AME CET Chemistry Sample Paper-7

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. A sample of gaseous hydrocarbon requires 5 times its volume of oxygen for complete combustion and produces 3 times its volume of carbon dioxide under similar conditions of temperature and pressure. What is the molecular formula of the hydrocarbon?

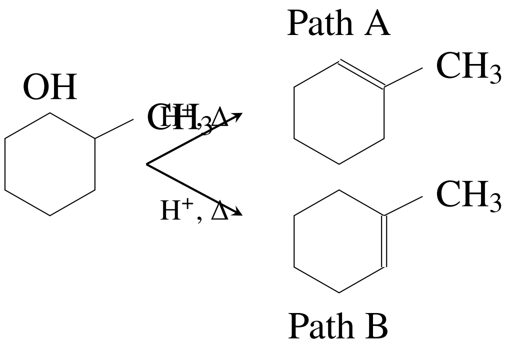
(A) C_3H_4

(B) C_3H_6

(C) C_3H_8

(D) C_4H_{10}

Q2. The major product obtained in the acid-catalyzed dehydration of 2-methylcyclohexanol is evaluated based on stability. Consider the thermodynamic dehydration pathways illustrated below:



Identify the structure and designation of the major alkene product generated via the most stable carbocation intermediate rearrangement.

(A) 1-Methylcyclohexene via Path A

(B) 3-Methylcyclohexene via Path B

(C) Methylenecyclohexane via Path A

(D) 1-Methylcyclohexene via Path B

Q3. According to Molecular Orbital Theory, which of the following diatomic species possesses the highest bond order and is simultaneously diamagnetic in nature?

(A) O_2^{2+}

(B) N_2^+

(C) O_2

(D) C_2

Q4. For the coordination complex $[Co(en)_2Cl_2]Cl$ (where en = ethylenediamine), what are the correct values for the coordination number of the central metal ion, its oxidation state, and the total number of possible stereoisomers (including optical isomers), respectively?

(A) 6, +3, 3

(B) 4, +2, 2

(C) 6, +2, 3

(D) 6, +3, 2

Q5. The limiting molar conductivities (Λ_m°) of CH_3COONa, HCl, and $NaCl$ at 298 K are 91.0, 426.0, and 126.0 S cm^2 mol^{-1} respectively. What is the value of Λ_m° for a aqueous solution of acetic acid (CH_3COOH)?

(A) 209.0 S cm^2 mol^{-1}

(B) 391.0 S cm^2 mol^{-1}

(C) 443.0 S cm^2 mol^{-1}

(D) 531.0 S cm^2 mol^{-1}

Q6. Which of the following physical phenomena correctly distinguishes physical adsorption (physisorption) from chemical adsorption (chemisorption)?

(A) Physisorption increases continuously with an increase in temperature.

(B) Physisorption is highly specific and forms only a unimolecular layer.

(C) Physisorption arises from weak van der Waals forces and is reversible.

(D) Physisorption possesses a significantly high enthalpy of adsorption (80–240 kJ mol^{-1}).

Q7. Which of the following statements is incorrect regarding the trends in properties of the p-block and d-block elements?

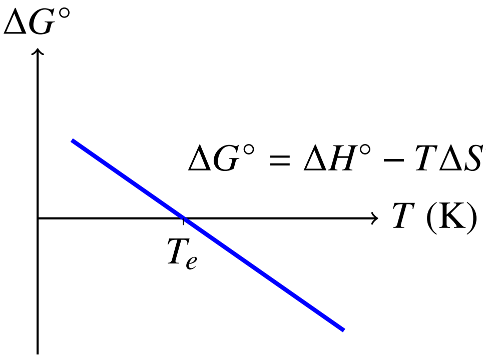
(A) $Bi(V)$ acts as a much stronger oxidizing agent than $Sb(V)$ due to the inert pair effect.

(B) Cr^{2+} is a strong reducing agent because its configuration changes from d^4 to the more stable t_{2g}^3 state.

(C) The basic character of the oxides of group 15 elements increases down the group.

(D) Ionization enthalpies of 5d transition elements are generally higher than those of 4d transition elements due to lanthanoid contraction.

Q8. For a reversible chemical reaction occurring under standard state conditions, the relationship between the equilibrium constant (K) and the standard Gibbs free energy change (ΔG°) can be plotted. Consider the following thermodynamic function profile:



If a reaction has a positive enthalpy change ($\Delta H^\circ > 0$) and a positive entropy change ($\Delta S^\circ > 0$), which statement describes the equilibrium constant K relative to temperature variations?

(A) $K < 1$ at all temperatures because the reaction is permanently endothermic.

(B) $K > 1$ only at temperatures below T_e where enthalpy dominates the system.

(C) $K > 1$ at temperatures above T_e because ΔG° becomes negative.

(D) $K = 0$ at $T = T_e$ since the standard cell potential matches the entropy state.

Q9. Arrange the following organic compounds in the decreasing order of their reactivity towards nucleophilic addition reactions: Formaldehyde (I), Acetaldehyde (II), Acetone (III), and Benzaldehyde (IV).

(A) I > II > III > IV

(B) I > II > IV > III

(C) IV > III > II > I

(D) II > I > III > IV

Q10. What are the correct shapes and central atom hybridization states of the interhalogen species ClF_3 and the noble gas halide XeF_4 based on VSEPR theory?

(A) ClF_3: T-shaped (sp^3d); XeF_4: Square planar (sp^3d^2)

(B) ClF_3: Trigonal planar (sp^2); XeF_4: Tetrahedral (sp^3)

(C) ClF_3: See-saw (sp^3d); XeF_4: Square planar (sp^3d^2)

(D) ClF_3: T-shaped (sp^3d); XeF_4: See-saw (sp^3d)

Q11. When an organic amide is treated with bromine (Br_2) and aqueous sodium hydroxide ($NaOH$), a primary amine containing one less carbon atom than the starting amide is generated. What is the name of this organic rearrangement, and what is its reactive intermediate?

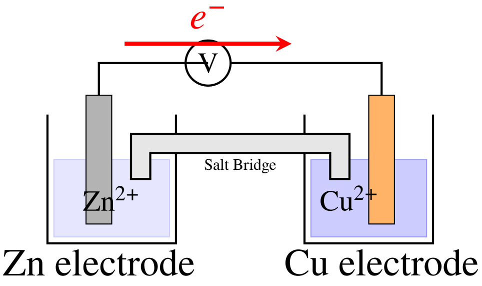
(A) Hoffmann bromamide degradation reaction via an isocyanate intermediate

(B) Gabriel phthalimide synthesis via a carbanion intermediate

(C) Carbylamine reaction via a dichlorocarbene intermediate

(D) Cannizzaro reaction via a hydride ion shift intermediate

Q12. Consider the galvanic cell represented below under standard conditions, showing the flow of electrons through the external circuit:



Given that the standard reduction potentials are $E^\circ_{Zn^{2+}/Zn} = -0.76$ V and $E^\circ_{Cu^{2+}/Cu} = +0.34$ V, what will be the cell potential (E_{cell}) when the concentration of Zn^{2+} is increased to 1.0 M and Cu^{2+} is decreased to 0.01 M at 298 K?

(A) 1.10 V

(B) 1.04 V

(C) 1.16 V

(D) 0.82 V

Q13. The crystal field stabilization energy (CFSE) for a high-spin d^6 octahedral complex and a low-spin d^6 octahedral complex, respectively, in terms of the octahedral crystal field splitting parameter (Δ_o) and pairing energy (P), are:

(A) $-0.4\Delta_o$ and $-2.4\Delta_o + 2P$

(B) $-2.4\Delta_o + 3P$ and $-0.4\Delta_o$

(C) $-0.6\Delta_o$ and $-1.8\Delta_o + P$

(D) $-0.4\Delta_o$ and $-2.4\Delta_o + 3P$

Q14. What is the correct sequence of steps involved in the mechanism of the acid-catalyzed hydration of an alkene to form an alcohol?

(A) Nucleophilic attack of water → Protonation of alkene → Deprotonation

(B) Protonation of alkene → Nucleophilic attack of water → Deprotonation

(C) Deprotonation → Protonation of alkene → Nucleophilic attack of water

(D) Protonation of alkene → Deprotonation → Nucleophilic attack of water

Q15. Which of the following molecules has a net non-zero dipole moment despite containing highly polar chemical bonds?

(A) BF_3

(B) CCl_4

(C) NF_3

(D) CO_2

Q16. Consider the chemical equilibrium for the synthesis of ammonia by Haber's process: $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ with $\Delta H = -92.4$ kJ mol^{-1}. According to Le Chatelier's principle, which set of experimental conditions will maximize the yield of ammonia at equilibrium?

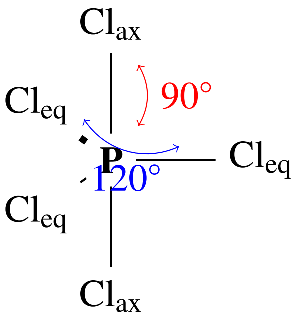
(A) High temperature, low pressure, and continuous removal of NH_3

(B) Low temperature, high pressure, and continuous removal of NH_3

(C) High temperature, high pressure, and addition of inert gas at constant volume

(D) Low temperature, low pressure, and addition of an iron catalyst

Q17. The molecular structure of phosphorus pentachloride (PCl_5) in the gas phase is dynamic due to axial and equatorial bond variations. Consider the orbital layout represented below:



Which of the following statements correctly explains why the axial P–Cl bonds are longer and weaker than the equatorial P–Cl bonds?

(A) The axial bonds experience greater steric and electrostatic repulsion from the three equatorial P–Cl bonds.

(B) The equatorial bonds are formed by d_{z^2} orbitals which have higher penetration power than the axial sp^2 orbitals.

(C) The axial bonds contain more s-character, making them longer according to Bent's Rule.

(D) The equatorial bonds experience strong lone pair-lone pair repulsions which compresses them.

Q18. An organic compound with the molecular formula $C_4H_{10}O$ does not react with sodium metal, does not decolorize bromine water, and undergoes cleavage when treated with excess hot hydroiodic acid (HI) to yield a single type of alkyl iodide. Identify the structural formula of the compound.

(A) $CH_3CH_2CH_2CH_2OH$

(B) $CH_3CH_2OCH_2CH_3$

(C) $CH_3OCH_2CH_2CH_3$

(D) $(CH_3)_3COH$

Q19. The standard reduction potentials of four metal ions W^{2+}, X^{2+}, Y^{2+}, and Z^{2+} are −2.87 V, +0.34 V, −0.76 V, and −0.44 V, respectively. What is the correct increasing order of their chemical reactivity as reducing agents in aqueous medium?

(A) $X < Z < Y < W$

(B) $W < Y < Z < X$

(C) $X < Y < Z < W$

(D) $W < Z < Y < X$

Q20. Which of the following sets of transition metal ions consists entirely of species that are strongly paramagnetic due to the presence of exactly 5 unpaired electrons in their d-subshell?

(A) Cr^{3+} and Mn^{2+}

(B) Fe^{3+} and Mn^{2+}

(C) Fe^{2+} and Co^{3+}

(D) Mn^{3+} and Cr^{2+}

Detailed Solutions

Q1.

Solution

Concept: Hydrocarbon combustion stoichiometry uses volume ratios directly as molar coefficients under constant temperature and pressure according to Avogadro's law. The balanced general equation is:

$$C_xH_y + \left(x + \frac{y}{4}\right) O_2 \rightarrow xCO_2 + \frac{y}{2}H_2O$$

Solution:

(a) Let the volume of the gaseous hydrocarbon C_xH_y be 1 unit.

(b) According to the problem statement, the volume of CO_2 produced is 3 units. Therefore, the number of carbon atoms $x = 3$.

(c) The volume of O_2 consumed is given as 5 units. Substituting $x = 3$ into the oxygen balance term $\left(x + \frac{y}{4}\right) = 5$:

$$3 + \frac{y}{4} = 5 \implies \frac{y}{4} = 2 \implies y = 8$$

(d) Combining these values gives the molecular formula as C_3H_8.

Final Answer: The molecular formula of the hydrocarbon is C_3H_8.

Answer: (C)

Go Back to Question 1

Q2.

Solution

Concept: Acid-catalyzed dehydration of secondary alcohols proceeds via a carbocation intermediate. The major product distribution is governed by the thermodynamic stability of the resulting alkene (Zaitsev's rule), prioritising more substituted double bonds.

Solution:

(a) Protonation of the hydroxyl group on 2-methylcyclohexanol creates an excellent leaving group ($-OH_2^+$), which departs to form a secondary carbocation at the C1 position.

(b) A subsequent $1, 2$-hydride shift occurs dynamically, converting the less stable secondary carbocation into a highly stable tertiary carbocation at the position containing the methyl group.

(c) Elimination of a neighboring proton from this tertiary intermediate yields the most highly substituted, tetrasubstituted alkene, which is 1-methylcyclohexene.

(d) Because Path A represents the formation of this highly stable alkene from the thermodynamic rearrangement pathway, it constitutes the major product.

Final Answer: The major product is 1-Methylcyclohexene via Path A.

Answer: (A)

Go Back to Question 2

Q3.

Solution

Concept: Molecular Orbital (MO) Theory determines bond order via $BO = \frac{N_b - N_a}{2}$. Diamagnetism requires all electrons within the molecular electronic configuration to be paired.

Solution:

(a) O_2^{2+} contains 14 electrons. Its electronic configuration matches N_2: $\sigma_{1s}^2 \sigma_{1s}^{*2} \sigma_{2s}^2 \sigma_{2s}^{*2} \sigma_{2p_z}^2 (\pi_{2p_x}^2 = \pi_{2p_y}^2)$. All electrons are paired, confirming it is diamagnetic.

(b) The bond order for O_2^{2+} is calculated as $\frac{10-4}{2} = 3$.

(c) N_2^+ has 13 electrons, giving a bond order of 2.5, and is paramagnetic due to an unpaired electron.

(d) O_2 has 16 electrons with a bond order of 2 and is paramagnetic. C_2 has 12 electrons with a bond order of 2. Thus, O_2^{2+} has both the highest bond order and a diamagnetic state.

Final Answer: The species with the highest bond order and diamagnetic nature is O_2^{2+}.

Answer: (A)

Go Back to Question 3

Q4.

Solution

Concept: Coordination parameters are determined by the denticity of ligands, metal oxidation numbers, and the spatial geometry governing geometric and optical isomerism in octahedral spaces.

Solution:

(a) Ethylenediamine (en) is a bidentate ligand, while chloride (Cl^-) is monodentate. The coordination number for $[Co(en)_2Cl_2]^+$ is $(2 \times 2) + (2 \times 1) = 6$.

(b) Let x be the oxidation state of Cobalt: $x + 2(0) + 2(-1) = +1 \implies x = +3$.

(c) The complex exhibits two geometric isomers: *cis* and *trans*. The *trans* isomer is symmetrical (achiral), while the *cis* isomer lacks a plane of symmetry, forming a pair of non-superimposable optical enantiomers (d and l).

(d) The total number of stereoisomers is 1 (trans) + 2 (cis enantiomers) = 3.

Final Answer: The properties are 6, +3, 3.

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

Go Back to Question 4

Q5.

Solution

Concept: Kohlrausch's Law of Independent Migration of Ions states that the limiting molar conductivity of an electrolyte can be calculated as the sum of the individual limiting ionic conductivities of its constituent ions.

Solution:

(a) To find the limiting molar conductivity of the weak acid CH_3COOH, we construct an algebraic combination of the strong electrolytes:

$$\Lambda_m^\circ(CH_3COOH) = \Lambda_m^\circ(CH_3COONa) + \Lambda_m^\circ(HCl) - \Lambda_m^\circ(NaCl)$$

(b) This mathematical configuration isolates the target ions because the conductivities of Na^+ and Cl^- cancel out exactly.

(c) Substituting the given values into the relationship:

$$\Lambda_m^\circ(CH_3COOH) = 91.0 + 426.0 - 126.0$$

(d) Performing the arithmetic yields: $517.0 - 126.0 = 391.0$ S cm^2 mol^{-1}.

Final Answer: The value of Λ_m° for acetic acid is 391.0 S cm^2 mol^{-1}.

Answer: (B)

Go Back to Question 5

Q6.

Solution

Concept: Surface chemistry categorizes adsorption into physisorption and chemisorption based on the nature of the binding forces acting between the adsorbate molecules and the adsorbent surface.

Solution:

(a) Physisorption involves weak, non-specific van der Waals interactions. Because no chemical bonds are broken or formed, the process requires no activation energy and is highly reversible.

(b) In contrast, chemisorption involves chemical bond formation, making it highly specific, irreversible, and characterized by a high enthalpy of adsorption (80–240 kJ mol^{-1}).

(c) Physisorption decreases with increasing temperature due to the exothermic nature of the physical equilibrium, forming multimolecular layers.

(d) Therefore, weak van der Waals forces and reversibility uniquely identify physisorption.

Final Answer: Physisorption arises from weak van der Waals forces and is reversible.

Answer: (C)

Go Back to Question 6

Q7.

Solution

Concept: Periodic and d-block trends are dictated by shielding effects, electronic configurations, and relativistic contractions occurring in heavier post-lanthanide elements.

Solution:

(a) The inert pair effect stabilizes the lower oxidation state down a group. In group 15, $Bi(V)$ is highly unstable compared to $Bi(III)$, making $Bi(V)$ an exceptionally strong oxidizing agent.

(b) Cr^{2+} (d^4) is strongly reducing because losing an electron yields a stable t_{2g}^3 half-filled configuration.

(c) As you move down group 15, the atomic size increases, causing metallic character to rise and the oxides to become more basic, not less.

(d) Lanthanoid contraction poor shielding by $4f$ electrons causes $5d$ elements to experience a high effective nuclear charge, leading to unexpectedly high ionization enthalpies.

Final Answer: The incorrect statement is that basic character decreases down the group.

Answer: (C)

Go Back to Question 7

Q8.

Solution

Concept: Thermodynamic equilibria link the standard free energy change to the equilibrium constant via $\Delta G^\circ = -RT \ln K$. The temperature dependence is governed by $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$.

Solution:

(a) For reactions where $\Delta H^\circ > 0$ and $\Delta S^\circ > 0$, the system is endothermic and entropy-driven.

(b) At the equilibrium crossover temperature (T_e), $\Delta G^\circ = 0$, meaning $\Delta H^\circ = T_e \Delta S^\circ$.

(c) When temperature rises above T_e, the $T\Delta S^\circ$ term outgrows ΔH°, making ΔG° negative ($\Delta G^\circ < 0$).

(d) Substituting a negative ΔG° into $-RT \ln K < 0$ forces $\ln K > 0$, which mathematically requires $K > 1$.

Final Answer: $K > 1$ at temperatures above T_e because ΔG° becomes negative.

Answer: (C)

Go Back to Question 8

Q9.

Solution

Concept: Nucleophilic addition reactivity in carbonyl compounds is determined by two main factors: steric hindrance and the electrophilic character (positive charge density) of the carbonyl carbon atom.

Solution:

(a) Formaldehyde (I) has two small hydrogen atoms, presenting minimal steric hindrance and maintaining a highly electrophilic carbonyl carbon.

(b) Acetaldehyde (II) contains an electron-donating methyl group ($+I$ effect) that reduces the positive charge on the carbon, and increases steric bulk.

(c) Acetone (III) contains two methyl groups, further decreasing reactivity through combined inductive stabilization and additional steric crowding.

(d) Benzaldehyde (IV) is stabilized by resonance with the benzene ring, which significantly reduces the positive charge density on the carbonyl carbon, making it less reactive than aliphatic aldehydes. Thus, the order is I > II > IV > III.

Final Answer: The decreasing order of reactivity is I > II > IV > III.

Answer: (B)

Go Back to Question 9

Q10.

Solution

Concept: The Valence Shell Electron Pair Repulsion (VSEPR) theory determines molecular geometries by calculating steric numbers (SN) to balance bonding pairs and non-bonding lone pairs.

Solution:

(a) For Chlorine trifluoride (ClF_3), the central Cl atom has 7 valence electrons. It forms 3 single bonds and retains 2 lone pairs. $SN = 3 + 2 = 5$, giving an sp^3d hybridization state. To minimize repulsion, the lone pairs occupy equatorial positions, producing a T-shaped geometry.

(b) For Xenon tetrafluoride (XeF_4), the central Xe atom has 8 valence electrons. It forms 4 single bonds and retains 2 lone pairs. $SN = 4 + 2 = 6$, giving an sp^3d^2 hybridization state. The two lone pairs position themselves opposite one another to minimize repulsion, yielding a square planar geometry.

Final Answer: ClF_3 is T-shaped (sp^3d) and XeF_4 is Square planar (sp^3d^2).

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

Go Back to Question 10

Q11.

Solution

Concept: The Hoffmann bromamide degradation converts a primary amide into a primary amine with one fewer carbon atom. The pathway involves base-mediated halogenation followed by an intramolecular alkyl migration to an electron-deficient nitrogen atom.

Solution:

(a) Deprotonation of the amide nitrogen by hydroxide ions occurs first, creating a nucleophilic conjugate base that attacks bromine to yield an N-bromoamide intermediate.

(b) A second deprotonation on the nitrogen atom induces an unstable, negatively charged intermediate. This triggers a concerted rearrangement where the organic alkyl or aryl group migrates directly to the nitrogen atom.

(c) Concurrently, the bromide ion departs as a leaving group, transforming the molecular framework into an alkyl or aryl isocyanate intermediate ($R - N = C = O$).

(d) Nucleophilic attack of water on the carbonyl carbon of this isocyanate generates an unstable carbamic acid, which rapidly undergoes decarboxylation to release carbon dioxide gas and leave behind the final primary amine.

Final Answer: The mechanism is the Hoffmann bromamide degradation reaction via an isocyanate intermediate.

Answer: (A)

Go Back to Question 11

Q12.

Solution

Concept: The non-standard electromotive force of an electrochemical system is quantified using the Nernst equation:

$$E_{\text{cell}} = E^{\circ}_{\text{cell}} - \frac{0.0591}{n} \log Q$$

Solution:

(a) Determine the standard cell potential by combining the half-cell potentials: $E^{\circ}_{\text{cell}} = E^{\circ}_{\text{cathode}} - E^{\circ}_{\text{anode}} = 0.34\text{ V} - (-0.76\text{ V}) = 1.10\text{ V}$.

(b) The overall redox reaction involves a two-electron transfer ($n = 2$): $\text{Zn}(s) + \text{Cu}^{2+}(aq) \rightarrow \text{Zn}^{2+}(aq) + \text{Cu}(s)$.

(c) Construct the reaction quotient expression using the molar concentrations of the ions:

$$Q = \frac{[\text{Zn}^{2+}]}{[\text{Cu}^{2+}]} = \frac{1.0}{0.01} = 10^2$$

(d) Substitute these values directly into the Nernst framework:

$$E_{\text{cell}} = 1.10 - \frac{0.0591}{2} \log(10^2) = 1.10 - 0.0591(1) = 1.0409\text{ V}$$

Final Answer: The cell potential under these conditions is 1.04 V.

Answer: (B)

Go Back to Question 12

Q13.

Solution

Concept: Crystal Field Stabilization Energy (CFSE) evaluates the thermodynamic split of d-orbitals into lower t_{2g} and higher e_g sets in an octahedral field, where each electron in t_{2g} contributes $-0.4\Delta_o$ and each electron in e_g contributes $+0.6\Delta_o$.

Solution:

(a) For a d^6 ion in a weak ligand field, pairing is energetically unfavorable, resulting in a high-spin distribution of $t_{2g}^4 e_g^2$. The baseline energy calculates as: $[4 \times (-0.4) + 2 \times (+0.6)]\Delta_o = -0.4\Delta_o$.

(b) For a d^6 ion in a strong ligand field, the splitting energy exceeds the pairing cost, forcing a low-spin configuration of $t_{2g}^6 e_g^0$. This energy states as: $[6\times(-0.4)+0\times(+0.6)]\Delta_o = -2.4\Delta_o$.

(c) High-spin naturally contains one paired set. Low-spin forces three pairs, requiring two net extra pairings ($2P$) over the fundamental ground state.

(d) Therefore, the stabilization states correspond directly to $-0.4\Delta_o$ and $-2.4\Delta_o + 2P$.

Final Answer: The crystal field stabilization values are $-0.4\Delta_o$ and $-2.4\Delta_o + 2P$.

Answer: (A)

Go Back to Question 13

Q14.

Solution

Concept: The acid-catalyzed hydration of alkenes follows a multi-step electrophilic addition pathway, obeying Markovnikov's regioselectivity rule via the formation of a carbocation intermediate.

Solution:

(a) In the initial step, the electron-rich pi bond of the alkene acts as a nucleophile, attacking an electrophilic hydronium ion (H_3O^+) present in the acidic solution. This protonation generates a stable carbocation intermediate.

(b) During the second step, water molecules function as the primary nucleophile in the system, attacking the electron-deficient carbocation carbon center to form a protonated oxonium ion intermediate.

(c) In the concluding step, a surrounding water molecule abstracts a proton from the oxonium ion, regenerating the acid catalyst and leaving behind the target alcohol product.

Final Answer: The correct mechanical sequence is Protonation of alkene → Nucleophilic attack of water → Deprotonation.

Answer: (B)

Go Back to Question 14

Q15.

Solution

Concept: The net molecular dipole moment depends on both individual bond polarities and the overall geometric symmetry of the molecule, which dictates whether bond dipoles cancel out vectorially.

Solution:

(a) BF_3 possesses a highly symmetrical trigonal planar molecular geometry. The three polar $B - F$ bond dipoles point symmetrically outward at 120° angles, canceling out perfectly to yield a net dipole moment of zero ($\mu = 0$).

(b) CCl_4 exhibits a highly symmetrical tetrahedral geometry where four polar $C - Cl$ bond vectors cancel each other completely in three-dimensional space ($\mu = 0$).

(c) CO_2 is a linear molecule where two equal and opposite $C = O$ double bond dipoles cancel out exactly ($\mu = 0$).

(d) NF_3 assumes an asymmetrical trigonal pyramidal geometry because of the presence of a lone pair on the nitrogen atom. The individual polar $N - F$ bond dipoles and the lone-pair dipole reinforce each other, resulting in a net non-zero dipole moment.

Final Answer: The molecule with a net non-zero dipole moment is NF_3.

Answer: (C)

Go Back to Question 15

Q16.

Solution

Concept: Le Chatelier's principle dictates that if a system at chemical equilibrium experiences a change in temperature, pressure, or concentration, the position of equilibrium shifts to counteract the perturbation.

Solution:

(a) The Haber synthesis of ammonia is exothermic ($\Delta H = -92.4\ \text{kJ mol}^{-1}$). Lowering the temperature shifts the equilibrium in the forward direction to generate heat, optimizing product yield.

(b) The forward process reduces gas moles from 4 to 2 ($N_2 + 3H_2 \rightarrow 2NH_3$). Increasing the total pressure drives the system toward fewer gas moles, accelerating ammonia formation.

(c) Continuously removing ammonia gas from the mixture decreases product concentrations, which forces the forward reaction to proceed continually to restore equilibrium.

(d) Combining low temperature, high pressure, and product extraction ensures maximum chemical yield.

Final Answer: The optimal operational conditions are low temperature, high pressure, and continuous removal of NH_3.

Answer: (B)

Go Back to Question 16

Q17.

Solution

Concept: The trigonal bipyramidal geometry of gas-phase PCl_5 presents non-equivalent coordinate positions. Axial and equatorial domains experience different spatial repulsions due to bond angle constraints.

Solution:

(a) The central phosphorus atom is sp^3d hybridized, organizing three equatorial links at 120° separations and two axial vertices projecting perpendicularly at 90° relative to the equatorial plane.

(b) Every individual axial $P - Cl$ bond is close to three equatorial bonds, experiencing intense steric and electrostatic repulsion at 90°.

(c) Conversely, the equatorial links feel less crowding because their closest intra-planar neighbors reside much further away at 120° separating angles.

(d) To lower this strong repulsive energy profile, the axial bonding pairs push outward from the nucleus, making these two axial paths significantly longer and weaker.

Final Answer: The axial bonds experience greater steric and electrostatic repulsion from the three equatorial P–Cl bonds.

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

Go Back to Question 17

Q18.

Solution

Concept: Functional group identification combines reactivity markers: lack of oxidation/reduction, inertness toward active metals, and structural acidic cleavage patterns of symmetric ether molecules.

Solution:

(a) An organic formula of $C_4H_{10}O$ matches the saturation profile of acyclic aliphatic alcohols and ethers ($C_nH_{2n+2}O$).

(b) The compound is inert toward sodium metal, ruling out reactive hydroxyl groups (alcohols), and fails to decolorize bromine water, indicating the absence of unsaturated double bonds.

(c) Treating an ether with excess hot hydroiodic acid (HI) cleaves both carbon-oxygen bonds, converting the alkyl fragments into corresponding iodoalkanes.

(d) Because the reaction produces a single type of alkyl iodide, the starting molecule must be a symmetrical ether structure. This uniquely matches diethyl ether, $CH_3CH_2OCH_2CH_3$, which yields two equivalents of ethyl iodide.

Final Answer: The structural formula of the compound is $CH_3CH_2OCH_2CH_3$.

Answer: (B)

Go Back to Question 18

Q19.

Solution

Concept: Standard reduction potentials ($E°$) measure a chemical species' tendency to gain electrons. A more negative reduction potential signifies a weaker oxidizing agent but a stronger, more reactive reducing agent.

Solution:

(a) Analyze the given values: $E^\circ_{W^{2+}/W} = -2.87$ V, $E^\circ_{X^{2+}/X} = +0.34$ V, $E^\circ_{Y^{2+}/Y} = -0.76$ V, and $E^\circ_{Z^{2+}/Z} = -0.44$ V.

(b) Metal W has the most negative potential, meaning it releases electrons most readily, making it the most powerful reducing agent.

(c) Metal X possesses a positive potential, showing a strong tendency to remain reduced, which makes it the weakest reducing agent in this group.

(d) Sorting the reduction potentials from highest to lowest establishes the increasing sequence of reducing power: $X(+0.34\text{ V}) < Z(-0.44\text{ V}) < Y(-0.76\text{ V}) < W(-2.87\text{ V})$.

Final Answer: The correct increasing order of reactivity as reducing agents is $X < Z < Y < W$.

Answer: (A)

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Q20.

Solution

Concept: Paramagnetism varies directly with the number of unpaired electrons in valence d-subshells, which is determined by the metal's oxidation state and elemental electronic configuration.

Solution:

(a) Iron (Fe, $Z = 26$) has a ground-state configuration of $[Ar]3d^6 4s^2$. The trivalent ion Fe^{3+} is formed by losing three electrons, leaving a valence configuration of $[Ar]3d^5$. According to Hund's rule, all 5 electrons occupy separate orbitals, yielding 5 unpaired electrons.

(b) Manganese (Mn, $Z = 25$) has a configuration of $[Ar]3d^5 4s^2$. The divalent ion Mn^{2+} is formed by losing the two $4s$ valence electrons, leaving an identical half-filled $[Ar]3d^5$ configuration with 5 unpaired electrons.

(c) Other configurations like Cr^{3+} ($3d^3$), Fe^{2+} ($3d^6$), and Mn^{3+} ($3d^4$) possess fewer than 5 unpaired electrons. Therefore, the Fe^{3+} and Mn^{2+} pair is strongly paramagnetic.

Final Answer: The correct set containing exactly 5 unpaired electrons is Fe^{3+} and Mn^{2+}.

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

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Answer Key

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