$\mu_s = \sqrt{5(5+2)} = \sqrt{5 \times 7} = \sqrt{35} \approx 5.92\ \text{BM}$$

Final Answer: 5.92 BM

Answer: (B)

Go Back to Question 26

Q27.

Solution

Concept: The change in entropy (ΔS) for an ideal gas undergoing a reversible isothermal expansion can be derived from the first law of thermodynamics. Since internal energy is constant at a constant temperature, the heat absorbed by the gas can be related directly to its volume change.

Solution: Step 1: Write down the mathematical equation for the entropy change of an ideal gas during an isothermal process:

$$\Delta S = nR \ln\left(\frac{V_2}{V_1}\right) = 2.303\, nR \log\left(\frac{V_2}{V_1}\right)$$

Step 2: Identify the given parameters from the problem:

$$n = 2 \text{ moles}, \quad V_1 = 10 \text{ L}, \quad V_2 = 100 \text{ L}$$

$$R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$$

Step 3: Substitute these values into the entropy equation:

$$\Delta S = 2.303 \times 2 \times 8.314 \times \log\left(\frac{100}{10}\right)$$

Step 4: Simplify the logarithmic term and calculate the final value. Since $\log(10) = 1$:

$$\Delta S = 2.303 \times 2 \times 8.314 \times 1 = 38.29 \text{ J K}^{-1}$$

Final Answer: 38.29 J K^{-1}

Answer: (A)

Go Back to Question 27

Q28.

Solution

Concept: The carboxylation of phenoxide ions is an industrial method for synthesizing hydroxy aromatic acids. Sodium phenoxide reacts with carbon dioxide under pressure via an electrophilic aromatic substitution pathway, introducing a carboxyl group ortho to the hydroxyl group.

Solution: Step 1: Sodium phenoxide is treated with carbon dioxide gas (CO_2) at a high temperature (400 K) under a pressure of 4–7 atmospheres.

Step 2: The phenoxide oxygen atom increases electron density on the aromatic ring, making it highly nucleophilic. This allows the ring to attack the weak electrophile CO_2, primarily at the less hindered ortho position.

Step 3: This reaction yields intermediate sodium salicylate. Subsequent acidification with a mineral acid converts the sodium salt into free salicylic acid (2-hydroxybenzoic acid).

Step 4: This synthetic pathway is known as the Kolbe-Schmitt reaction, and its primary chemical product is salicylic acid, which serves as a precursor for aspirin.

Final Answer: Salicylic acid

Answer: (B)

Go Back to Question 28

Q29.

Solution

Concept: The lanthanoid contraction describes the steady decrease in atomic and ionic radii observed across the lanthanoid series from lanthanum to lutetium. It is caused by the poor shielding ability of $4f$ electrons, which leads to an increase in effective nuclear charge that pulls the outer electron shells closer to the nucleus.

Solution: Step 1: Evaluate the chemical impact of the lanthanoid contraction on basic strength. As ionic size decreases from La^{3+} to Lu^{3+}, the covalent character of the M – OH bond increases according to Fajan's rules.

Step 2: Analyze how this covalent character affects basicity. An increase in covalent character means the hydroxide ion (OH^-) is held more tightly and released less easily in water. Therefore, the basic strength of the hydroxides actually decreases from $La(OH)_3$ to $Lu(OH)_3$. This makes statement (C) false.

Step 3: Verify the correctness of the other options: The contraction makes the atomic radii of $4d$ and $5d$ transition elements nearly identical, and their similar chemical properties make separation exceptionally difficult. This confirms option (C) as the incorrect statement.

Final Answer: Basic strength of lanthanoid hydroxides increases from $La(OH)_3$ to $Lu(OH)_3$.

Answer: (C)

Go Back to Question 29

Q30.

Solution

Concept: The solubility product constant (K_{sp}) is an equilibrium constant that quantifies the dissolution of a sparingly soluble salt in an aqueous solution. For an A_2B type salt, the relationship between K_{sp} and molar solubility (S) depends on the stoichiometry of the dissolved ions.

Solution: Step 1: Write down the balanced dissolution equilibrium for silver chromate (Ag_2CrO_4) in water:

$$Ag_2CrO_4(s) \rightleftharpoons 2Ag^+(aq) + CrO_4^{2-}(aq)$$

Step 2: Express the equilibrium concentrations of the individual ions in terms of the molar solubility S:

$$[Ag^+] = 2S, \quad [CrO_4^{2-}] = S$$

Step 3: Substitute these concentration terms into the solubility product expression:

$$K_{sp} = [Ag^+]^2[CrO_4^{2-}] = (2S)^2 \times S = 4S^3$$

Step 4: Solve the mathematical equation for S using the given K_{sp} value (3.2×10^{-11}):

$$4S^3 = 3.2 \times 10^{-11} \implies S^3 = 8.0 \times 10^{-12}$$

Taking the cube root of both sides gives:

$$S = \sqrt[3]{8.0 \times 10^{-12}} = 2.0 \times 10^{-4} \text{ mol L}^{-1}$$

Final Answer: 2.0×10^{-4} mol L^{-1}

Answer: (A)

Go Back to Question 30

Q31.

Solution

Concept: The carbylamine reaction serves as a qualitative chemical test used to identify primary amines. Heating a primary amine with chloroform and an alcoholic base generates a functional group with a characteristic strong, foul odor.

Solution: Step 1: A primary amine ($R - NH_2$) reacts with chloroform ($CHCl_3$) in the presence of hot ethanolic potassium hydroxide (KOH).

Step 2: The reaction begins with the base alpha-eliminating HCl from chloroform to generate a highly reactive dichlorocarbene intermediate ($: CCl_2$).

Step 3: The nucleophilic primary amine attacks the dichlorocarbene intermediate. Subsequent elimination steps remove two molecules of water and three molecules of halogen salts.

Step 4: This process yields an organic derivative containing a terminal carbon-nitrogen triple bond structure ($R - N \equiv C$), which belongs to the class of alkyl isocyanides (carbylamines).

Final Answer: Alkyl isocyanide

Answer: (B)

Go Back to Question 31

Q32.

Solution

Concept: Metallurgical smelting involves adding a chemical flux to an ore to remove infusible impurities. The flux reacts with the impurities to form a fusible compound called slag, which can be easily separated from the molten metal.

Solution: Step 1: In the blast furnace extraction of iron, the raw hematite ore contains an infusible acidic impurity: silicon dioxide (SiO_2, sand).

Step 2: Limestone ($CaCO_3$) is added to the furnace charge as a flux. At high temperatures inside the furnace, it thermally decomposes into a basic oxide:

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

Step 3: The resulting calcium oxide (CaO) acts as a basic flux, reacting directly with the acidic silicon dioxide impurity via a neutralization reaction:

$$CaO(s) + SiO_2(s) \rightarrow CaSiO_3(l)$$

Step 4: This reaction forms molten calcium silicate ($CaSiO_3$), which acts as the principal slag. Because it is less dense than molten iron, it floats to the top and can be skimmed off easily.

Final Answer: $CaSiO_3$

Answer: (B)

Go Back to Question 32

Q33.

Solution

Concept: The ionization constant (K_a) of a weak monobasic acid quantifies its strength in an aqueous solution. It can be calculated using the initial concentration of the acid and the equilibrium concentration of hydrogen ions, which is determined from the pH of the solution.

Solution: Step 1: Relate the given pH value (4.0) to the equilibrium concentration of hydrogen ions ($[H^+]$):

$$[H^+] = 10^{-pH} = 10^{-4}\ M$$

Step 2: Set up the ionization equilibrium expression for a weak monobasic acid (HA):

$$HA(aq) \rightleftharpoons H^+(aq) + A^-(aq)$$

$$\text{Initial concentration } (C) = 0.1\ M$$

$$\text{Equilibrium concentrations: } [H^+] = [A^-] = 10^{-4}\ M$$

Step 3: Write down the mathematical formula for the acid ionization constant (K_a):

$$K_a = \frac{[H^+][A^-]}{[HA]} = \frac{[H^+]^2}{C - [H^+]}$$

Step 4: Since the acid is weak ($10^{-4}\ M \ll 0.1\ M$), we can approximate $C - [H^+] \approx C$:

$$K_a = \frac{(10^{-4})^2}{0.1} = \frac{10^{-8}}{10^{-1}} = 10^{-7}$$

Final Answer: 1.0×10^{-7}

Answer: (B)

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Q34.

Solution

Concept: The dehydrohalogenation of an alkyl halide using a strong, concentrated base proceeds via an E2 elimination mechanism. When multiple elimination products are possible, the regioselectivity is governed by Zaitsev's rule, which favors the formation of the more highly substituted, thermodynamically stable alkene.

Solution: Step 1: 2-Bromobutane ($CH_3CH(Br)CH_2CH_3$) contains two distinct sets of beta-hydrogens available for elimination: one on the terminal C_1 carbon and one on the internal C_3 carbon.

Step 2: The ethoxide ion (OH^- in alcohol) acts as a strong base, abstracting a beta-proton while the bromide leaving group departs in a single concerted step.

Step 3: Abstracting a proton from the C_1 carbon yields the less substituted alkene, but-1-ene. Abstracting a proton from the internal C_3 carbon yields the more stable disubstituted alkene, but-2-ene.

Step 4: According to Zaitsev's rule, the more substituted alkene is the major product. Between the two geometric isomers of but-2-ene, trans-but-2-ene is favored over cis-but-2-ene because it has less steric strain between the methyl groups.

Final Answer: trans-But-2-ene

Answer: (B)

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Q35.

Solution

Concept: Crystal Field Theory (CFT) describes how the five d-orbitals of a transition metal ion split into t_{2g} and e_g sub-levels in an octahedral coordination environment. The electron distribution between these sub-levels depends on the crystal field splitting energy (Δ_o) relative to the electron pairing energy (P).

Solution: Step 1: Determine the oxidation state of the cobalt ion in $[CoF_6]^{3-}$. Fluoride is a unidentate anionic ligand (F^-):

$$x + 6(-1) = -3 \implies x = +3$$

Cobalt(III) has a d^6 electron configuration ($[Ar]3d^6$).

Step 2: Assess the field strength of the ligand. Fluoride (F^-) is located at the weaker end of the spectrochemical series, making it a weak-field ligand. This means the crystal field splitting energy is less than the pairing energy ($\Delta_o < P$).

Step 3: Distribute the six d-electrons across the split orbitals according to Hund's rule. Since pairing requires more energy than moving to the higher sub-level, electrons occupy the orbitals singly before pairing:
- Place the first three electrons in the lower t_{2g} orbitals.
- Place the next two electrons in the higher e_g orbitals.
- Pair the final electron in a t_{2g} orbital.

This yields an electron configuration of $t_{2g}^4 e_g^2$.

Step 4: Count the unpaired electrons to determine the spin state. The configuration contains four unpaired electrons, making it a highly paramagnetic, high-spin complex.

Final Answer: $t_{2g}^4 e_g^2$, paramagnetic with high spin

Answer: (A)

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Q36.

Solution

Concept: The total number of atoms in a given mass of gas can be calculated using the mole concept. First, determine the number of moles of the gas from its mass and molar mass, then use Avogadro's number (N_A) and the atomicity of the molecule to find the total atom count.

Solution: Step 1: Calculate the molar mass of ammonia gas (NH_3):

$$\text{Molar Mass} = 14 + (3 \times 1) = 17 \text{ g mol}^{-1}$$

Step 2: Determine the number of moles (n) in 4.25 g of ammonia gas:

$$n = \frac{\text{Mass}}{\text{Molar Mass}} = \frac{4.25 \text{ g}}{17 \text{ g mol}^{-1}} = 0.25 \text{ moles}$$

Step 3: Determine the number of atoms per molecule of ammonia. Each individual NH_3 molecule contains 1 nitrogen atom and 3 hydrogen atoms, giving an atomicity of 4.

Step 4: Calculate the total number of atoms by multiplying the moles, the atomicity, and Avogadro's number (6.022×10^{23}):

$$\text{Total Atoms} = 0.25 \times 4 \times 6.022 \times 10^{23} = 1.0 \times 6.022 \times 10^{23} = 6.022 \times 10^{23}$$

Final Answer: 6.022×10^{23}

Answer: (A)

Go Back to Question 36

Q37.

Solution

Concept: The Williamson ether synthesis is an organic reaction used to prepare symmetrical and unsymmetrical ethers. It involves a bimolecular nucleophilic substitution (S_N2) mechanism where an alkoxide ion acts as a nucleophile to displace a halide leaving group from an unhindered primary alkyl halide.

Solution: Step 1: A sodium alkoxide ($R - O^-Na^+$) dissociates in solution to yield a strongly nucleophilic alkoxide ion ($R - O^-$).

Step 2: The alkoxide ion approaches the alkyl halide ($R' - X$) from the backside, opposite the leaving group, to minimize steric and electrostatic repulsion.

Step 3: The reaction proceeds via a single concerted step. As the new $C - O$ covalent bond forms, the carbon-halogen bond breaks simultaneously, passing through a single high-energy pentacoordinate transition state.

Step 4: Because this is a concerted, single-step substitution whose rate depends on the concentrations of both the nucleophile and the substrate, it follows an S_N2 kinetic mechanism.

Final Answer: S_N2

Answer: (B)

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Q38.

Solution

Concept: Most transition metals display variable oxidation states due to the small energy difference between their $3d$ and $4s$ subshells, allowing electrons from both levels to participate in bonding. However, elements at the beginning or end of the transition series may show fewer oxidation states.

Solution: Step 1: Examine the electron configuration of scandium ($Z = 21$):

$$\text{Sc} = [\text{Ar}]3d^1 4s^2$$

Step 2: Analyze its ionization behavior. Scandium readily loses its two $4s$ electrons and its single $3d$ electron together to achieve a highly stable, inert gas configuration matching argon ([Ar]).

Step 3: Because losing this specific combination of electrons is energetically favorable, scandium forms chemical compounds almost exclusively in the +3 oxidation state. It does not display the variable oxidation states typical of other transition metals.

Step 4: Contrast with the alternatives: Iron (Fe), copper (Cu), and manganese (Mn) all exhibit multiple stable oxidation states in their everyday compounds (e.g., $Fe^{2+/3+}$, $Cu^{+/2+}$, $Mn^{2+/4+/7+}$). This confirms scandium as the correct answer.

Final Answer: Sc

Answer: (C)

Go Back to Question 38

Q39.

Solution

Concept: The dependence of a chemical reaction's rate constant on temperature is quantified by the Arrhenius equation. This relationship allows us to calculate the activation energy (E_a) by comparing rate constants measured at two different temperatures.

Solution: Step 1: Write down the logarithmic form of the Arrhenius equation:

$$\log\left(\frac{k_2}{k_1}\right) = \frac{E_a}{2.303 \times R}\left[\frac{T_2 - T_1}{T_1 \times T_2}\right]$$

Step 2: Substitute the given values into the equation:

$$\frac{k_2}{k_1} = 4, \quad T_1 = 300 \text{ K}, \quad T_2 = 320 \text{ K}$$

$$R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$$

Step 3: Set up the mathematical expression with the substituted values:

$$\log(4) = \frac{E_a}{2.303 \times 8.314}\left[\frac{320 - 300}{300 \times 320}\right]$$

$$0.6020 = \frac{E_a}{19.147}\left[\frac{20}{96000}\right] = \frac{E_a}{19.147}\left[\frac{1}{4800}\right]$$

Step 4: Solve for the activation energy (E_a):

$$E_a = 0.6020 \times 19.147 \times 4800 = 55331 \text{ J mol}^{-1} \approx 55.33 \text{ kJ mol}^{-1}$$

Final Answer: $55.33 \text{ kJ mol}^{-1}$

Answer: (A)

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Q40.

Solution

Concept: The Cannizzaro reaction is a base-catalyzed redox disproportionation characteristic of aldehydes that lack alpha-hydrogens. In the presence of a concentrated strong base, these aldehydes undergo self-oxidation and reduction, yielding an alcohol and a carboxylic acid salt. Aldehydes with alpha-hydrogens undergo aldol condensation instead.

Solution: Step 1: Examine the chemical structure of acetaldehyde (CH_3CHO). The carbon atom adjacent to the carbonyl group (the alpha-carbon) is bonded to three hydrogen atoms, meaning it possesses alpha-hydrogens.

Step 2: Analyze its behavior in a concentrated base. Because alpha-hydrogens are acidic, the base abstracts a proton from the alpha-carbon to generate a reactive enolate ion, initiating an aldol condensation pathway rather than a Cannizzaro reaction.

Step 3: Evaluate the alternatives: Formaldehyde (HCHO), benzaldehyde (C_6H_5CHO), and trimethylacetaldehyde ($(CH_3)_3CCHO$) all lack alpha-hydrogens. Consequently, they readily undergo the Cannizzaro reaction when treated with concentrated alkali. This identifies acetaldehyde as the compound that fails to undergo the reaction.

Final Answer: Acetaldehyde

Answer: (D)

Go Back to Question 40

Q41.

Solution

Concept: The spatial geometry and hybridization of a central atom in a polyatomic ion can be determined using valence bond theory and steric principles. The total number of sigma bonds and lone pairs determines the hybrid orbitals required.

Solution: Step 1: Write down the primary Lewis resonance structures for the linear azide ion (N_3^-):

$$\overline{N} = \overset{+}{N} = \overline{N}$$

Step 2: Determine the steric environment around the central nitrogen atom (N_{center}). In this arrangement, the central nitrogen forms two double bonds—one to each of the terminal nitrogen atoms.

Step 3: Count the components of the bonds. Each double bond consists of one strong sigma (σ) bond and one weaker pi (π) bond. Therefore, the central nitrogen atom forms exactly two sigma bonds and holds no lone pairs.

Step 4: Relate the steric number to hybridization and geometry. A steric number of 2 signifies sp hybridization. This electronic configuration arranges the hybrid orbitals as far apart as possible, resulting in a linear molecular geometry with a bond angle of 180°.

Final Answer: sp, linear

Answer: (B)

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Q42.

Solution

Concept: Faraday's first law of electrolysis states that the quantity of electricity required to complete a chemical redox transformation depends on the stoichiometry of the electrons transferred in the balanced half-cell reaction. One mole of electrons carries a total charge equal to one Faraday (1 F = 96, 500 C).

Solution: Step 1: Examine the balanced half-cell reduction reaction for the dichromate ion in an acidic medium:

$$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$$

Step 2: Determine the electron stoichiometry. According to the equation, reducing 1 mole of $Cr_2O_7^{2-}$ ions requires exactly 6 moles of electrons.

Step 3: Convert the moles of electrons into Faraday units of charge (Q):

$$Q = 6 \text{ Faradays}$$

Step 4: Calculate the total charge in coulombs by multiplying the number of Faradays by Faraday's constant ($96,500 \text{ C F}^{-1}$):

$$Q = 6 \times 96,500 \text{ C} = 579,000 \text{ C}$$

Final Answer: 579, 000 C

Answer: (B)

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Q43.

Solution

Concept: Polysaccharides are macromolecular polymers composed of repeating monosaccharide units linked by glycosidic bonds. The chemical and physical properties of the polymer are determined by the specific isomer of the monomer (α or β) and the carbon positions involved in the linkages.

Solution: Step 1: Analyze the structural components of cellulose. Cellulose is a linear, unbranched biopolymer that serves as a structural framework in plant cell walls.

Step 2: Identify its monomeric building block. The polymer consists exclusively of repeating β-D-glucose units.

Step 3: Identify the nature of the chemical linkages. The monomeric units are joined together by glycosidic bonds formed between the C_1 anomeric carbon of one glucose molecule and the C_4 carbon of the adjacent unit. This specific linkage is classified as a β-1,4-glycosidic bond.

Step 4: Contrast with the alternatives: Amylose, amylopectin, and glycogen are energy-storage polymers composed of α-D-glucose units linked primarily by α-1,4 bonds. This confirms cellulose as the correct choice.

Final Answer: Cellulose

Answer: (C)

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Q44.

Solution

Concept: Electron gain enthalpy ($\Delta_{eg}H$) measures the energy change that occurs when an electron is added to a neutral gaseous atom. Halogens release a large amount of energy because adding an electron allows them to achieve a stable, closed-shell noble gas configuration. However, anomalously small sizes can introduce electron-electron repulsions that affect the expected periodic trend.

Solution: Step 1: Analyze the general group trend for halogens. Usually, electron gain enthalpy becomes less negative down a group as atomic size increases, because the incoming electron is shielded from the nucleus by inner shells. This suggests fluorine should have the highest value.

Step 2: Account for the anomaly involving fluorine. Fluorine has an exceptionally small atomic size, meaning its seven valence electrons are crowded together in a compact $2p$ subshell.

Step 3: Analyze the effect of this crowding. When an extra electron approaches a fluorine atom, it experiences strong electrostatic repulsion from the dense electron cloud, which reduces the net energy released during the capture process.

Step 4: Contrast this with chlorine. Chlorine has a larger $3p$ subshell that accommodates the incoming electron with much less electron-electron repulsion, allowing it to release the largest amount of energy. Therefore, chlorine has the highest negative electron gain enthalpy in the group.

Final Answer: Chlorine

Answer: (B)

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Q45.

Solution

Concept: Osmotic pressure (Π) is a colligative property governed by the van 't Hoff equation. For a dilute solution, the osmotic pressure depends on the molar concentration of the solute, the ideal gas constant, and the absolute temperature of the system.

Solution: Step 1: Write down the equation for osmotic pressure:

$$\Pi = C \times R \times T = \left(\frac{n}{V}\right) \times R \times T$$

Step 2: Calculate the number of moles (n) of urea present. The molar mass of urea ($(NH_2)_2CO$) is given as 60 g mol^{-1}.

$$n = \frac{\text{Mass}}{\text{Molar Mass}} = \frac{6.0 \text{ g}}{60 \text{ g mol}^{-1}} = 0.1 \text{ moles}$$

Step 3: Determine the molar concentration (C) of the solution. The volume (V) of the solution is given as 1 L.

$$C = \frac{0.1 \text{ moles}}{1 \text{ L}} = 0.1 \text{ M}$$

Step 4: Substitute the concentration and the given thermodynamic parameters ($R = 0.0821$ L atm K^{-1} mol^{-1} and $T = 300$ K) into the osmotic pressure formula:

$$\Pi = 0.1 \times 0.0821 \times 300 = 2.46 \text{ atm}$$

Final Answer: 2.46 atm

Answer: (A)

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Q46.

Solution

Concept: Diazo coupling is a classic organic reaction where an activated aromatic ring reacts with an arena diazonium ion. This process follows an electrophilic aromatic substitution mechanism, preserving the stable azo functional group ($-N = N-$) in the final product.

Solution: Step 1: Benzenediazonium chloride ($C_6H_5N_2^+Cl^-$) dissociates in solution to act as a weak electrophile due to its positively charged terminal nitrogen atom.

Step 2: Phenol is treated with a weakly basic medium, converting it into a phenoxide ion. This ion is highly activated because it strongly donates electron density into the ring through resonance effects ($+M$).

Step 3: The highly nucleophilic phenoxide ring attacks the terminal nitrogen atom of the diazonium ion, primarily at the less hindered para position.

Step 4: The loss of a proton from the ring restores its aromatic stability, completing the electrophilic aromatic substitution pathway to form the brightly colored dye *p*-hydroxyazobenzene.

Final Answer: Electrophilic substitution reaction

Answer: (A)

Go Back to Question 46

Q47.

Solution

Concept: Analytical identification of gases relies on evaluating their characteristic redox and acid-base reactions. Certain gases can dissolve to form an acidic solution that precipitates carbonates, while also possessing reducing properties that can reduce transition metal indicators.

Solution: Step 1: Analyze the reaction with lime water. When sulfur dioxide (SO_2) gas is bubbled into a solution of lime water ($Ca(OH)_2$), it forms an insoluble precipitate of calcium sulfite ($CaSO_3$), which turns the solution milky:

$$Ca(OH)_2(aq) + SO_2(g) \rightarrow CaSO_3(s) + H_2O(l)$$

Step 2: Analyze its redox properties. Sulfur dioxide contains sulfur in a intermediate +4 oxidation state, allowing it to act as a reducing agent.

Step 3: Evaluate its reaction with potassium permanganate. When SO_2 is introduced into an acidic solution of $KMnO_4$, it reduces the purple heptavalent manganese ion (Mn^{7+}) to a colorless divalent manganese species (Mn^{2+}), decolorizing the solution:

$$2MnO_4^- + 5SO_2 + 2H_2O \rightarrow 2Mn^{2+} + 5SO_4^{2-} + 4H^+$$

Step 4: Contrast with carbon dioxide (CO_2). While CO_2 also turns lime water milky by forming $CaCO_3$, it cannot act as a reducing agent because carbon is already in its maximum oxidation state (+4). Thus, it cannot decolorize a $KMnO_4$ solution. This confirms SO_2 as the correct gas.

Final Answer: SO_2

Answer: (B)

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Q48.

Solution

Concept: Hess's law of constant heat summation states that the total enthalpy change for a chemical reaction is independent of the pathway taken. Consequently, the standard enthalpy of a combustion reaction ($\Delta_c H^\circ$) can be calculated by subtracting the total enthalpies of formation of the reactants from the total enthalpies of formation of the products.

Solution: Step 1: Write down the balanced chemical equation for the complete combustion of ethene gas (C_2H_4):

$$C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l)$$

Step 2: Write out the equation for the enthalpy of combustion using the individual enthalpies of formation ($\Delta_f H^\circ$):

$$\Delta_c H^\circ = \left[2\Delta_f H^\circ(CO_2) + 2\Delta_f H^\circ(H_2O)\right] - \left[\Delta_f H^\circ(C_2H_4) + 3\Delta_f H^\circ(O_2)\right]$$

Step 3: Substitute the given enthalpy values into the expression. Remember that the enthalpy of formation for an element in its standard state, such as $O_2(g)$, is zero:

$$\Delta_f H^\circ(CO_2) = -393.5 \text{ kJ mol}^{-1}, \quad \Delta_f H^\circ(H_2O) = -285.8 \text{ kJ mol}^{-1}$$

$$\Delta_f H^\circ(C_2H_4) = +52.3 \text{ kJ mol}^{-1}, \quad \Delta_f H^\circ(O_2) = 0$$

Step 4: Perform the calculation:

$$\Delta_c H^\circ = [2(-393.5) + 2(-285.8)] - [+52.3 + 0]$$

$$\Delta_c H^\circ = [-787.0 - 571.6] - 52.3 = -1358.6 - 52.3 = -1410.9 \text{ kJ mol}^{-1}$$

Final Answer: $-1410.9 \text{ kJ mol}^{-1}$

Answer: (A)

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Q49.

Solution

Concept: The reaction of an alkyl halide with silver oxide depends on the hydration state of the reagent. While moist silver oxide acts like silver hydroxide to yield an alcohol, dry silver oxide facilitates an intermolecular substitution that couples two alkyl groups together around an oxygen atom.

Solution: Step 1: Write down the formula for the reactants: ethyl chloride (CH_3CH_2Cl) and dry silver oxide (Ag_2O).

Step 2: Analyze the role of dry silver oxide. It acts as an oxide donor (O^{2-}), and the silver ions (Ag^+) help pull the chlorine atoms off the alkyl substrate by forming an insoluble silver chloride (AgCl) precipitate.

Step 3: Map the pathway of the substitution reaction. Two molecules of ethyl chloride react with one formula unit of dry silver oxide:

$$2CH_3CH_2Cl + Ag_2O \rightarrow CH_3CH_2 - O - CH_2CH_3 + 2AgCl(s)$$

Step 4: Identify the resulting product. The reaction links the two ethyl chains together via an ether linkage, forming diethyl ether as the major organic product.

Final Answer: Diethyl ether

Answer: (A)

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Q50.

Solution

Concept: Boric acid (H_3BO_3) behaves as a weak monobasic acid in water, but its acidity does not come from losing a proton from its own structure. Instead, its behavior is explained by the electron-deficient nature of its central boron atom, which acts as a Lewis acid.

Solution: Step 1: Examine the electronic structure of orthoboric acid (H_3BO_3). The central boron atom is surrounded by three hydroxyl groups and has only six valence electrons, leaving it two electrons short of a stable octet.

Step 2: Analyze its interaction with water. Because it is electron-deficient, boric acid acts as a Lewis acid by accepting a lone pair of electrons from a water molecule (H_2O).

Step 3: Trace the steps of the reaction. Boric acid abstracts a hydroxyl ion (OH^-) from a water molecule to form a stable tetrahedral complex, leaving a free hydronium ion behind:

$$B(OH)_3 + 2H_2O \rightleftharpoons [B(OH)_4]^- + H_3O^+$$

Step 4: Conclude how it behaves as an acid. The acid behavior is an indirect process: boric acid removes an OH^- ion from water, causing the solvent to release a proton. This confirms that it acts as a Lewis acid rather than a traditional proton donor.

Final Answer: It acts as a Lewis acid by accepting a hydroxyl ion (OH^-) from water, releasing a proton.

Answer: (B)

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Answer Key

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