AME CET Chemistry Sample Paper-6

Duration: 20 Minutes **Maximum Marks: 80**

Instructions

- This paper contains **20** Multiple Choice Questions (Single Correct).
- Each correct answer carries **+4 marks**.
- Each incorrect answer carries: **−1 marks**.
- Use of mobile phones, smartwatches, calculators, or any electronic gadgets is strictly prohibited.

Q1. In the extraction of copper from copper pyrites, silica is added to the reverberatory furnace to serve as a flux. The slag formed during this process is composed of which of the following?

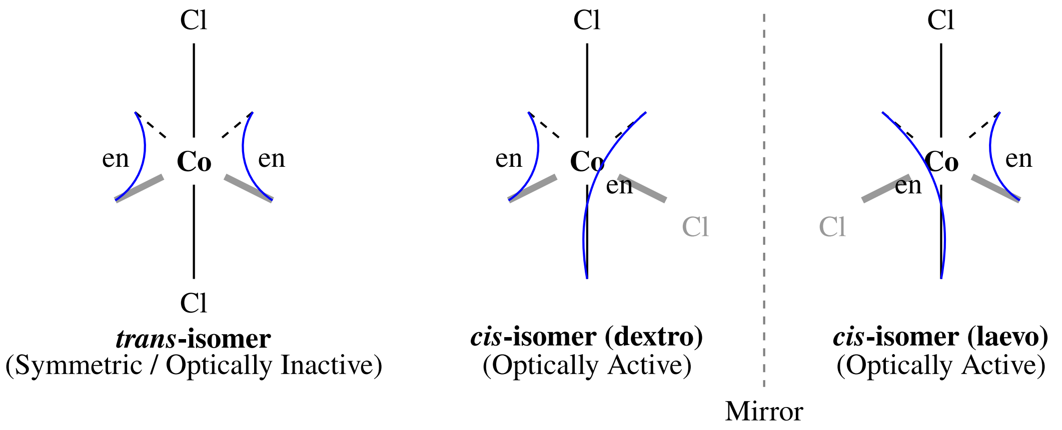
(A) Cu_2SiO_3

(B) $FeSiO_3$

(C) $CaSiO_3$

(D) $Al_2(SiO_3)_3$

Q2. What is the total number of optical isomers possible for the octahedral coordination complex $[Co(en)_2Cl_2]^+$, considering both its cis and trans geometric configurations? Isomers of $[Co(en)_2Cl_2]^+$



(A) 1

(B) 2

(C) 3

(D) 4

Q3. A closed system undergoes a reversible isothermal expansion against a variable external pressure. Which statement correctly describes the changes in the thermodynamic parameters for this process?

(A) $\Delta H = 0$ and $\Delta S_{\text{system}} = 0$

(B) $\Delta U = 0$ and $\Delta S_{\text{surroundings}} = 0$

(C) $\Delta U = 0$ and $\Delta S_{\text{total}} = 0$

(D) $\Delta H > 0$ and $\Delta S_{\text{system}} > 0$

Q4. Which of the following molecules possesses a permanent molecular dipole moment ($\mu \neq 0$) despite having highly symmetric covalent bonds?

(A) SF_4

(B) XeF_4

(C) BF_3

(D) SiF_4

Q5. An organic compound with the molecular formula $C_4H_{10}O$ does not react with metallic sodium, but when heated with an excess of hydroiodic acid (HI), it yields a single alkyl iodide. The original compound is:

(A) Diethyl ether

(B) Methyl propyl ether

(C) 1-Butanol

(D) Methyl isopropyl ether

Q6. During the preparation of a lyophobic sol like gold sol, a small amount of gelatin is often added. The primary role of gelatin in this context is to:

(A) Accelerate coagulation by neutralizing surface charges

(B) Act as a reducing agent to form gold particles

(C) Form a protective layer around the gold particles to prevent coagulation

(D) Increase the zeta potential of the solution exponentially

Q7. In a fundamental electrochemical cell, a standard hydrogen electrode (SHE) is coupled with a zinc electrode immersed in a 1.0 M Zn^{2+} solution. If the temperature is maintained at 298 K, what occurs at the anode?

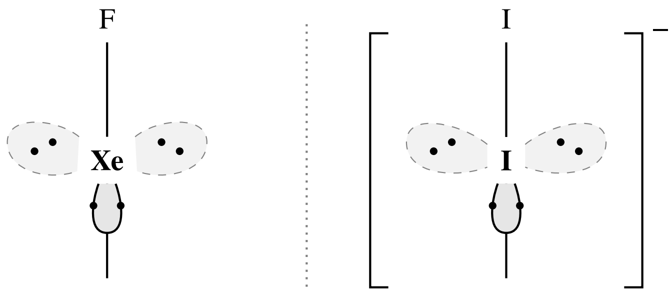
(A) H^+ ions are reduced to H_2 gas

(B) Zn^{2+} ions are reduced to metallic zinc

(C) H_2 gas is oxidized to H^+ ions

(D) Metallic zinc is oxidized to Zn^{2+} ions

Q8. Which statement correctly describes the structural properties and hybridisation of the central atom in XeF_2 and I_3^-, respectively?



XeF_2 (Linear, sp^3d) I_3^- (Linear, sp^3d)

(A) Both are linear in geometry and feature sp^3d hybridisation on the central atom

(B) XeF_2 is linear with sp^3 hybridisation; I_3^- is bent with sp^3d hybridisation

(C) Both are bent in geometry and feature sp^3d^2 hybridisation on the central atom

(D) XeF_2 is bent with sp^3d hybridisation; I_3^- is linear with sp^2 hybridisation

Q9. When an aqueous solution of sodium chloride is subjected to electrolysis using inert platinum electrodes, the products liberated at the cathode and anode are, respectively:

(A) Na and Cl_2

(B) H_2 and O_2

(C) H_2 and Cl_2

(D) Na and O_2

Q10. Consider the following chemical equilibrium established in a closed vessel: $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$. If the volume of the reaction container is suddenly halved at a constant temperature, what happens to the degree of dissociation (α) of PCl_5?

(A) α increases

(B) α decreases

(C) α remains completely unchanged

(D) α becomes equal to unity

Q11. The core structural building block of all silicate minerals is the silicate anion. What is the spatial geometry and net charge of this fundamental silicate unit?

(A) Tetrahedral geometry with a net charge of −4

(B) Planar geometry with a net charge of −2

(C) Octahedral geometry with a net charge of −4

(D) Linear geometry with a net charge of −2

Q12. The major organic product obtained from the reaction of 2-bromobutane with alcoholic KOH under reflux conditions is:

(A) 1-Butene

(B) trans-2-Butene

(C) cis-2-Butene

(D) 2-Butanol

Q13. How many moles of electrons are required to completely reduce 1.0 mole of $Cr_2O_7^{2-}$ ions to Cr^{3+} ions in an acidic aqueous medium?

(A) 2

(B) 3

(C) 5

(D) 6

Q14. Arrange the following chemical species in the exact increasing order of their bond lengths based on Molecular Orbital Theory (MOT): O_2, O_2^+, O_2^-, and O_2^{2-}.

(A) $O_2^+ < O_2 < O_2^- < O_2^{2-}$

(B) $O_2^{2-} < O_2^- < O_2 < O_2^+$

(C) $O_2 < O_2^+ < O_2^- < O_2^{2-}$

(D) $O_2^- < O_2^{2-} < O_2^+ < O_2$

Q15. An organic compound (X) with molecular formula C_3H_6O gives a positive test with 2,4-dinitrophenylhydrazine (2,4-DNP) reagent but fails to reduce Tollens' reagent or Fehling's solution. Compound (X) is:

(A) Propanal

(B) Propan-1-ol

(C) Propanone

(D) Propanoic acid

Q16. Which of the following pairs represents a set of coordination isomers?

(A) $[Co(NH_3)_5Br]SO_4$ and $[Co(NH_3)_5(SO_4)]Br$

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

(C) $[Pt(NH_3)_2Cl_2]$ (cis and trans forms)

(D) $[Co(H_2O)_6]Cl_3$ and $[Co(H_2O)_5Cl]Cl_2 \cdot H_2O$

Q17. The reaction of toluene with chlorine (Cl_2) in the presence of anhydrous $FeCl_3$ in the dark yields predominantly a mixture of ortho- and para-chlorotoluene. However, when the same reaction is carried out in the presence of sunlight and heat, the primary product is:

(A) Meta-chlorotoluene

(B) Hexachlorocyclohexane

(C) Benzyl chloride

(D) 2,4,6-Trichlorotoluene

Q18. For a first-order chemical reaction, a straight-line plot is obtained when which of the following parameters are plotted against each other?

(A) Concentration of reactant vs Time

(B) Natural logarithm of concentration ($\ln[R]$) vs Time

(C) Half-life ($t_{1/2}$) vs Initial concentration ($[R]_0$)

(D) Rate of reaction vs Time

Q19. Phenol undergoes an electrophilic aromatic substitution reaction when treated with chloroform ($CHCl_3$) in the presence of aqueous sodium hydroxide ($NaOH$) at 340 K. After acidification, the major product isolated is salicylaldehyde. This chemical transformation is known as the:

(A) Kolbe-Schmitt Reaction

(B) Reimer-Tiemann Reaction

(C) Friedel-Crafts Formylation

(D) Rosenmund Reduction

Q20. What is the total volume of oxygen gas (O_2) measured at Standard Temperature and Pressure (STP) that is consumed during the complete combustion of exactly 4.4 g of propane (C_3H_8) gas?

(A) 11.2 L

(B) 2.24 L

(C) 22.4 L

(D) 44.8 L

Detailed Solutions

Q1.

Solution

Concept:
In the pyrometallurgy of copper, copper pyrites ($CuFeS_2$) are roasted and smelted in a reverberatory furnace. The objective is to remove iron impurities, which have a high affinity for oxygen, from the desired copper species. This separation relies on slag formation using an acidic flux to chemically bind basic metal oxide impurities into an immiscible liquid layer.

Solution:

(a) During roasting and smelting in the reverberatory furnace, iron sulfide (FeS) present in the ore is preferentially oxidized to form basic iron(II) oxide (FeO), while copper remains primarily as copper(I) sulfide (Cu_2S).

(b) Iron(II) oxide (FeO) is a basic impurity that cannot be easily separated by melting alone because it remains mixed with the molten copper matte layer.

(c) To remove this basic impurity, silica (SiO_2) is intentionally added to the furnace to act as an acidic flux.

(d) The acidic flux (SiO_2) reacts chemically with the basic impurity (FeO) at high temperatures to form ferrous silicate ($FeSiO_3$).

(e) Ferrous silicate ($FeSiO_3$) forms a lightweight, fusible molten layer known as slag. Because it has a lower density than the copper matte ($Cu_2S + FeS$), it floats to the top and can be easily skimmed off.

Final Answer: Ferrous silicate ($FeSiO_3$)

Answer: (B)

Go Back to Question 1

Q2.

Solution

Concept:
Coordination complexes exhibit stereoisomerism, which includes geometric and optical isomerism. For an octahedral complex of the type $[M(aa)_2X_2]$, where aa is a bidentate ligand like ethylenediamine (en) and X is a monodentate ligand like Cl^-, stereoisomerism depends heavily on molecular symmetry and the presence or absence of a plane of symmetry.

Solution:

(a) The coordination complex $[Co(en)_2Cl_2]^+$ exhibits two distinct geometric isomers based on the relative spatial positions of the two chloride ligands: the cis-isomer and the trans-isomer.

(b) In the trans-isomer, the two chloride ligands are positioned exactly opposite to each other (180° angle). This linear arrangement imparts a high degree of symmetry to the molecule, specifically introducing a plane of symmetry (P_s) and an inversion center.

(c) Due to this internal symmetry, the trans-isomer is entirely achiral (optically inactive) and possesses a superimposable mirror image. Thus, it exists as a single non-resolvable form.

(d) In the cis-isomer, the two chloride ligands are adjacent to each other (90° angle). This asymmetric arrangement lacks a plane of symmetry and a center of inversion, making the molecule chiral.

(e) Because the cis-isomer is chiral, it exists as a pair of non-superimposable mirror images: a dextrorotatory (d) form and a levorotatory (l) form, which are optical enantiomers. Therefore, counting both the 1 achiral trans-form and the 2 optical forms of the cis-isomer, the total number of optical isomers is 3.

Final Answer: 3

Answer: (C)

Go Back to Question 2

Q3.

Solution

Concept:

Thermodynamics dictates state functions and path functions for ideal systems undergoing specific pathways. For an ideal gas expanding or compressing isothermally (T = constant) in a closed system, internal energy and enthalpy depend solely on temperature. Entropy changes for the system, surroundings, and total universe depend on the reversibility of the thermal and mechanical work.

Solution:

(a) Internal energy (U) and enthalpy (H) of an ideal gas are functions of temperature only. Because the process is explicitly specified as isothermal, the temperature change (ΔT) is zero, which mathematically mandates that $\Delta U = 0$ and $\Delta H = 0$.

(b) During an expansion process, the volume of the system increases, leading to a higher positional disorder of the gas molecules. Consequently, the entropy change of the system must be greater than zero ($\Delta S_{\text{system}} > 0$).

(c) Since the process is fully reversible, heat is transferred between the system and the surroundings in infinitesimally small amounts, maintaining thermodynamic equilibrium at every step.

(d) For any perfectly reversible process, the total entropy change of the universe—which is the sum of the entropy change of the system and the surroundings—must be zero ($\Delta S_{\text{total}} = \Delta S_{\text{system}} + \Delta S_{\text{surroundings}} = 0$).

(e) This requirement means that $\Delta S_{\text{surroundings}} = -\Delta S_{\text{system}}$. Since $\Delta S_{\text{system}} > 0$, the entropy of the surroundings must decrease ($\Delta S_{\text{surroundings}} < 0$), keeping the total net entropy change zero.

Final Answer: $\Delta U = 0$ and $\Delta S_{\text{total}} = 0$

Answer: (C)

Go Back to Question 3

Q4.

Solution

Concept:
The molecular dipole moment (μ) is a vector quantity that depends on both individual bond dipoles and molecular geometry. According to Valence Shell Electron Pair Repulsion (VSEPR) theory, the spatial distribution of bonding pairs and lone pairs around a central atom determines whether individual bond dipole vectors cancel each other out or combine to create a net molecular dipole.
Solution:

(a) XeF_4 contains a central xenon atom with 4 bonding pairs and 2 lone pairs (sp^3d^2 hybridization), yielding a square planar geometry where symmetric bond dipoles and opposing lone pairs completely cancel out ($\mu = 0$).

(b) BF_3 contains a central boron atom with 3 bonding pairs (sp^2 hybridization), producing a highly symmetric trigonal planar geometry where the vectors of the three polar $B - F$ bonds perfectly cancel each other out ($\mu = 0$).

(c) SiF_4 contains a central silicon atom with 4 bonding pairs (sp^3 hybridization), resulting in a regular tetrahedral structure where the four equivalent polar $Si - F$ bond dipoles cancel completely due to structural symmetry ($\mu = 0$).

(d) SF_4 contains a central sulfur atom with 4 bonding pairs and 1 lone pair (sp^3d hybridization). This configuration adopts a see-saw geometry derived from a trigonal bipyramidal arrangement.

(e) Due to the asymmetric positioning of the lone pair in the equatorial position, the axial and equatorial $S - F$ bond dipole vectors do not cancel each other out, resulting in a net permanent molecular dipole moment ($\mu \neq 0$).

Final Answer: SF_4

Answer: (A)

Go Back to Question 4

Q5.

Solution

Concept:
Functional group chemistry and functional isomerism can be inferred through qualitative organic tests and ether cleavage mechanisms. An organic compound with the formula $C_4H_{10}O$ matches the general formula $C_nH_{2n+2}O$, indicating it is either an alcohol or an ether. Alcohols react with active metals, whereas ethers undergo nucleophilic cleavage when exposed to concentrated halogen acids.
Solution:

(a) The compound with molecular formula $C_4H_{10}O$ does not react with metallic sodium. Since alcohols possess an acidic hydrogen atom bonded to oxygen and readily release hydrogen gas with sodium metal, the lack of reaction proves that the compound cannot be an alcohol; it must be an ether.

(b) Ethers contain an inert $-O-$ linkage that resists basic reagents but undergoes nucleophilic substitution reactions when treated with concentrated hydroiodic acid (HI) under thermal conditions.

(c) The cleavage of an unsymmetrical ether like methyl propyl ether ($CH_3-O-CH_2CH_2CH_3$) by excess HI yields two distinct alkyl iodides: methyl iodide (CH_3I) and propyl iodide ($CH_3CH_2CH_2I$).

(d) The problem states that the reaction with excess HI yields only a single type of alkyl iodide. This outcome structurally implies that the starting ether must be highly symmetrical.

(e) Diethyl ether ($CH_3CH_2-O-CH_2CH_3$) is a completely symmetrical ether. When heated with an excess of hydroiodic acid, both ethyl-oxygen bonds are cleaved, converting both alkyl groups into ethyl iodide (CH_3CH_2I) as the sole organic product.

Final Answer: Diethyl ether

Answer: (A)

Go Back to Question 5

Q6.

Solution

Concept:
Surface chemistry classifies colloidal sols into lyophilic (liquid-loving) and lyophobic (liquid-hating) categories based on the nature of interaction between the dispersed phase and the dispersion medium. Lyophobic sols, such as gold or sulfur sols, are inherently unstable and easily coagulated by small amounts of electrolytes, necessitating protective agents.
Solution:

(a) Lyophobic colloids lack affinity between the dispersed particles and the liquid medium. They owe their thermodynamic stability solely to the mutual electrostatic repulsion of the shared electrical charges on their surfaces.

(b) When a small amount of an electrolyte is introduced, it neutralizes these surface charges, causing the colloidal particles to aggregate, form larger clusters, and precipitate out of solution (coagulation).

(c) Lyophilic colloids, such as gelatin, starch, or proteins, are highly stable because they are extensively solvated by the dispersion medium.

(d) When a lyophilic sol like gelatin is added to a lyophobic gold sol, the gelatin molecules spontaneously adsorb onto the surface of the gold particles, encapsulating them completely.

(e) This process forms a protective hydrophilic outer layer around the gold particles. This physical barrier prevents close contact between individual gold particles and shields them from electrolyte-induced coagulation, thereby acting as a protective colloid.

Final Answer: Form a protective layer around the gold particles to prevent coagulation

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

Go Back to Question 6

Q7.

Solution

Concept:

Electrochemical cells consist of two half-cells where oxidation and reduction reactions occur simultaneously at distinct electrodes. By universal convention, oxidation always takes place at the anode, while reduction occurs at the cathode. The driving force and directional flow of electrons depend directly on the standard reduction potentials (E°) of the coupled chemical species.

Solution:

(a) The cell is constructed by coupling a standard hydrogen electrode (SHE) with a zinc electrode immersed in a 1.0 M Zn^{2+} solution under standard conditions (298 K).

(b) According to the electrochemical series, the standard reduction potential of the zinc electrode ($E^\circ_{Zn^{2+}/Zn}$) is −0.76 V, whereas the standard reduction potential of the standard hydrogen electrode ($E^\circ_{H^+/H_2}$) is defined exactly as 0.00 V.

(c) Since zinc has a lower (more negative) reduction potential than hydrogen, it possesses a much greater tendency to lose electrons and undergo oxidation compared to hydrogen.

(d) Consequently, the zinc electrode acts as the negative terminal or anode of the electrochemical cell, while the standard hydrogen electrode acts as the cathode.

(e) Because oxidation occurs exclusively at the anode, metallic zinc atoms lose electrons and are converted into zinc ions that dissolve into the solution according to the half-reaction: $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$.

Final Answer: Metallic zinc is oxidized to Zn^{2+} ions

Answer: (D)

Go Back to Question 7

Q8.

Solution

Concept:
The structural geometry and hybridization of interhalogen compounds and polyhalide ions are accurately explained by Valence Shell Electron Pair Repulsion (VSEPR) theory and hybridization models. The total number of steric valence electronic pairs surrounding a central atom dictates its ideal spatial geometry and orbital mixing pattern.
Solution:

(a) For xenon difluoride (XeF_2), the central xenon atom contains 8 valence electrons. It forms 2 single covalent bonds with two fluorine atoms, leaving 6 unshared valence electrons, which form exactly 3 lone pairs.

(b) The steric number for the central Xe atom is calculated as the sum of sigma bonds and lone pairs: Steric Number = 2 + 3 = 5. A steric number of 5 corresponds to sp^3d hybridization.

(c) For the triiodide ion (I_3^-), the central iodine atom has 7 valence electrons plus 1 negative charge, totaling 8 valence electrons. It binds to two terminal iodine atoms using 2 sigma bonds, leaving 3 lone pairs.

(d) The steric number for the central I atom in I_3^- is also $2 + 3 = 5$, which dictates sp^3d hybridization for its central atom.

(e) For both chemical species, a steric number of 5 directs a trigonal bipyramidal electronic geometry. According to VSEPR rules, the 3 lone pairs occupy the equatorial positions to minimize repulsion, leaving the 2 bonding atoms in axial positions, which results in a linear molecular geometry for both.

Final Answer: Both are linear in geometry and feature sp^3d hybridisation on the central atom

Answer: (A)

Go Back to Question 8

Q9.

Solution

Concept:

Electrolysis of aqueous solutions involves competing oxidation and reduction reactions at the electrodes. When an electric current passes through an aqueous solution of sodium chloride ($NaCl$), multiple ionic species (Na^+, Cl^-, H^+, and OH^-) migrate toward the electrodes. The product liberated depends on the standard discharge potentials of these competing species.

Solution:

(a) In an aqueous solution of sodium chloride, the chemical species present are sodium ions (Na^+) and chloride ions (Cl^-) from the salt, along with hydrogen ions (H^+) and hydroxyl ions (OH^-) from the autoionization of water molecules.

(b) At the cathode (the negative electrode), both Na^+ ions and H^+ ions compete for reduction. The standard reduction potential of H^+ (0.00 V) is significantly higher than that of Na^+ (−2.71 V).

(c) Because hydrogen ions are much easier to reduce than sodium ions, H^+ ions preferentially gain electrons at the cathode, forming neutral hydrogen atoms that pair to evolve as hydrogen gas (H_2).

(d) At the anode (the positive electrode), both Cl^- ions and OH^- ions compete to undergo oxidation. Although the standard oxidation potential of water to yield oxygen is thermodynamically favored, it suffers from a high activation energy barrier known as overpotential.

(e) Due to this kinetic overpotential for oxygen evolution, chloride ions (Cl^-) are preferentially discharged and oxidized at the anode to liberate chlorine gas (Cl_2).

Final Answer: H_2 and Cl_2

Answer: (C)

Go Back to Question 9

Q10.

Solution

Concept:

Le Chatelier's principle states that if a dynamic chemical equilibrium is subjected to a change in concentration, temperature, or total pressure, the position of the equilibrium shifts in a direction that counteracts the imposed disturbance. For gas-phase reactions, a change in container volume alters the total pressure and concentrations, shifting the equilibrium toward the side with fewer or more moles of gas.

Solution:

(a) Consider the gaseous decomposition reaction: $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$. Summing the stoichiometric coefficients gives 1 mole of gaseous reactant on the left side and 2 moles of gaseous products on the right side ($\Delta n_g = 2 - 1 = +1$).

(b) When the volume of the reaction container is suddenly halved at a constant temperature, the total pressure inside the closed vessel doubles, and the molar concentrations of all gaseous components instantly double.

(c) According to Le Chatelier's principle, when the total pressure of a gaseous system is increased by reducing its volume, the system responds by shifting its equilibrium position in the direction that decreases the total number of gaseous moles to relieve the pressure stress.

(d) Since the forward reaction increases the total number of gas moles ($\Delta n_g > 0$), the system must shift in the reverse direction (from right to left) to reduce the total number of moles.

(e) This reverse shift causes PCl_3 and Cl_2 to recombine to form more PCl_5. Consequently, the degree of dissociation (α) of PCl_5 must decrease.

Final Answer: α decreases

Answer: (B)

Go Back to Question 10

Q11.

Solution

Concept:

The structural framework of mineral chemistry is fundamentally rooted in the configuration of silicates. Silicates constitute a vast class of compounds found in the earth's crust. Their diverse architectures—ranging from chain and sheet silicates to complex three-dimensional frameworks—all arise from the repetitive arrangements of a single basic, highly stable structural anion unit.

Solution:

(a) The absolute fundamental building block of all silicate minerals and synthetic silicates is the orthosilicate monomeric unit, which contains a single central silicon atom bound to oxygen.

(b) The central silicon atom possesses 4 valence electrons and undergoes sp^3 hybridization to establish equivalent bonds with surrounding oxygen atoms.

(c) This sp^3 hybridization forces the four oxygen atoms to reside at the corners of a regular three-dimensional spatial geometry known as a tetrahedron.

(d) In this configuration, the silicon atom exhibits a stable +4 oxidation state, while each of the four surrounding, unshared oxygen atoms retains a -1 formal oxidation charge.

(e) Summing these individual electronic contributions yields a net chemical formula of SiO_4^{4-}. Thus, the unit possesses a clear tetrahedral geometry paired with an overall negative charge of -4.

Final Answer: Tetrahedral geometry with a net charge of -4

Answer: (A)

Go Back to Question 11

Q12.

Solution

Concept:

Alkyl halides readily undergo dehydrohalogenation reactions when exposed to strong, concentrated bases under thermal reflux conditions. This elimination transformation typically proceeds via a concerted second-order ($E2$) reaction mechanism. The regioselectivity and structural distribution of the resulting alkene products are governed by standard thermodynamic stability rules.

Solution:

(a) When 2-bromobutane is heated under reflux with a solution of alcoholic potassium hydroxide (KOH), the strong base ($ethoxide$ or $hydroxide$) induces an $E2$ elimination reaction by abstracting a proton.

(b) The elimination requires the removal of a halide ion from the second carbon atom along with a hydrogen atom from an adjacent β-carbon atom.

(c) 2-Bromobutane contains two non-equivalent sets of β-hydrogens: three located on the terminal $C1$ methyl group and two located on the internal $C3$ methylene group.

(d) Elimination involving a $C1$ hydrogen yields 1-butene, whereas elimination utilizing a more substituted $C3$ hydrogen generates a mixture of stereoisomeric 2-butenes.

(e) According to Zaitsev's rule, the more highly substituted alkene is the thermodynamically favored major product. Therefore, 2-butene is preferred over 1-butene, and trans-2-butene is produced in the highest yield because its opposing alkyl groups minimize steric hindrance compared to cis-2-butene.

Final Answer: trans-2-Butene

Answer: (B)

Go Back to Question 12

Q13.

Solution

Concept:

Oxidation-reduction processes in analytical chemistry rely on precise electron transfers that can be tracked using formal oxidation states. To determine the quantity of electricity or the stoichiometric moles of electrons required to reduce an oxidizing agent in an acidic medium, a balanced chemical half-reaction tracking the change in oxidation number must be established.

Solution:

(a) Consider the reduction half-reaction of the dichromate oxidizing agent in an acidic aqueous environment: $Cr_2O_7^{2-} + 14H^+ + ne^- \rightarrow 2Cr^{3+} + 7H_2O$.

(b) To determine the exact number of electrons, n, needed for this conversion, the formal oxidation state of the chromium atom must be evaluated on both sides of the equation.

(c) In the reactant oxoanion $Cr_2O_7^{2-}$, oxygen has an oxidation state of -2. Setting up the charge balance equation yields $2x + 7(-2) = -2$, which simplifies to $2x = 12$, confirming that each chromium atom exists in a $+6$ oxidation state.

(d) On the product side, the chromium species is converted into simple mononuclear chromic ions, where each Cr^{3+} ion carries an explicit oxidation state of $+3$.

(e) The change in oxidation state for a single chromium atom is $+6 - 3 = 3$. Because each dichromate ion contains exactly two chromium atoms, the net transition requires a total of $2 \times 3 = 6$ moles of electrons per mole of reactant.

Final Answer: 6

Answer: (D)

Go Back to Question 13

Q14.

Solution

Concept:

Molecular Orbital Theory (MOT) provides a quantum-mechanical framework for describing homonuclear diatomic molecules of the second period. By filling electronic molecular configurations according to the Aufbau principle, the precise bond order can be mathematically calculated. This bond order serves as a direct indicator of bond strength and shares an inverse relationship with bond length.

Solution:

(a) The ground-state molecular orbital configuration for a neutral oxygen molecule (O_2, containing 16 electrons) features a filling pattern that leaves two electrons in the degenerate antibonding π^* orbitals, yielding a bond order of $\frac{14-10}{2} = 2$.

(b) When an electron is removed to form the dioxygen cation (O_2^+, 15 electrons), an electron is evacuated from an antibonding π^* orbital. This increases the structural bond order to $\frac{11-6}{2} = 2.5$.

(c) Adding an electron to form the superoxide anion (O_2^-, 17 electrons) introduces a destabilizing electron into the antibonding π^* orbitals, dropping the bond order to $\frac{10-7}{2} = 1.5$.

(d) Introducing a second electron to form the peroxide peroxide peroxide peroxide peroxide dianion (O_2^{2-}, 18 electrons) completely fills the antibonding π^* shell, lowering the bond order to $\frac{10-8}{2} = 1$.

(e) Since bond length is strictly inversely proportional to bond order, the species with the highest bond order has the shortest bond length. The exact increasing order of bond lengths is therefore $O_2^+ < O_2 < O_2^- < O_2^{2-}$.

Final Answer: $O_2^+ < O_2 < O_2^- < O_2^{2-}$

Answer: (A)

Go Back to Question 14

Q15.

Solution

Concept:
Organic qualitative analysis distinguishes between different carbonyl functions using structural reactivity profiling. The structural formula C_3H_6O corresponds to an unsaturated alcohol, an ether, or a saturated carbonyl compound (aldehyde or ketone). Nucleophilic addition reagents identify carbonyl groups, while mild oxidizing agents differentiate between aldehydes and ketones.

Solution:

(a) The organic unknown compound (X) with the molecular formula C_3H_6O reacts positively with 2,4-dinitrophenylhydrazine (2,4-DNP) reagent to form a brightly colored hydrazone precipitate, which confirms the presence of either an aldehyde or a ketone functional group.

(b) Both aldehydes and ketones contain a highly polarizable carbon-oxygen double bond (C = O) that undergoes rapid nucleophilic attack by hydrazine derivatives.

(c) To distinguish between these two families, mild chemical oxidizing agents like Tollens' reagent ($[Ag(NH_3)_2]^+$) or Fehling's solution (Cu^{2+} tartrate complex) are employed.

(d) Aldehydes possess a vulnerable hydrogen atom directly attached to the carbonyl carbon, allowing them to be oxidized to carboxylic acids while reducing Tollens' reagent to metallic silver.

(e) Ketones lack this formyl hydrogen atom and cannot be oxidized by mild reagents. Because compound (X) fails to react with Tollens' or Fehling's reagents, it must be a ketone. The only three-carbon ketone matching this formula is propanone (acetone).

Final Answer: Propanone

Answer: (C)

Go Back to Question 15

Q16.

Solution

Concept:
Structural isomerism within coordination chemistry manifests in several distinct forms, including ionization, linkage, hydrate, and coordination isomerism. Coordination isomerism is a unique phenomenon restricted to complex salts where both the cationic species and the anionic species are coordination complexes, allowing a mutual exchange of ligands between the two coordination spheres.

Solution:

(a) Ionization isomerism occurs when counter-ions swap places with coordinated ligands, as seen in the pair $[Co(NH_3)_5Br]SO_4$ and $[Co(NH_3)_5(SO_4)]Br$, which release different ions in solution.

(b) Hydrate isomerism involves an exchange between coordinated aqua ligands and counter-halide ions within the crystal lattice, as shown by $[Co(H_2O)_6]Cl_3$ and $[Co(H_2O)_5Cl]Cl_2 \cdot H_2O$.

(c) Geometric isomerism, such as cis and trans arrangements in square planar $[Pt(NH_3)_2Cl_2]$, represents stereoisomerism rather than structural rearrangement.

(d) Coordination isomerism requires a dual-complex salt system containing a complex cation and a complex anion. Isomers arise when the ligands attached to the two central metal zones are interchanged.

(e) The pair $[Co(NH_3)_6][Cr(CN)_6]$ and $[Cr(NH_3)_6][Co(CN)_6]$ represents a clear example of coordination isomerism, where the ammine and cyanide ligands are swapped between the cobalt and chromium centers.

Final Answer: $[Co(NH_3)_6][Cr(CN)_6]$ and $[Cr(NH_3)_6][Co(CN)_6]$

Answer: (B)

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Q17.

Solution

Concept:
The chlorination of aromatic hydrocarbons like toluene can proceed via two completely different mechanistic pathways depending on the reaction conditions: electrophilic aromatic substitution or free-radical side-chain substitution. The choice of catalyst and energy source dictates whether the reaction takes place on the electron-rich aromatic ring or along the aliphatic alkyl side-chain.

Solution:

(a) When toluene is treated with chlorine gas (Cl_2) in the dark using a Lewis acid catalyst such as anhydrous $FeCl_3$, the catalyst polarizes the halogen molecule to generate a highly reactive chloronium electrophile (Cl^+).

(b) This electrophile attacks the electron-dense aromatic ring. Because the methyl group is activating and ortho-/para-directing, this pathway yields a mixture of ortho-chlorotoluene and para-chlorotoluene.

(c) When the Lewis acid catalyst is omitted and the reaction mixture is exposed to sunlight ($h\nu$) and elevated temperatures, the reaction mechanism switches entirely to a free-radical chain pathway.

(d) Sunlight induces homolytic cleavage of the nonpolar chlorine-chlorine bond, generating highly reactive chlorine free radicals ($Cl^\bullet$).

(e) These chlorine radicals preferentially abstract a hydrogen atom from the aliphatic methyl group of toluene because the resulting benzyl radical ($C_6H_5CH_2^\bullet$) is stabilized by resonance across the aromatic ring. This leads to side-chain substitution, producing benzyl chloride ($C_6H_5CH_2Cl$).

Final Answer: Benzyl chloride

Answer: (C)

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Q18.

Solution

Concept:
Chemical kinetics utilizes integrated rate laws to mathematically establish relationships between reactant concentrations and elapsed time. By converting differential rate equations into integrated linear forms, experimental kinetic data can be graphically analyzed to determine the order of a reaction and extract its specific rate constant (k).

Solution:

(a) The differential rate expression for a basic first-order chemical reaction is represented as: $-\frac{d[R]}{dt} = k[R]$, where $[R]$ represents the instantaneous concentration of the limiting reactant.

(b) Separating the variables and integrating this expression from an initial time $t = 0$ (concentration $[R]_0$) to an arbitrary time t yields the classical integrated rate equation: $\ln[R]_t = -kt + \ln[R]_0$.

(c) This integrated mathematical expression matches the standard equation for a straight line, $y = mx + c$, where y represents the dependent variable, x represents the independent variable, m represents the slope, and c represents the y-intercept.

(d) By mapping the parameters directly, plotting the natural logarithm of the reactant concentration ($\ln[R]$) on the vertical y-axis against time (t) on the horizontal x-axis yields a straight line.

(e) This linear plot features a negative slope equal to $-k$ and a vertical y-intercept equal to $\ln[R]_0$. In contrast, plotting the raw concentration directly against time yields an exponential decay curve rather than a straight line.

Final Answer: Natural logarithm of concentration ($\ln[R]$) vs Time

Answer: (B)

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Q19.

Solution

Concept:
Phenols exhibit distinct chemical reactivity when exposed to haloforms in strongly basic media, undergoing controlled formylation. This transformation introduces a formyl group (−CHO) onto the aromatic ring via an electrophilic aromatic substitution mechanism driven by an electron-deficient carbene intermediate.

Solution:

- (a) Treating chloroform ($CHCl_3$) with a strong base like aqueous sodium hydroxide ($NaOH$) initiates an alpha-elimination process, losing a proton and a chloride ion to generate a highly reactive, neutral dichlorocarbene intermediate ($: CCl_2$).
- (b) At the same time, the sodium hydroxide deprotonates phenol to form a highly nucleophilic phenoxide ion, which increases the electron density of the aromatic ring.
- (c) The electron-deficient dichlorocarbene intermediate acts as an electrophile, attacking the ortho-position of the phenoxide ion to form a benzal chloride intermediate.
- (d) Subsequent alkaline hydrolysis of this chlorinated intermediate replaces the two chlorine atoms with hydroxyl groups, which spontaneously lose a molecule of water to form a formyl group.
- (e) Final acidification converts the phenoxide salt into a free phenol, yielding salicylaldehyde (ortho-hydroxybenzaldehyde) as the major product. This synthetic sequence is universally known as the Reimer-Tiemann reaction.

Final Answer: Reimer-Tiemann Reaction

Answer: (B)

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Q20.

Solution

Concept:

Stoichiometry links the mass of reacting chemical species to the corresponding volumes of gaseous products or reactants involved in a chemical conversion. By balancing the underlying chemical equation, molar relationships can be established, allowing the application of Avogadro's law to determine gas volumes at Standard Temperature and Pressure (STP).

Solution:

(a) Write the fully balanced chemical equation for the complete combustion of propane gas: $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$. This stoichiometry shows that 1 mole of propane requires exactly 5 moles of oxygen gas.

(b) Next, calculate the molar mass of propane (C_3H_8). Using atomic weights ($C = 12$ g/mol, $H = 1$ g/mol), the molar mass is calculated as $(3 \times 12) + (8 \times 1) = 44$ g/mol.

(c) Convert the given mass of the propane sample into moles: Moles of $C_3H_8 = \frac{\text{Given Mass}}{\text{Molar Mass}} = \frac{4.4 \text{ g}}{44 \text{ g/mol}} = 0.1$ mole.

(d) Use the balanced stoichiometric coefficients to determine the moles of oxygen required: Moles of $O_2 = 5 \times$ moles of $C_3H_8 = 5 \times 0.1 = 0.5$ mole.

(e) According to ideal gas behavior at Standard Temperature and Pressure (STP), 1 mole of any ideal gas occupies a fixed volume of 22.4 L. Therefore, the total volume of oxygen gas consumed is 0.5 mole × 22.4 L/mole = 11.2 L.

Final Answer: 11.2 L

Answer: (A)

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Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	C	3	C	4	A	5	A
6	C	7	D	8	A	9	C	10	B
11	A	12	B	13	D	14	A	15	C
16	B	17	C	18	B	19	B	20	A