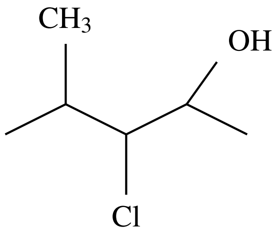
AME CET Chemistry Sample Paper-10

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. Consider the organic molecule represented below. What is the correct IUPAC name for this compound?



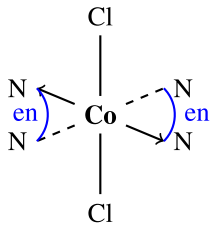
(A) 3-Chloro-2-methylpentan-4-ol

(B) 3-Chloro-4-methylpentan-2-ol

(C) 3-Chloro-2,4-dimethylbutan-1-ol

(D) 2-Methyl-3-chloropentan-4-ol

Q2. The complex ion $[Co(en)_2Cl_2]^+$ exhibits both geometrical and optical isomerism. For the specific isomer shown below, determine its structural classification.



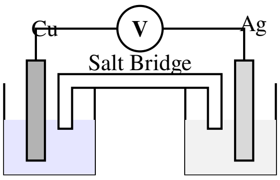
(A) trans-isomer, optically active

(B) cis-isomer, optically active

(C) trans-isomer, optically inactive

(D) cis-isomer, optically inactive

Q3. A student sets up a standard electrochemical cell at 298 K as schematically illustrated below. If the standard reduction potentials are $E°(Ag^+/Ag) = +0.80$ V and $E°(Cu^{2+}/Cu) = +0.34$ V, what is the primary direction of electron flow in the external circuit under operating conditions?



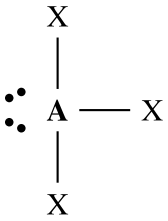
(A) From the Silver electrode to the Copper electrode through the wire

(B) From the Copper electrode to the Silver electrode through the wire

(C) From the Silver electrode to the Copper electrode through the salt bridge

(D) No electron flow occurs because the cell is already at equilibrium

Q4. The spatial arrangement of the valence electron pairs around the central atom of a molecule determines its overall geometry. Consider the T-shaped geometry shown below. Which of the following chemical species possesses this exact molecular structure?



(A) BF_3

(B) NH_3

(C) ClF_3

(D) PCl_3

Q5. An aqueous solution of ethanol (C_2H_5OH) is prepared by dissolving 4.6 g of ethanol in 90 g of pure water. What is the mole fraction of ethanol in this binary solution? (Molar masses: C_2H_5OH = 46 g/mol, H_2O = 18 g/mol)

(A) 0.0196

(B) 0.0200

(C) 0.0488

(D) 0.0500

Q6. For the reversible gaseous reaction $N_2O_4(g) \rightleftharpoons 2NO_2(g)$, the equilibrium constant K_p is found to be related to K_c at a specific thermodynamic temperature T. What is the correct numerical expression for the ratio K_p/K_c if R is the universal gas constant?

(A) $(RT)^{-1}$

(B) 1

(C) RT

(D) $(RT)^2$

Q7. For a spontaneous dynamic process occurring in a closed system at constant pressure and uniform temperature, which of the following combinations of thermodynamic criteria must be strictly satisfied?

(A) $\Delta H < 0, \Delta S < 0$ at all temperatures

(B) $\Delta G < 0, \Delta S_{\text{universe}} > 0$

(C) $\Delta G > 0, \Delta S_{\text{system}} > 0$

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

Q8. When toluene is treated with a boiling mixture of concentrated $KMnO_4$ followed by acidic workup using dilute HCl, what is the primary organic product obtained?

(A) Benzyl alcohol

(B) Benzaldehyde

(C) Benzoic acid

(D) o-Cresol

Q9. Arrange the following carbocations in the exact decreasing order of their relative thermodynamic stabilities: (I) Benzyl carbocation, (II) Allyl carbocation, (III) tert-Butyl carbocation, (IV) Isopropyl carbocation.

(A) I > III > II > IV

(B) III > I > II > IV

(C) I > II > III > IV

(D) III > IV > I > II

Q10. Based on Molecular Orbital Theory (MOT), choose the correct increasing order of bond lengths among the diatomic oxygen species listed below.

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

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

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

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

Q11. According to Crystal Field Theory (CFT), what is the correct electronic configuration and spin status of the central metal ion in the octahedral coordination complex $[Fe(CN)_6]^{4-}$?

(A) $t_{2g}^4 e_g^2$, High spin

(B) $t_{2g}^6 e_g^0$, Low spin

(C) $t_{2g}^5 e_g^1$, Low spin

(D) $t_{2g}^3 e_g^3$, High spin

Q12. During the quantitative electrolysis of an aqueous solution of $CuSO_4$ using inert platinum electrodes, a steady current of 2.0 A is passed through the electrolyte for exactly 965 seconds. What is the mass of pure copper metal deposited at the cathode? (Atomic mass of Cu = 63.5 g/mol, Faraday's constant = 96500 C/mol)

(A) 0.3175 g

(B) 0.6350 g

(C) 1.2700 g

(D) 3.1750 g

Q13. Which of the following statements is fundamentally incorrect regarding the physical adsorption (physisorption) of a gas on a solid surface?

(A) It is highly specific in nature and forms only a localized unimolecular layer.

(B) It arises primarily due to weak van der Waals intermolecular forces.

(C) It is an exothermic process, and the extent of adsorption decreases with increasing temperature.

(D) It can transition into a multimolecular layer under high pressure.

Q14. When copper metal reacts vigorously with concentrated nitric acid (HNO_3), which principal nitrogen oxide gas is evolved, and what color does the reaction mixture display?

(A) N_2O gas, colorless solution

(B) NO gas, pale green solution

(C) NO_2 gas, deep blue/green solution

(D) N_2O_5 gas, yellow solution

Q15. The observed progressive decrease in ionic radii across the lanthanide series, known as the Lanthanide Contraction, is primarily attributed to which electronic phenomenon?

(A) Imperfect shielding of the nuclear charge by the inner $4f$ electrons.

(B) Strong shielding of the nuclear charge by the outer $5d$ electrons.

(C) Effective shielding of the nuclear charge by the inner $4d$ electrons.

(D) Stable half-filled or completely filled configurations of the f-orbital.

Q16. What volume of 0.5 M HCl solution must be mixed with 200 mL of 0.2 M HCl solution to prepare a final solution having a homogeneous molarity of exactly 0.4 M?

(A) 100 mL

(B) 200 mL

(C) 400 mL

(D) 500 mL

Q17. For the ideal combustion of one mole of liquid benzene (C_6H_6) at 298 K, according to the chemical equation: $C_6H_6(l) + \frac{15}{2}O_2(g) \rightarrow 6CO_2(g) + 3H_2O(l)$, what is the true algebraic difference between the enthalpy of reaction (ΔH) and internal energy change (ΔU)?

(A) $-1.5\,RT$

(B) $+1.5\,RT$

(C) $-0.5\,RT$

(D) $+0.5\,RT$

Q18. An organic compound containing a carbonyl group undergoes a nucleophilic addition reaction. Identify the correct relative rate of reactivity towards a standard nucleophile (CN^-) among the following substrate compounds: (I) Formaldehyde, (II) Acetaldehyde, (III) Acetone.

(A) I > II > III

(B) III > II > I

(C) II > I > III

(D) I > III > II

Q19. In an S_N2 nucleophilic substitution mechanism involving a chiral secondary alkyl halide reactant, which stereochemical outcome is universally observed at the asymmetric carbon center?

(A) Complete retention of configurations

(B) Inversion of configurations (Walden inversion)

(C) 50% inversion and 50% retention resulting in racemization

(D) Total loss of chirality forming an achiral planar intermediate

Q20. Which of the following molecules possesses a permanent, non-zero dipole moment ($\mu \neq 0$) due to an asymmetrical spatial orientation of its polar chemical bonds?

(A) CO_2

(B) XeF_4

(C) SF_4

(D) BF_3

Detailed Solutions

Q1.

Solution

Concept:
The systematic nomenclature of organic molecules follows strict rules established by the International Union of Pure and Applied Chemistry (IUPAC). For acyclic compounds containing multiple substituents and a principal functional group, the primary objective is to identify the longest continuous carbon chain containing the principal functional group. Once this principal chain is established, numbering must be assigned from the terminus that gives the lowest possible locant to the principal functional group, followed by secondary substituents in alphabetical sequence.

Solution:

(a) Analyzing the skeletal structure provided in the TikZ diagram reveals a continuous carbon chain consisting of five distinct carbon atoms, defining the parent alkane backbone as pentane.

(b) The principal functional group present in this molecule is the hydroxyl group (-OH), which designates the compound as an alcohol, changing the suffix to ol.

(c) Numbering the main carbon chain from right to left assigns the hydroxyl group to carbon position 2, whereas numbering from left to right would place it at position 4. According to the lowest locant rule, numbering from right to left is correct, making the parent name pentan-2-ol.

(d) Following this right-to-left numbering sequence, the other substituents are identified along the backbone: a chlorine atom is attached to carbon 3, and a methyl group is attached to carbon 4.

(e) When combining these substituents into the final prefix, they must be arranged alphabetically. Since chloro precedes methyl alphabetically, the prefix becomes 3-chloro-4-methyl. Combining this with the parent name yields the full name.

Final Answer: The correct IUPAC name is 3-Chloro-4-methylpentan-2-ol.

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

Go Back to Question 1

Q2.

Solution

Concept:
Coordination chemistry involves the study of complexes formed between central metal ions and surrounding ligands. Isomerism in these coordination compounds can be broadly categorized into structural isomerism and stereoisomerism. Stereoisomerism is further divided into geometrical isomerism (cis/trans variations based on spatial arrangement) and optical isomerism (the presence of non-superimposable mirror images due to a lack of an internal plane or center of symmetry).

Solution:

(a) The given coordination complex is dichlorobis(ethane-1,2-diamine)cobalt(III), represented formulaically as $[Co(en)_2Cl_2]^+$, where ethylenediamine (en) acts as a bidentate chelating ligand.

(b) In the provided diagram, the two monodentate chloride ligands are situated directly opposite to each other at an angle of 180 degrees along the vertical axis of the octahedral coordination sphere.

(c) This symmetrical linear arrangement of identical ligands opposite to each other explicitly defines the compound as the trans-isomer, whereas a 90-degree relative positioning would define the cis-isomer.

(d) Evaluating the symmetry elements of this specific trans-configuration reveals that it possesses both an internal plane of symmetry and an inversion center directly passing through the central cobalt core.

(e) The presence of these symmetry elements ensures that the molecule is completely superimposable on its mirror image, rendering the trans-configuration optically inactive and incapable of rotating plane-polarized light.

Final Answer: The complex is the trans-isomer and is optically inactive.

Answer: (C)

Go Back to Question 2

Q3.

Solution

Concept:
Galvanic or voltaic electrochemical cells generate electrical energy from spontaneous redox reactions. The direction of electron flow through the external circuit is dictated entirely by the relative standard reduction potentials ($E°$) of the chemical half-cells involved. Electrons spontaneously migrate from the electrode with the lower reduction potential (the anode, where oxidation takes place) to the electrode with the higher reduction potential (the cathode, where reduction takes place).

Solution:

(a) The standard reduction potentials given for the two half-cells are +0.80 V for the silver system (Ag^+/Ag) and +0.34 V for the copper system (Cu^{2+}/Cu).

(b) Comparing these values shows that the silver electrode has a higher affinity for electrons due to its larger positive reduction potential, making it the cathode where reduction spontaneously occurs.

(c) Conversely, the copper half-cell possesses the lower reduction potential, meaning metallic copper will lose electrons and undergo oxidation, classifying the copper electrode as the anode.

(d) The oxidation reaction occurring at the copper anode releases electrons into the metallic conductor, while the reduction reaction at the silver cathode consumes electrons from the wire.

(e) Consequently, in the external circuit containing the voltmeter, electrons must flow away from the site of oxidation to the site of reduction, moving from the copper electrode to the silver electrode through the wire.

Final Answer: Electrons flow from the Copper electrode to the Silver electrode through the wire.

Answer: (B)

Go Back to Question 3

Q4.

Solution

Concept:
The Valence Shell Electron Pair Repulsion (VSEPR) theory provides a systematic framework for predicting the three-dimensional geometric structures of covalent molecules. It posits that polyatomic molecular geometries are dictated entirely by minimizing the electrostatic repulsion between all valence electron pairs (both bonding pairs and non-bonding lone pairs) surrounding the central coordinate atom.

Solution:

(a) The diagram illustrates a central atom bonded to three peripheral substituents with two distinct non-bonding lone pairs localized on one side, which corresponds directly to a T-shaped geometry.

(b) A T-shaped molecular geometry requires a steric number of five, which corresponds to sp^3d hybridization with a basic trigonal bipyramidal electron-pair geometry.

(c) Evaluating chlorine trifluoride (ClF_3), the central chlorine atom belongs to halogen group 17 and contributes seven valence electrons, while each of the three fluorine atoms contributes one electron for sharing.

(d) This results in three single covalent chlorine-fluorine bonds and leaves four unshared valence electrons, which organize themselves into two separate lone pairs situated in the equatorial positions to minimize repulsion.

(e) The resulting structural framework leaves the three chlorine-fluorine bonds arranged in a planar T-shape, matching the provided illustration exactly, unlike trigonal planar boron trifluoride or pyramidal phosphorus trichloride.

Final Answer: The chemical species with this exact molecular structure is Chlorine Trifluoride.

Answer: (C)

Go Back to Question 4

Q5.

Solution

Concept:
The concentration of a solution component can be quantified using the concept of mole fraction, which represents the ratio of the number of moles of that specific solute or solvent component to the total number of moles of all chemical chemical species present within the mixture. This thermodynamic value is dimensionless and independent of temperature changes.

Solution:

(a) To calculate the mole fraction of ethanol in the binary aqueous solution, we must first determine the individual molar quantities of both ethanol (C_2H_5OH) and water (H_2O).

(b) The number of moles of ethanol is calculated by dividing its given mass by its molecular mass: 4.6 g divided by 46 g/mol yields exactly 0.1 mol of ethanol.

(c) Next, the number of moles of the solvent, water, is found by dividing its given mass by its molecular mass: 90 g divided by 18 g/mol yields exactly 5.0 mol of water.

(d) The total number of moles present within this homogeneous binary system is the sum of the solute and solvent moles, which equals 0.1 mol + 5.0 mol = 5.1 mol.

(e) Finally, the mole fraction of ethanol is computed by dividing the moles of ethanol by the total moles: $0.1/5.1$, which evaluates arithmetically to approximately 0.0196.

Final Answer: The mole fraction of ethanol in this binary solution is 0.0196.

Answer: (A)

Go Back to Question 5

Q6.

Solution

Concept:
In chemical equilibrium chemistry, the equilibrium state of a reversible gas-phase reaction can be expressed quantitatively using two different constants: K_p, which utilizes partial pressures, and K_c, which utilizes molar concentrations. These two thermodynamic constants are explicitly related through the ideal gas law equations as a function of temperature and change in gaseous moles.

Solution:

(a) The fundamental mathematical equation governing the relationship between these two equilibrium expressions is defined as $K_p = K_c(RT)^{\Delta n_g}$, where R is the ideal gas constant and T is absolute temperature.

(b) The exponent Δn_g represents the change in the stoichiometric coefficients of gaseous species, calculated as the total moles of gaseous products minus the total moles of gaseous reactants.

(c) For the specific chemical reaction provided, dinitrogen tetroxide dissociates reversibly into nitrogen dioxide according to the equation: $N_2O_4(g) \rightleftharpoons 2NO_2(g)$.

(d) Examining the stoichiometry, there are two moles of gaseous products (NO_2) and one mole of gaseous reactant (N_2O_4), meaning the change in moles is calculated as $\Delta n_g = 2 - 1 = 1$.

(e) Substituting this value into the core equation gives $K_p = K_c(RT)^1$. Rearranging this expression to find the requested ratio K_p/K_c simplifies directly to the term RT.

Final Answer: The correct numerical expression for the ratio is RT.

Answer: (C)

Go Back to Question 6

Q7.

Solution

Concept:
The second law of thermodynamics establishes the ultimate criteria for determining whether a chemical reaction or physical transformation can occur spontaneously within a system. For any spontaneous process in an isolated macro-system, the total entropy of the universe must consistently increase, which can be linked to the change in Gibbs free energy for closed systems operating under conditions of constant pressure and temperature.

Solution:

(a) The total entropy change of the universe is defined as the sum of the entropy change of the system and the entropy change of the surrounding environment: $\Delta S_{\text{universe}} = \Delta S_{\text{system}} + \Delta S_{\text{surroundings}}$.

(b) According to the second law of thermodynamics, a process can only occur spontaneously if the total entropy of the universe increases, which mathematically requires that $\Delta S_{\text{universe}} > 0$.

(c) For processes occurring under constant temperature and pressure, the heat transferred to the surroundings is related to the enthalpy change of the system, allowing the formulation of the Gibbs free energy equation.

(d) The change in Gibbs free energy is defined by the equation $\Delta G = \Delta H - T\Delta S$, which serves as a direct indicator of spontaneity localized entirely to the thermodynamic properties of the system.

(e) A negative Gibbs free energy value ($\Delta G < 0$) indicates that a process is exergonic and thermodynamically favored to proceed spontaneously, which aligns perfectly with an overall increase in universal entropy.

Final Answer: The criteria that must be strictly satisfied are $\Delta G < 0$ and $\Delta S_{\text{universe}} > 0$.

Answer: (B)

Go Back to Question 7

Q8.

Solution

Concept:
Alkylbenzenes undergo significant side-chain oxidation reactions when treated with powerful transition-metal oxidizing agents such as potassium permanganate ($KMnO_4$). The stability of the aromatic benzene ring resists oxidative cleavage, leaving the benzylic carbon center as the primary site of oxidation, provided it possesses at least one benzylic hydrogen atom.

Solution:

(a) Toluene consists of a single methyl group directly attached to a benzene ring core. The three hydrogen atoms on this methyl group are classified as benzylic hydrogens.

(b) When toluene is heated with a boiling, concentrated aqueous solution of potassium permanganate under alkaline or neutral conditions, the permanganate ion vigorously attacks the electron-dense benzylic carbon position.

(c) Regardless of the length of the alkyl chain in such alkylbenzenes, the presence of benzylic hydrogens ensures that the entire side chain is oxidized down to a carboxylic acid salt intermediate.

(d) In this specific reaction, the intermediate formed after the initial oxidative phase is potassium benzoate, while the purple permanganate is reduced to a brown manganese dioxide (MnO_2) precipitate.

(e) To isolate the final neutral organic product, an acidic workup using dilute hydrochloric acid (HCl) is required, which protonates the soluble benzoate anions into insoluble benzoic acid.

Final Answer: The primary organic product obtained is Benzoic Acid.

Answer: (C)

Go Back to Question 8

Q9.

Solution

Concept:
The relative thermodynamic stability of organic carbocation intermediates is dictated by electronic effects that delocalize the positive charge. These primary stabilizing factors include inductive effects from alkyl groups, hyperconjugation involving adjacent carbon-hydrogen sigma bonds, and resonance effects arising from delocalization via adjacent pi-electron networks.

Solution:

(a) Evaluating the tert-butyl carbocation (3°), the central positively charged carbon is directly bonded to three methyl groups, providing stability through strong inductive effects and nine stabilizing hyperconjugative interactions.

(b) The benzyl carbocation features a positive charge adjacent to an aromatic ring, allowing the electron deficit to be delocalized across the ortho and para positions through resonance.

(c) While resonance is generally powerful, standard thermodynamic data shows that the dense hyperconjugative stabilization of the nine alpha-hydrogens in the tert-butyl carbocation provides slightly greater overall stability than the benzyl carbocation.

(d) The allyl carbocation is stabilized by a single resonance interaction with an adjacent carbon-carbon double bond, which distributes the positive charge over two carbons, making it more stable than standard secondary alkyl carbocations.

(e) The isopropyl carbocation (2°) is stabilized solely by the inductive and hyperconjugative contributions of six alpha-hydrogens, making it the least stable among the four options. This leads to the final decreasing stability sequence.

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

Answer: (B)

Go Back to Question 9

Q10.

Solution

Concept:

Molecular Orbital Theory (MOT) describes the covalent bonding in diatomic molecules by combining atomic orbitals to form bonding and antibonding molecular orbitals. The bond order, which quantifies the net stability of a chemical bond, is calculated as half the difference between the number of bonding electrons and antibonding electrons. The bond order is inversely proportional to the experimental bond length.

Solution:

(a) Neutral diatomic oxygen (O_2) possesses 16 total valence electrons, resulting in a ground-state molecular orbital configuration with a bond order of exactly 2.0.

(b) When oxygen is oxidized to the monocationic species O_2^+, an electron is removed from an antibonding π^* orbital, which increases the net bond order to 2.5.

(c) Further oxidation to the dicationic species O_2^{2+} removes a second electron from the antibonding π^* orbitals, resulting in a higher bond order of 3.0.

(d) Conversely, when neutral oxygen accepts an electron to form the superoxide anion (O_2^-), the extra electron enters an antibonding π^* orbital, decreasing the bond order to 1.5.

(e) Since a higher bond order corresponds to a stronger, shorter covalent bond, the bond lengths follow the opposite trend of the bond orders, giving the final increasing sequence.

Final Answer: The correct increasing order of bond lengths is $\mathrm{O_2^{2+} < O_2^+ < O_2 < O_2^-}$.

Answer: (A)

Go Back to Question 10

Q11.

Solution

Concept:

Crystal Field Theory describes the electronic structure of transition metal complexes by considering the electrostatic interactions between the d-orbitals of the central metal ion and the surrounding ligands. In an octahedral coordination field, the five degenerate d-orbitals split into two distinct energy levels: a lower energy triplet designated as t_{2g} and a higher energy doublet designated as e_g. The distribution of electrons within these split levels depends entirely on the relative field strength of the ligands.

Solution:

(a) In the hexacyanoferrate(II) complex ion, represented as $[Fe(CN)_6]^{4-}$, the central iron atom is coordinated to six monodentate cyano ligands, indicating an octahedral geometry.

(b) Calculating the oxidation state of the central iron atom reveals it to be in the +2 oxidation state, which corresponds to a d^6 transition metal electronic configuration.

(c) The cyano ligand (CN^-) is classified as a very strong-field ligand according to the spectrochemical series, meaning it generates a large crystal field splitting energy.

(d) Because the crystal field splitting energy is significantly greater than the electron pairing energy, it is thermodynamically favorable for electrons to pair up within the lower energy levels.

(e) Consequently, all six valence d-electrons are forced to pair completely within the lower three t_{2g} orbitals rather than entering the higher e_g orbitals, resulting in a low-spin configuration.

Final Answer: The electronic configuration is $t_{2g}^6 e_g^0$ and the complex is low spin.

Answer: (B)

Go Back to Question 11

Q12.

Solution

Concept:

Faraday's laws of electrolysis establish a quantitative relationship between the magnitude of electric current passed through an electrolytic solution and the total mass of the chemical substance liberated or deposited at the electrodes. The total electrical charge transferred is proportional to the product of current and time, and the deposition of one gram-equivalent of any substance requires exactly one Faraday of electrical charge.

Solution:

(a) The first step requires determining the total quantity of electrical charge passed through the aqueous copper sulfate electrolyte using the relationship where charge equals current multiplied by time.

(b) Multiplying the steady current of 2.0 A by the operational duration of 965 seconds yields a total electrical charge of exactly 1930 Coulombs.

(c) Converting this electrical charge into Faradays by dividing by the Faraday constant reveals that $1930/96500$ equals exactly 0.02 Faradays of electricity consumed.

(d) The reduction half-reaction occurring at the cathode involves divalent copper ions accepting two electrons to form pure metallic copper, meaning two Faradays deposit one mole of copper.

(e) Since two Faradays deposit 63.5 g of copper, the mass deposited by 0.02 Faradays is calculated as 0.01 multiplied by 63.5, which equals 0.635 grams.

Final Answer: The mass of pure copper metal deposited at the cathode is 0.6350 g.

Answer: (B)

Go Back to Question 12

Q13.

Solution

Concept:

Surface chemistry distinguishes between two primary categories of gas adsorption onto solid surfaces based on the nature of the binding forces involved: physical adsorption and chemical adsorption. Physical adsorption involves weak, non-specific intermolecular attractions that resemble gas condensation behavior, whereas chemical adsorption involves the formation of true covalent or ionic chemical bonds localized at specific surface sites.

Solution:

(a) Physical adsorption is driven entirely by weak van der Waals forces, which lack directional characteristics and operate uniformly across any accessible solid surface interface.

(b) Because these intermolecular forces are universal and do not depend on specific chemical compatibility, physical adsorption is fundamentally non-specific in nature, allowing any gas to adsorb.

(c) This non-specific character allows incoming gas molecules to continuously stack on top of previously adsorbed layers under high pressure conditions, leading to multimolecular layer formation.

(d) The process of physical adsorption is inherently exothermic due to the net reduction in surface residual forces, meaning that increasing temperature shifts the equilibrium to favor desorption.

(e) Stating that physical adsorption is highly specific and restricted to forming only a localized unimolecular layer is incorrect because those specific properties uniquely define chemical adsorption.

Final Answer: The incorrect statement is that physical adsorption is highly specific and forms only a localized unimolecular layer.

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

Go Back to Question 13

Q14.

Solution

Concept:

The chemical reactivity of transition metals with mineral acids depends heavily on the oxidizing strength of the acid and the concentration of the solution. Nitric acid is a powerful oxidizing agent that does not yield hydrogen gas upon reaction with metals; instead, the nitrogen center undergoes reduction to form various oxides depending on the concentration of the acid.

Solution:

(a) When metallic copper is treated with concentrated nitric acid, the high concentration of hydronium and nitrate ions favors a deep reduction pathway yielding nitrogen dioxide.

(b) The balanced chemical equation for this redox process shows that one mole of copper reacts with four moles of concentrated nitric acid to generate copper nitrate, water, and two moles of gas.

(c) The principal gaseous product evolved during this vigorous reaction is nitrogen dioxide (NO_2), which is characterized visually as a dense, choking brown gas.

(d) Simultaneously, the oxidation of elemental copper produces divalent copper ions (Cu^{2+}) in the aqueous medium, which coordinate with water molecules to form a characteristic deep blue-green solution.

(e) Dilute nitric acid would instead yield colorless nitric oxide gas, making the evolution of brown nitrogen dioxide gas combined with a blue-green solution unique to the concentrated acid reaction.

Final Answer: The reaction evolves nitrogen dioxide gas and forms a deep blue/green solution.

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

Go Back to Question 14

Q15.

Solution

Concept:
The atomic and ionic radii of elements normally increase down a group and decrease across a period due to increasing effective nuclear charge. Within the inner transition series, the progressive filling of the deeper f-orbitals introduces unique shielding characteristics that alter these standard periodic trends, affecting the chemical properties of post-lanthanide elements.

Solution:

(a) The Lanthanide Contraction refers to the steady, regular decrease in atomic and ionic radii observed across the lanthanide series from lanthanum to lutetium.

(b) This phenomenon is caused by the peculiar spatial distribution and diffuse geometric shape of the inner $4f$ atomic orbitals being progressively filled across the series.

(c) The diffuse nature of these $4f$ electron clouds results in exceptionally poor and imperfect shielding of the outer valence electrons from the growing positive charge of the nucleus.

(d) As the atomic number increases by one unit at each successive element, the nuclear charge increases while the poorly shielding $4f$ electrons fail to compensate for this increase.

(e) Consequently, the effective nuclear charge experienced by the outermost valence electrons increases steadily, pulling the electron shells closer to the nucleus and causing a contraction.

Final Answer: The contraction is attributed to the imperfect shielding of the nuclear charge by the inner $4f$ electrons.

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

Go Back to Question 15

Q16.

Solution

Concept:
The mixing of multiple solutions containing the same working solute follows the law of conservation of mass, which dictates that the total number of moles of solute present in the final mixture must equal the sum of the individual moles contributed by each component solution. Molarity is defined as the moles of solute per unit volume of solution.

Solution:

(a) Let the unknown volume of the first hydrochloric acid solution required for mixing be represented as a variable V_1 expressed in milliliters.

(b) The number of millimoles of solute in the first solution is found by multiplying its molarity by its volume, which yields the expression 0.5 multiplied by V_1.

(c) The number of millimoles of solute contributed by the second solution is calculated by multiplying its volume of 200 mL by its molarity of 0.2 M, yielding 40 millimoles.

(d) The total volume of the resulting homogeneous mixture is the sum of the two individual volumes, which can be represented mathematically as $V_1 + 200$ mL.

(e) Setting up the conservation equation shows that $0.5V_1 + 40 = 0.4(V_1 + 200)$. Simplifying this linear algebraic equation reveals that $0.1V_1 = 40$, which gives 400 mL.

Final Answer: The volume of the 0.5 M solution required is 400 mL.

Answer: (C)

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Q17.

Solution

Concept:

The enthalpy change and the internal energy change of a chemical reaction are fundamental thermodynamic quantities linked by the pressure-volume work performed during a chemical change. For reactions involving gases, this relationship can be quantified by applying the ideal gas law, which isolates the volumetric changes to variations in the stoichiometric coefficients of the gaseous species.

Solution:

(a) The primary thermodynamic equation relating these two quantities under conditions of constant temperature and pressure is defined as enthalpy change equals internal energy change plus $\Delta n_g RT$.

(b) The crucial term Δn_g represents the net change in the number of moles of gaseous components, calculated as total gaseous product moles minus total gaseous reactant moles.

(c) Examining the provided combustion reaction for liquid benzene: $C_6H_6(l) + 7.5O_2(g) \rightarrow 6CO_2(g) + 3H_2O(l)$, we must identify the physical states of all species.

(d) The only components in the gaseous phase are the six moles of carbon dioxide product and the seven and a half moles of oxygen reactant.

(e) Calculating the change yields $\Delta n_g = 6 - 7.5 = -1.5$. Substituting this into the rearranged expression for the difference, $\Delta H - \Delta U$, yields the final value of $-1.5RT$.

Final Answer: The true algebraic difference is $-1.5RT$.

Answer: (A)

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Q18.

Solution

Concept:

The reactivity of carbonyl compounds toward nucleophilic addition reactions is governed by a combination of electronic and steric factors localized at the electrophilic carbonyl carbon atom. Nucleophiles attack the carbonyl carbon by donating an electron pair, meaning that any factor reducing the partial positive charge or physically blocking access to this carbon will decrease the overall reaction rate.

Solution:

(a) In formaldehyde, the carbonyl carbon is bonded to two small hydrogen atoms, presenting minimal steric hindrance and allowing easy spatial access for an incoming cyano nucleophile.

(b) In acetaldehyde, one hydrogen is replaced by a methyl group, which increases steric crowding around the reaction center and releases electron density via inductive effects, reducing its electrophilicity.

(c) Acetone contains two bulky methyl groups flanking the carbonyl center, creating significant steric hindrance that physically impedes the trajectory of the attacking nucleophile.

(d) Furthermore, the combined electron-donating inductive effects of the two methyl groups in acetone greatly diminish the partial positive charge on the carbonyl carbon atom.

(e) Comparing these factors shows that formaldehyde is the most reactive, followed by acetaldehyde, while acetone is the least reactive, establishing a clear decreasing order of reactivity.

Final Answer: The correct relative rate of reactivity is I > II > III.

Answer: (A)

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Q19.

Solution

Concept:
Nucleophilic substitution pathways at saturated carbon centers typically proceed via two distinct mechanisms: bimolecular (S_N2) or unimolecular (S_N1). The bimolecular pathway is a concerted, single-step process where bond-breaking and bond-making occur simultaneously, imposing strict stereochemical requirements on the trajectory of the incoming nucleophile relative to the departing leaving group.

Solution:

(a) The S_N2 mechanism involves a backside attack where the nucleophile approaches the electrophilic carbon center from the side directly opposite the bond connecting the carbon to the leaving group.

(b) This backside approach is required because the leaving group blocks a frontside attack, and it aligns the nucleophile with the empty antibonding orbital of the carbon-halogen bond.

(c) As the reaction reaches its transition state, the central carbon transitions into a pentacoordinate planar arrangement, with the remaining three substituents pushed into a single plane.

(d) As the leaving group departs fully, the remaining substituents are forced to flip to the opposite side, resembling an umbrella being blown inside out in strong winds.

(e) This mechanical inversion at the asymmetric chiral center results in a complete inversion of stereochemical configuration, a phenomenon universally referred to as Walden inversion.

Final Answer: The stereochemical outcome universally observed is inversion of configuration.

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

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Q20.

Solution

Concept:
The net molecular dipole moment of a polyatomic covalent molecule is the vector sum of all individual bond dipole moments present within its three-dimensional structure. A molecule will possess a permanent, non-zero dipole moment if its spatial geometry is asymmetric, preventing individual bond dipoles and lone pair dipoles from canceling each other out.

Solution:

(a) Carbon dioxide (CO_2) features a linear geometry where two equal carbon-oxygen bond dipoles point in opposite directions, resulting in perfect vector cancellation and a net dipole moment of zero.

(b) Boron trifluoride (BF_3) adopts a symmetric trigonal planar geometry with bond angles of 120 degrees, causing the three individual boron-fluorine bond dipoles to cancel each other completely.

(c) Xenon tetrafluoride (XeF_4) features a square planar molecular geometry with two axial lone pairs that counteract each other, leading to complete vector cancellation of all individual components.

(d) Sulfur tetrafluoride (SF_4) features a central sulfur atom with five electron pairs, resulting in a see-saw molecular geometry derived from a trigonal bipyramidal arrangement with one lone pair.

(e) This see-saw geometry lacks a center or plane of symmetry to cancel the highly polar sulfur-fluorine bond dipoles, resulting in an asymmetrical distribution of charge and a permanent dipole moment.

Final Answer: The molecule that possesses a permanent, non-zero dipole moment is sulfur tetrafluoride.

Answer: (C)

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Answer Key

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