AME CET Chemistry Sample Paper-9

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. An organic compound undergoes alkaline hydrolysis. The reaction rate doubles when the concentration of the substrate is doubled, but remains unchanged when the concentration of the nucleophile (OH^-) is doubled. Which of the following statements is correct regarding this reaction?

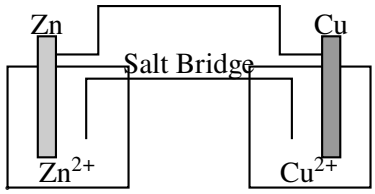
(A) The reaction proceeds with complete inversion of configuration via a pentavalent transition state.

(B) The reaction involves a planar carbocation intermediate and results in racemization if the starting material is optically active.

(C) The reaction is a single-step concerted process without any intermediate formation.

(D) Non-polar aprotic solvents like DMF will significantly increase the rate of this reaction compared to polar protic solvents.

Q2. Consider the cell representation shown in the diagram below:



If the standard reduction potentials of Zn^{2+}/Zn and Cu^{2+}/Cu are -0.76 V and $+0.34$ V respectively, what will be the EMF of the cell at 298 K when $[Zn^{2+}] = 0.1$ M and $[Cu^{2+}] = 0.01$ M? (Take $2.303RT/F = 0.06$)

(A) 1.13 V

(B) 1.07 V

(C) 1.10 V

(D) 0.73 V

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

(A) O_2^{2+}

(B) O_2^-

(C) N_2^-

(D) C_2

Q4. The formal charges on the central oxygen atom and the two terminal oxygen atoms in the ozone (O_3) molecule are, respectively:

(A) $0, +1, -1$

(B) $+1, 0, -1$

(C) $+1, -1, 0$

(D) $0, 0, 0$

Q5. In a multi-electron atom, which of the following combinations of quantum numbers (n, l, m_l, m_s) represents an electron belonging to the subshell that fills immediately after the $4s$ subshell is completely occupied?

(A) $4, 1, 0, +\frac{1}{2}$

(B) $3, 2, -1, -\frac{1}{2}$

(C) $3, 1, +1, +\frac{1}{2}$

(D) $4, 2, -2, -\frac{1}{2}$

Q6. An ideal gas expands isothermally against a constant external pressure of 1.5 atm from an initial volume of 2.0 L to a final volume of 6.0 L at a temperature of 300 K. Calculate the total work done (W) by the gas and the change in internal energy (ΔU) for this process. ($1\ \text{L} \cdot \text{atm} = 101.3\ \text{J}$)

(A) $W = -607.8$ J, $\Delta U = 0$ J

(B) $W = +607.8$ J, $\Delta U = -607.8$ J

(C) $W = -405.2$ J, $\Delta U = 0$ J

(D) $W = -607.8$ J, $\Delta U = +607.8$ J

Q7. The major organic product formed when propene reacts with hydrogen bromide (HBr) in the presence of benzoyl peroxide is treated with aqueous KOH. What is the final major product of this two-step sequence?

(A) Propan-2-ol

(B) Propan-1-ol

(C) Propene

(D) Propanone

Q8. An evaluation of the crystalline structure of an oxide shows a close-packed lattice arrangement. For a solid substance consisting of elements X and Y, element Y forms a cubic close-packed (ccp) array, while atoms of element X occupy exactly one-third of the tetrahedral voids. What is the empirical formula of the compound?

(A) X_2Y_3

(B) XY_3

(C) X_3Y_2

(D) X_2Y

Q9. Identify the correct order of increasing field strength of ligands in the spectrochemical series among the options given below:

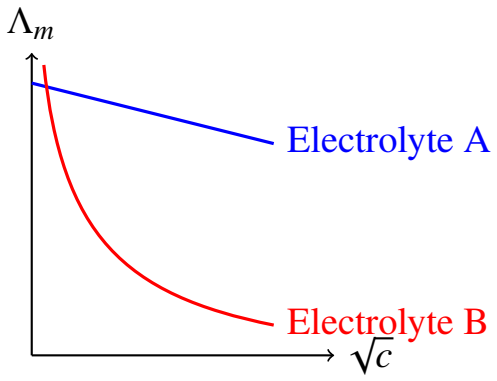
(A) $I^- < F^- < H_2O < NH_3 < CN^-$

(B) $CN^- < NH_3 < H_2O < F^- < I^-$

(C) $I^- < H_2O < F^- < NH_3 < CN^-$

(D) $F^- < I^- < H_2O < CN^- < NH_3$

Q10. The variation of molar conductivity (Λ_m) with the square root of concentration ($\sqrt{c}$) for two different electrolytes A and B is shown in the graph below:



Which statement accurately describes the characteristics of Electrolyte A and Electrolyte B?

(A) Electrolyte A is a weak electrolyte like CH_3COOH, and Electrolyte B is a strong electrolyte like KCl.

(B) Electrolyte A is a strong electrolyte like KCl, and Electrolyte B is a weak electrolyte like CH_3COOH.

(C) Both A and B are strong electrolytes, but B dissociates into more ions per formula unit.

(D) Molar conductivity at infinite dilution (Λ_m°) for Electrolyte B can be easily obtained by direct extrapolation of the curve to the y-axis.

Q11. For the reversible gas-phase equilibrium reaction: $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$, the equilibrium constant K_p is related to K_c at a temperature T by which of the following expressions?

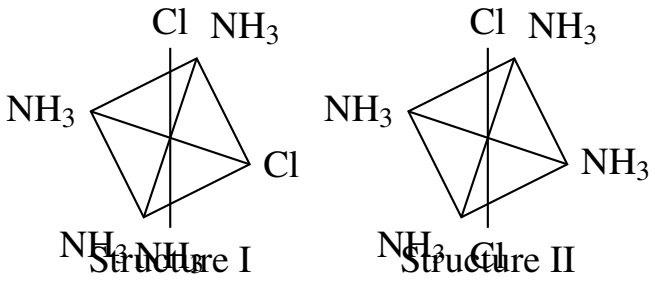
(A) $K_p = K_c(RT)$

(B) $K_p = K_c(RT)^{-1}$

(C) $K_p = K_c(RT)^{-2}$

(D) $K_p = K_c(RT)^2$

Q12. The octahedral complex $[Co(NH_3)_4Cl_2]^+$ can exist in two distinct spatial arrangements as illustrated by the structural representations below:



Which type of isomerism is demonstrated by Structure I and Structure II?

(A) Linkage isomerism

(B) Ionization isomerism

(C) Geometrical isomerism

(D) Optical isomerism

Q13. When phenol is treated with chloroform ($CHCl_3$) in the presence of aqueous sodium hydroxide (NaOH), followed by acid hydrolysis, an aromatic aldehyde is formed as the major product. What is the electrophile involved in this transformation?

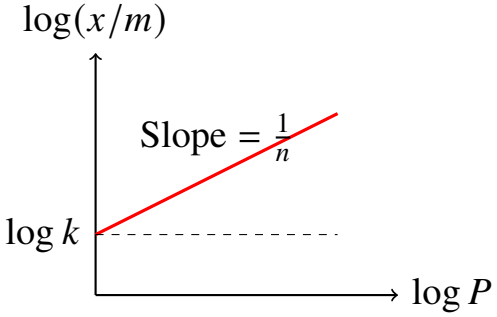
(A) The trichloromethyl anion ($:CCl_3^-$)

(B) The formyl cation (CHO^+)

(C) Dichlorocarbene ($:CCl_2$)

(D) The chloromethyl cation (CH_2Cl^+)

Q14. The adsorption of a gas on a solid surface follows the Freundlich adsorption isotherm model. The relationship between the mass of the gas adsorbed per gram of adsorbent (x/m) and the equilibrium pressure (P) can be visualized by the linear trend shown below:



If the slope of the straight line is found to be 0.5, which statement regarding the physical parameters is correct?

(A) Adsorption is entirely independent of pressure.

(B) The value of n is equal to 2, indicating that adsorption varies as the square root of pressure.

(C) The process is an example of chemisorption which forms a multi-molecular layer.

(D) The rate of desorption increases dramatically at higher pressures when the slope reaches unity.

Q15. Which of the following elements among the given $3d$-transition series exhibits the maximum number of stable oxidation states due to the participation of both $(n-1)d$ and ns electrons?

(A) Sc ($Z = 21$)

(B) Cr ($Z = 24$)

(C) Mn ($Z = 25$)

(D) Cu ($Z = 29$)

Q16. A sample of a substance contains 3.011×10^{23} molecules of glucose ($C_6H_{12}O_6$). What is the total mass of the glucose sample and the total number of moles of carbon atoms present in it? (Molar mass of glucose = 180 g/mol, Avogadro's constant = 6.022×10^{23} mol^{-1})

(A) 90 g and 3.0 moles

(B) 180 g and 6.0 moles

(C) 90 g and 0.5 moles

(D) 45 g and 1.5 moles

Q17. Among the following oxoacids of phosphorus, which one exhibits the strongest reducing behavior due to the presence of the highest number of direct P – H bonds?

(A) Orthophosphoric acid (H_3PO_4)

(B) Pyrophosphoric acid ($H_4P_2O_7$)

(C) Orthophosphorous acid (H_3PO_3)

(D) Hypophosphorous acid (H_3PO_2)

Q18. The major organic product formed by the reaction of an aromatic primary amine with nitrous acid (HNO_2) at $0-5^\circ C$ is subsequently warmed with ethanol. What is the final organic product obtained?

(A) Phenol

(B) Benzene

(C) Nitrobenzene

(D) Chlorobenzene

Q19. Which of the following organic structures represents an optically active molecule that cannot be superimposed on its mirror image?

(A) 2-Methylbutane

(B) Butan-1-ol

(C) 2-Chlorobutane

(D) Propan-2-ol

Q20. The VSEPR model configuration and the hybridisation state of the central atom in the xenon fluorides XeF_2 and XeF_4 are, respectively:

(A) Linear (sp^3d) and Square Planar (sp^3d^2)

(B) Bent (sp^2) and Tetrahedral (sp^3)

(C) Linear (sp^3) and Octahedral (sp^3d^2)

(D) T-shaped (sp^3d) and Square Planar (sp^3d)

Detailed Solutions

Q1.

Solution

Concept: The kinetics of a nucleophilic substitution reaction dictate its mechanism. When a reaction rate depends exclusively on the concentration of the substrate and is independent of the nucleophile concentration, it follows first-order kinetics. This behavior characterizes the S_N1 (Substitution Nucleophilic Unimolecular) pathway.

Solution:

(a) Given that doubling the substrate concentration doubles the rate, but changing the hydroxide ion (OH^-) concentration has no effect, the rate law is expressed as Rate = $k[\text{Substrate}]^1[OH^-]^0$.

(b) This rate law indicates a two-step S_N1 mechanism where the first and slowest step (the rate-determining step) involves the heterolytic cleavage of the leaving group to generate a carbocation intermediate.

(c) The generated carbocation adopts a planar geometry with sp^2 hybridization at the cationic center.

(d) Because the intermediate is planar, the nucleophile can attack with equal probability from either the front or back side. If the starting material is optically active, this symmetrical attack leads to equal amounts of inversion and retention configurations, causing racemization.

(e) Options describing a single-step concerted pathway, a pentavalent transition state, or acceleration by non-polar aprotic solvents describe S_N2 characteristics, which contradict the experimental rate law.

Final Answer: The reaction involves a planar carbocation intermediate and results in racemization if the starting material is optically active.

Answer: (B)

Go Back to Question 1

Q2.

Solution

Concept: The electromotive force (EMF) of a non-standard galvanic cell can be calculated using the Nernst equation. This relates the standard cell potential (E°_{cell}), temperature, and the reaction quotient (Q) based on the stoichiometry of the redox process.

Solution:

(a) The standard cell potential is computed from the standard reduction potentials of the cathode and anode: $E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}} = E^\circ_{Cu^{2+}/Cu} - E^\circ_{Zn^{2+}/Zn} = +0.34\ \text{V} - (-0.76\ \text{V}) = 1.10\ \text{V}$.

(b) The overall cell reaction involves the oxidation of zinc and the reduction of copper(II) ions: $Zn(s) + Cu^{2+}(aq) \rightleftharpoons Zn^{2+}(aq) + Cu(s)$. The number of moles of electrons transferred (n) is 2.

(c) The reaction quotient for this system is written as $Q = [Zn^{2+}]/[Cu^{2+}]$. Substituting the given concentrations yields $Q = 0.1/0.01 = 10$.

(d) Applying the Nernst equation at 298 K with the simplified constant: $E_{\text{cell}} = E^\circ_{\text{cell}} - \frac{0.06}{n} \log Q$.

(e) Substituting the calculated values gives $E_{\text{cell}} = 1.10 - \frac{0.06}{2} \log(10) = 1.10 - 0.03(1) = 1.07\ \text{V}$.

Final Answer: 1.07 V

Answer: (B)

Go Back to Question 2

Q3.

Solution

Concept: Molecular Orbital (MO) Theory provides the electronic configurations of homonuclear diatomic molecules and ions. The bond order is calculated as B.O. $= \frac{1}{2}(N_b - N_a)$, where N_b and N_a represent the number of electrons in bonding and antibonding molecular orbitals, respectively. Diamagnetism occurs when all electrons are paired.

Solution:

(a) For O_2^{2+}, the total electron count is 14. Its MO configuration follows the lighter element filling order due to s-p mixing or the standard heavy order without valence mixing: $\sigma_{1s}^2\sigma_{1s}^{*2}\sigma_{2s}^2\sigma_{2s}^{*2}\sigma_{2p_z}^2\pi_{2p_x}^2\pi_{2p_y}^2$. The bond order is $\frac{1}{2}(10-4) = 3$. It contains no unpaired electrons, making it diamagnetic.

(b) For O_2^-, the total electron count is 17. The configuration places electrons in the antibonding π^* orbitals: $\ldots\pi_{2p_x}^{*2}\pi_{2p_y}^{*1}$. This results in one unpaired electron (paramagnetic) and a bond order of $\frac{1}{2}(10-7) = 1.5$.

(c) For N_2^-, the total electron count is 15. The configuration is $\ldots\sigma_{2p_z}^2\pi_{2p_x}^{*1}$. This leaves one unpaired electron (paramagnetic) and yields a bond order of $\frac{1}{2}(10-5) = 2.5$.

(d) For C_2, the total electron count is 8 valence electrons (12 total). The configuration is $\sigma_{2s}^2\sigma_{2s}^{*2}\pi_{2p_x}^2\pi_{2p_y}^2$. All electrons are paired (diamagnetic), but the bond order is $\frac{1}{2}(8-4) = 2$.

Final Answer: O22+

Answer: (A)

Go Back to Question 3

Q4.

Solution

Concept: The formal charge of an atom in a polyatomic molecule evaluates electron distribution using the expression: Formal Charge $= V - N - \frac{1}{2}B$, where V is the number of valence electrons of the free atom, N is the number of non-bonding valence electrons, and B is the number of bonding electrons.

Solution:

(a) The Lewis structure of ozone (O_3) consists of a central oxygen atom double-bonded to one terminal oxygen atom and single-bonded to the other terminal oxygen atom, maintaining a resonance hybrid.

(b) Let the central oxygen atom be labeled O_c. It forms 3 bonds (one double, one single) and retains one lone pair. Thus, $V = 6$, $N = 2$, and $B = 6$. Its formal charge is $6 - 2 - \frac{1}{2}(6) = +1$.

(c) Let the double-bonded terminal oxygen atom be labeled O_d. It forms 2 bonds and retains two lone pairs. Thus, $V = 6$, $N = 4$, and $B = 4$. Its formal charge is $6 - 4 - \frac{1}{2}(4) = 0$.

(d) Let the single-bonded terminal oxygen atom be labeled O_s. It forms 1 bond and retains three lone pairs. Thus, $V = 6$, $N = 6$, and $B = 2$. Its formal charge is $6 - 6 - \frac{1}{2}(2) = -1$.

(e) Combined, the formal charges on the central and the two terminal atoms are $+1, 0, -1$ (or $+1, -1, 0$ depending on left/right orientation). Looking at the options, $+1, 0, -1$ matches perfectly.

Final Answer: +1, 0, -1

Answer: (B)

Go Back to Question 4

Q5.

Solution

Concept: The filling order of atomic subshells is governed by the Aufbau principle, which sequences subshells according to increasing values of the principal quantum number (n) and azimuthal quantum number (l), collectively estimated by the $(n + l)$ rule.

Solution:

(a) The standard energy sequence for subshell filling follows the order: $1s \rightarrow 2s \rightarrow 2p \rightarrow 3s \rightarrow 3p \rightarrow 4s \rightarrow 3d \rightarrow 4p \ldots$

(b) According to this established sequence, once the $4s$ subshell is completely occupied, incoming electrons begin to occupy the $3d$ subshell.

(c) For a $3d$ subshell, the principal quantum number (n) must equal 3.

(d) The azimuthal quantum number (l) specifies the subshell type, where $l = 0$ for s, $l = 1$ for p, $l = 2$ for d, and $l = 3$ for f. Therefore, for a d orbital, $l = 2$.

(e) The magnetic quantum number (m_l) can take any integral value from $-l$ to $+l$. For $l = 2$, permissible values are $-2, -1, 0, +1, +2$. The spin quantum number (m_s) must be either $+\frac{1}{2}$ or $-\frac{1}{2}$. This isolates the combination $(3, 2, -1, -\frac{1}{2})$ as correct.

Final Answer: 3, 2, -1, -1/2

Answer: (B)

Go Back to Question 5

Q6.

Solution

Concept: For an ideal gas, the internal energy (U) depends strictly on temperature. In any isothermal process ($\Delta T = 0$), the change in internal energy (ΔU) must equal zero. The work done (W) during irreversible gas expansion against a constant external pressure is given by $W = -P_{\text{ext}}\Delta V$.

Solution:

(a) Because the ideal gas expansion is specified as isothermal (T = constant), the temperature remains unchanged. Consequently, the change in internal energy is $\Delta U = 0$ J.

(b) The change in volume during expansion is calculated as $\Delta V = V_{\text{final}} - V_{\text{initial}} = 6.0\text{ L} - 2.0\text{ L} = 4.0\text{ L}$.

(c) The work done against the constant external atmospheric pressure is expressed as: $W = -P_{\text{ext}} \times \Delta V = -1.5\text{ atm} \times 4.0\text{ L} = -6.0\text{ L} \cdot \text{atm}$.

(d) To convert the work done from liter-atmospheres to Joules, multiply by the given conversion factor: $W = -6.0\text{ L} \cdot \text{atm} \times 101.3\text{ J}/(\text{L} \cdot \text{atm}) = -607.8\text{ J}$.

(e) The negative sign physically represents work done by the system on the surroundings during expansion.

Final Answer: W = -607.8 J, $\Delta U = 0J$

Answer: (A)

Go Back to Question 6

Q7.

Solution

Concept: The addition of hydrogen halides to unsymmetrical alkenes follows different regiochemical pathways depending on reaction conditions. Standard additions proceed via Markovnikov's rule, whereas addition in the presence of organic peroxides undergoes a free-radical mechanism governed by Anti-Markovnikov regioselectivity.

Solution:

(a) In the first step, propene (CH_3-CH = CH_2) reacts with HBr in the presence of benzoyl peroxide. The peroxide prompts a free-radical chain mechanism where the bromine radical attacks the terminal carbon to yield a more stable secondary carbon radical.

(b) This radical pathway ensures Anti-Markovnikov addition, placing the bromine atom at the terminal position to form 1-bromopropane (CH_3-CH_2-CH_2Br) as the major intermediate product.

(c) In the second step, 1-bromopropane is treated with aqueous potassium hydroxide (KOH).

(d) Aqueous KOH acts as a source of nucleophilic hydroxide ions (OH^-), which undergo a nucleophilic substitution reaction (S_N2) displacing the bromide leaving group.

(e) This substitution transforms the terminal alkyl halide into a primary alcohol, yielding propan-1-ol (CH_3-CH_2-CH_2OH) as the final major organic product.

Final Answer: Propan-1-ol

Answer: (B)

Go Back to Question 7

Q8.

Solution

Concept: The empirical formula of an ionic crystalline solid can be derived from the spatial arrangement of its constituent atoms within the unit cell and the fractional occupancy of its structural interstitial voids.

Solution:

(a) Element Y forms a cubic close-packed (ccp) array. In a ccp lattice (equivalent to a face-centered cubic structure), the total effective number of lattice points or atoms of Y per unit cell is exactly 4.

(b) For a close-packed lattice containing N atoms, the total number of generated octahedral voids is equal to N, and the total number of tetrahedral voids is equal to $2N$.

(c) Since there are 4 atoms of element Y per unit cell ($N = 4$), the total number of available tetrahedral voids is $2 \times 4 = 8$.

(d) Atoms of element X occupy exactly one-third of these tetrahedral voids. Therefore, the effective number of X atoms per unit cell is given by: $4 \times \frac{1}{3} \times 2 = \frac{8}{3}$.

(e) Establish the atomic ratio of the constituent elements in the crystal unit cell: $X : Y = \frac{8}{3} : 4$. Multiplying both parts by 3 clears the fraction: $X : Y = 8 : 12$. Simplifying by dividing by their greatest common divisor (4) gives $2 : 3$. This leads to the empirical formula X_2Y_3.

Final Answer: X2Y3

Answer: (A)

Go Back to Question 8

Q9.

Solution

Concept: The spectrochemical series is an experimentally derived arrangement of ligands organized in order of increasing field strength, which correlates to their capacity to split the degenerate *d*-orbitals of a central transition metal ion in a coordination complex.

Solution:

(a) Ligands that produce small crystal field splittings (Δ) are classified as weak-field ligands, whereas those causing large splittings are termed strong-field ligands.

(b) Halide donors generally sit at the weakest end of the series due to electrostatic repulsions and filled *p*-orbitals participating in π-donation. Among halides, field strength increases with decreasing ionic radius: $I^- < Br^- < S^{2-} < SCN^- < Cl^- < N_3^- < F^-$.

(c) Oxygen-donor ligands like water (H_2O) exert a stronger field than halides but remain weaker than nitrogen-donor groups.

(d) Nitrogen-donor ligands, such as ammonia (NH_3) and ethylenediamine, exhibit intermediate-to-strong behavior due to effective σ-donation capabilities.

(e) Carbon-donor ligands like cyanide (CN^-) and carbon monoxide (CO) act as exceptionally strong-field ligands owing to strong σ-donation combined with powerful synergistic π-backbonding. This yields the relative order: $I^- < F^- < H_2O < NH_3 < CN^-$.

Final Answer: I- < F- < H2O < NH3 < CN-

Answer: (A)

Go Back to Question 9

Q10.

Solution

Concept: The relationship between molar conductivity (Λ_m) and electrolyte concentration (c) is described by the Debye-Hückel-Onsager equation for strong electrolytes, expressed linearly as $\Lambda_m = \Lambda_m^\circ - A\sqrt{c}$. Weak electrolytes show distinct non-linear exponential variations due to changing degrees of dissociation.

Solution:

(a) In the provided graph, Electrolyte A exhibits a linear decrease in molar conductivity as the square root of concentration ($\sqrt{c}$) increases. This straight-line behavior is characteristic of a strong electrolyte like KCl, which dissociates completely across all concentration ranges.

(b) For strong electrolytes, the slight drop in conductivity at higher concentrations is caused by increased interionic attractions that hinder ionic mobility.

(c) Electrolyte B shows a non-linear, steep curvature. At high dilutions, its molar conductivity rises sharply. This profile is characteristic of a weak electrolyte like acetic acid (CH_3COOH).

(d) For weak electrolytes, dilution drastically shifts the dissociation equilibrium according to Ostwald's dilution law, increasing the total fraction of active conducting ions.

(e) Because the curve for weak electrolyte B becomes nearly parallel to the y-axis at extreme dilutions, its limiting molar conductivity (Λ_m°) cannot be found via direct linear extrapolation. Instead, it must be determined indirectly using Kohlrausch's law of independent migration of ions.

Final Answer: Electrolyte A is a strong electrolyte like KCl, and Electrolyte B is a weak electrolyte like CH3COOH.

Answer: (B)

Go Back to Question 10

Q11.

Solution

Concept: The relationship between the equilibrium constant determined by partial pressures (K_p) and the equilibrium constant determined by molar concentrations (K_c) for a ideal gas-phase chemical reaction is derived from the ideal gas law and is expressed mathematically by the standard thermodynamic equation: $K_p = K_c(RT)^{\Delta n_g}$.

Solution:

(a) The term Δn_g represents the change in the total number of moles of gaseous products minus the total number of moles of gaseous reactants in the balanced chemical equation.

(b) For the given chemical equilibrium reaction, $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$, all species are explicitly in the gaseous phase.

(c) Count the total number of moles of gaseous products: there are exactly 2 moles of $SO_3(g)$.

(d) Count the total number of moles of gaseous reactants: there are 2 moles of $SO_2(g)$ and 1 mole of $O_2(g)$, totaling $2 + 1 = 3$ moles of gaseous reactants.

(e) Compute the value of the stoichiometric difference: Δn_g = Moles of gaseous product − Moles of gaseous reactant $= 2 - 3 = -1$.

(f) Substitute this calculated value of Δn_g back into the primary mathematical expression to yield: $K_p = K_c(RT)^{-1}$.

Final Answer: $K_p = K_c(RT)^{-1}$

Answer: (B)

Go Back to Question 11

Q12.

Solution

Concept: Isomerism in coordination chemistry describes compounds with identical chemical formulas but unique spatial orientations. Geometrical isomerism is a form of stereoisomerism that arises in coordinated complexes when ligands assume different relative positions around the central transition metal ion.

Solution:

(a) The given compound is an octahedral coordination complex of type $[MA_4B_2]^+$, specifically $[Co(NH_3)_4Cl_2]^+$, where cobalt serves as the central transition metal.

(b) In Structure I, the two chloride ligands (Cl^-) occupy adjacent positions relative to each other, forming a 90° bond angle at the central metal core. This specific configuration represents the cis-isomer.

(c) In Structure II, the two chloride ligands are arranged on directly opposing coordination sites of the octahedron, establishing a straight 180° axial line through the central cobalt ion. This specific configuration represents the trans-isomer.

(d) Because these two separate structures differ exclusively in the geometric orientation of the ligands in space without breaking structural linkages or swapping outer-sphere ions, they constitute geometrical isomers.

(e) Linkage and ionization options are invalid because the bonding atoms and counter-ions remain completely unchanged.

Final Answer: Geometrical isomerism

Answer: (C)

Go Back to Question 12

Q13.

Solution

Concept: The synthesis of salicylaldehyde from phenol using chloroform and an aqueous alkali base is widely known as the Reimer-Tiemann reaction. This classic organic chemical transformation proceeds via a highly reactive, neutral alpha-elimination intermediate.

Solution:

(a) In the initial step of the reaction, the strong base (OH^-) abstracts an acidic proton from the chloroform molecule ($CHCl_3$).

(b) This deprotonation leaves a strongly unstable trichloromethyl carbanion intermediate, which is formulated as : CCl_3^-.

(c) The carbanion immediately undergoes spontaneous alpha-elimination, losing a chloride ion (Cl^-) to regain a neutral, stable state.

(d) The elimination of the chloride ion leaves behind a divalent carbon atom containing a non-bonding lone pair, known as dichlorocarbene (: CCl_2).

(e) Dichlorocarbene possesses a vacant *p*-orbital, making it a highly electrophilic species. It is this neutral dichlorocarbene that acts as the active electrophile, attacking the nucleophilic ortho-position of the phenoxide ring to form the formyl group.

Final Answer: Dichlorocarbene ($:CCl_2$)

Answer: (C)

Go Back to Question 13

Q14.

Solution

Concept: The Freundlich adsorption isotherm empirical equation models the mathematical relationship between the quantity of gas adsorbed per unit mass of a solid adsorbent (x/m) and the equilibrium gas pressure (P) via the relation: $x/m = kP^{1/n}$.

Solution:

(a) Taking the logarithm of both sides of the Freundlich equation converts it into a linear slope-intercept form: $\log(x/m) = \log k + \frac{1}{n}\log P$.

(b) Comparing this expression to the equation of a straight line ($y = mx + c$), the slope of the linear graph corresponds to the fractional term $\frac{1}{n}$.

(c) The problem states that the measured mathematical slope of the straight line is exactly 0.5.

(d) Equating the theoretical term to the experimental measurement: $\frac{1}{n} = 0.5 = \frac{1}{2}$. This yields an absolute integer value of $n = 2$.

(e) Substituting $1/n = 0.5$ back into the original adsorption formula reveals $x/m = kP^{0.5} = k\sqrt{P}$. This confirms that the mass of gas adsorbed per gram varies directly as the square root of the pressure.

Final Answer: The value of n is equal to 2, indicating that adsorption varies as the square root of pressure.

Answer: (B)

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Q15.

Solution

Concept: The range of oxidation states shown by transition elements in the $3d$ series depends on the number of valence electrons available in both the outer $4s$ subshell and the inner, partially filled $(n-1)d$ subshell.

Solution:

(a) Scandium ($Z = 21$) has a valence shell configuration of $3d^1 4s^2$. It loses all three valence electrons to achieve a stable noble gas configuration, exhibiting almost exclusively the +3 oxidation state.

(b) Chromium ($Z = 24$) has a configuration of $3d^5 4s^1$ and shows states from +2 to +6, but its states are less numerous and varied than those of manganese.

(c) Manganese ($Z = 25$) possesses a ground-state valence electron configuration of $3d^5 4s^2$. It features a maximum number of five unpaired electrons in its d-orbitals alongside two electrons in the s-orbital.

(d) Because all seven valence electrons can participate in chemical bonding, manganese exhibits the largest number of stable oxidation states in the series, ranging continuously from +2, +3, +4, +5, +6 to +7.

(e) Copper ($Z = 29, 3d^{10} 4s^1$) exhibits only +1 and +2 oxidation states due to its completely filled d-subshell.

Final Answer: Mn (Z = 25)

Answer: (C)

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Q16.

Solution

Concept: Stoichiometric conversions between molecular quantities, absolute molar amounts, and macro-scale masses are governed by Avogadro's principle and the defined molecular formula of a chemical compound.

Solution:

(a) The absolute number of moles of glucose molecules present in the sample is determined by dividing the given particle count by Avogadro's number: Moles of glucose = $\frac{3.011\times10^{23}}{6.022\times10^{23}}$ = 0.5 moles.

(b) The total macro-scale mass of this glucose sample is calculated by multiplying the molar amount by the given molar mass: Mass = 0.5 mol × 180 g/mol = 90 grams.

(c) Examine the molecular formula of glucose, which is explicitly $C_6H_{12}O_6$. This atomic ratio demonstrates that exactly 1 mole of individual glucose molecules contains 6 moles of constituent carbon atoms.

(d) Consequently, the total molar quantity of carbon atoms present in a 0.5 mole sample of glucose is calculated as: Moles of C = 0.5 mol glucose × 6 mol C/mol glucose = 3.0 moles.

Final Answer: 90 g and 3.0 moles

Answer: (A)

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Q17.

Solution

Concept: The chemical reducing capability of oxoacids of phosphorus is determined by the presence of hydrogen atoms bonded directly to the central phosphorus core (P−H bonds). Hydroxyl groups (P − OH) dissociate to give acidic protons but do not impart reducing character.

Solution:

(a) Orthophosphoric acid (H_3PO_4) has a central phosphorus atom bonded to three −OH groups and one oxo oxygen (= O). It contains zero direct P − H bonds and possesses no reducing capacity.

(b) Pyrophophosphoric acid ($H_4P_2O_7$) contains four −OH groups, two oxo oxygens, and a P − O − P linkage, leaving zero direct P − H bonds.

(c) Orthophosphorous acid (H_3PO_3) features a central phosphorus atom bonded to two −OH groups, one oxo oxygen (= O), and exactly one direct P − H bond.

(d) Hypophosphorous acid (H_3PO_2) structures a central phosphorus atom bonded to one −OH group, one oxo oxygen (= O), and exactly two direct, highly reducing P − H bonds.

(e) Because hypophosphorous acid contains the highest numerical count of direct phosphorus-hydrogen linkages among all options, it exhibits the strongest reducing activity.

Final Answer: Hypophosphorous acid (H_3PO_2)

Answer: (D)

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Q18.

Solution

Concept: The diazotization of primary aromatic amines forms highly reactive arenediazonium salts. These intermediate compounds undergo a variety of synthetic replacement reactions when treated with specific chemical reducing agents or nucleophiles.

Solution:

(a) Aniline ($C_6H_5NH_2$), which is a classic aromatic primary amine, reacts with nitrous acid (HNO_2) generated in situ at a chilled temperature of $0 - 5^{\circ}C$.

(b) This low-temperature diazotization process yields a stable intermediate known as benzenediazonium chloride ($C_6H_5N_2^+Cl^-$).

(c) When an arenediazonium salt is treated with a mild reducing agent such as ethanol (CH_3CH_2OH) or hypophosphorous acid (H_3PO_2) and warmed gently, a reduction takes place.

(d) Ethanol acts as a reducing agent and undergoes oxidation itself, transforming into ethanal (CH_3CHO).

(e) Simultaneously, the diazonium group ($-N_2^+$) is reduced and completely replaced by a hydride ion, liberating nitrogen gas (N_2) and hydrochloric acid (HCl), which leaves pure benzene (C_6H_6) as the final major organic product.

Final Answer: Benzene

Answer: (B)

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Q19.

Solution

Concept: A molecule is classified as optically active if it is chiral, meaning it lacks an internal plane of symmetry or an inversion center, and possesses a non-superimposable mirror image. The most common source of molecular chirality is the presence of an asymmetric stereocenter.

Solution:

(a) An asymmetric stereocenter (or chiral carbon) is a sp^3-hybridized carbon atom that is covalently bonded to four entirely distinct chemical groups or substituents.

(b) Evaluate 2-Methylbutane: CH_3-$CH(CH_3)$-CH_2-CH_3. The second carbon is attached to two identical methyl groups, making it achiral.

(c) Evaluate Butan-1-ol: CH_3-CH_2-CH_2-CH_2OH. Every single carbon atom contains at least two identical hydrogen atoms, meaning no chiral stereocenter exists.

(d) Evaluate 2-Chlorobutane: CH_3-$C^*H(Cl)$-CH_2-CH_3. Examine the second carbon atom (C^*). It is covalently bound to four completely distinct chemical substituents: a methyl group ($-CH_3$), a hydrogen atom ($-H$), a chlorine atom ($-Cl$), and an ethyl group ($-CH_2CH_3$).

(e) This satisfies the structural requirements for molecular asymmetry, rendering 2-chlorobutane a chiral molecule that is optically active.

Final Answer: 2-Chlorobutane

Answer: (C)

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Q20.

Solution

Concept: The Valence Shell Electron Pair Repulsion (VSEPR) theory predicts the three-dimensional geometric configuration of a molecule based on minimizing electron repulsion between bonding pairs and non-bonding lone pairs surrounding a central core atom.

Solution:

(a) For XeF_2, the central xenon atom ($Z = 54$) possesses 8 valence electrons. It forms 2 single covalent bonds with two fluorine atoms, leaving $8 - 2 = 6$ non-bonding valence electrons, which form exactly 3 lone pairs.

(b) The steric number is calculated as Steric Number = Bond Pairs + Lone Pairs = $2 + 3 = 5$. This indicates a sp^3d hybridization state corresponding to a trigonal bipyramidal electronic geometry. To minimize repulsion, the 3 lone pairs sit equatorially, producing a linear molecular geometry.

(c) For XeF_4, xenon forms 4 single covalent bonds with four fluorine atoms, leaving $8 - 4 = 4$ non-bonding electrons, which form exactly 2 lone pairs.

(d) The steric number is Steric Number = $4 + 2 = 6$, indicating a sp^3d^2 hybridization state corresponding to an octahedral electronic geometry. The 2 lone pairs occupy axial positions opposite each other, resulting in a square planar molecular geometry.

Final Answer: Linear (sp^3d)$and Square Planar (sp^3d^2)$

Answer: (A)

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Answer Key

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