AME CET Chemistry Sample Paper-2

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. The mass of sodium carbonate (Na_2CO_3, molar mass = 106 g mol^{-1}) required to prepare 250 mL of a 0.1 M aqueous solution is:

(A) 10.6 g

(B) 5.30 g

(C) 2.65 g

(D) 1.06 g

Q2. Which of the following compounds will undergo nucleophilic substitution (S_N1) reaction most readily?

(A) $CH_3CH_2CH_2Cl$

(B) $(CH_3)_3CCl$

(C) $(CH_3)_2CHCl$

(D) CH_3Cl

Q3. According to Molecular Orbital Theory, which of the following species is diamagnetic and has a bond order equal to 3?

(A) O_2

(B) N_2

(C) O_2^{2-}

(D) N_2^+

Q4. The correct IUPAC name of the coordination complex $[Co(NH_3)_5(CO_3)]Cl$ is:

(A) Pentaaminecarbonatocobalt(III) chloride

(B) Carbonatopentaaminecobaltic chloride

(C) Pentaaminecarbonatocobalt(II) chloride

(D) Pentaaminecarbonatocobaltate(III) chloride

Q5. For a cell reaction involving a two-electron change, the standard EMF of the cell is found to be 0.295 V at 298 K. The equilibrium constant (K_c) for the reaction at this temperature is closest to: (Given: $\frac{2.303RT}{F} = 0.059$ V)

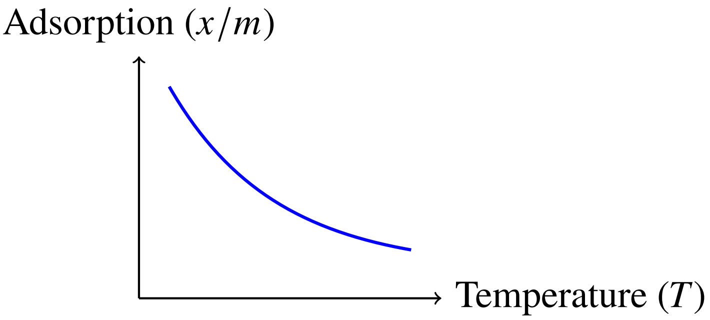
(A) 1×10^{10}

(B) 1×10^{5}

(C) 1×10^{-10}

(D) 2×10^{10}

Q6. Physical adsorption (physisorption) of a gas on a solid surface can be analyzed under changing conditions. Consider the graphical representation of adsorption variation with temperature:



Based on this behavior, physical adsorption:

(A) increases with an increase in temperature.

(B) is highly specific in nature.

(C) is irreversible in nature.

(D) decreases with an increase in temperature.

Q7. Which of the following p-block elements forms a stable +2 oxidation state predominantly due to the inert pair effect?

(A) Carbon
(B) Silicon
(C) Lead
(D) Tin

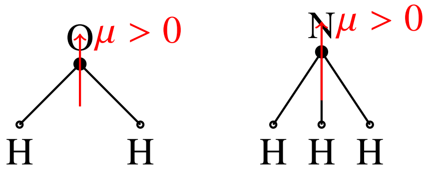
Q8. In a reversible chemical reaction, if the concentration of reactants is doubled, the value of the equilibrium constant (K_{eq}) will:

(A) double.
(B) be halved.
(C) remain unchanged.
(D) become four times the original value.

Q9. The major organic product formed when propene reacts with hydrogen bromide (HBr) in the presence of benzoyl peroxide is:

(A) 2-bromopropane
(B) 1-bromopropane
(C) 1,2-dibromopropane
(D) 2-bromopropan-2-ol

Q10. Consider the spatial geometry of water (H_2O) and ammonia (NH_3) molecule dipoles indicated schematically below:



Which of the following pairs of molecules both possess a dipole moment greater than zero?

(A) CO_2 and H_2O

(B) BF_3 and NH_3

(C) H_2O and NH_3

(D) CH_4 and NF_3

Q11. For a particular chemical reaction, $\Delta H = -92.4$ kJ mol^{-1} and $\Delta S = -198.3$ J K^{-1} mol^{-1}. This reaction will be spontaneous at:

(A) all temperatures.

(B) temperatures below 466 K.

(C) temperatures above 466 K.

(D) no temperature.

Q12. The structural isomerism shown by the pair of coordination complexes $[Co(NH_3)_5(SO_4)]Br$ and $[Co(NH_3)_5(Br)]SO_4$ is classified as:

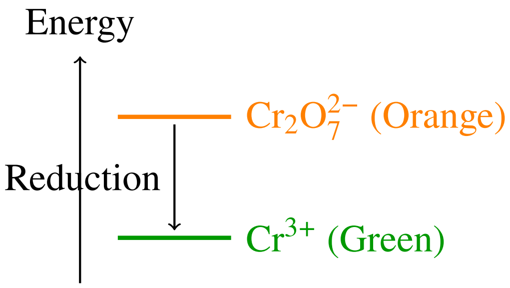
(A) Linkage isomerism

(B) Ionisation isomerism

(C) Coordination isomerism

(D) Solvate isomerism

Q13. Acidified potassium dichromate ($K_2Cr_2O_7$) solution turns green when a stream of sulfur dioxide (SO_2) gas is passed through it. The reduction of the chromium center can be visualized by the simplified energy transition layout below:



This green color is due to the formation of:

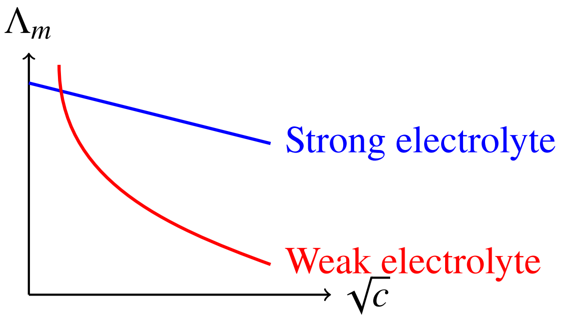
(A) Cr^{3+} ions

(B) CrO_4^{2-} ions

(C) CrO_5

(D) SO_4^{2-} ions

Q14. The dynamic resistance offered by an aqueous solution of an electrolyte to the flow of current decreases as the dilution increases. This variations of molar conductivity (Λ_m) versus $\sqrt{c}$ are represented below:



This implies that the molar conductivity (Λ_m) of a weak electrolyte:

(A) decreases sharply with dilution.

(B) increases sharply with dilution.

(C) remains constant regardless of dilution.

(D) decreases linearly with square root of concentration.

Q15. The correct order of decreasing acid strength among the following carboxylic acids is:

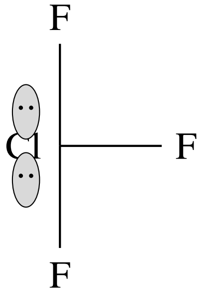
(A) $CH_3COOH > ClCH_2COOH > Cl_2CHCOOH > Cl_3CCOOH$

(B) $Cl_3CCOOH > Cl_2CHCOOH > ClCH_2COOH > CH_3COOH$

(C) $ClCH_2COOH > Cl_2CHCOOH > Cl_3CCOOH > CH_3COOH$

(D) $CH_3COOH > Cl_3CCOOH > Cl_2CHCOOH > ClCH_2COOH$

Q16. The geometry and hybridisation state of the central atom in chlorine trifluoride (ClF_3) are analyzed using its VSEPR steric representation below:



The configuration and hybridisation are respectively:

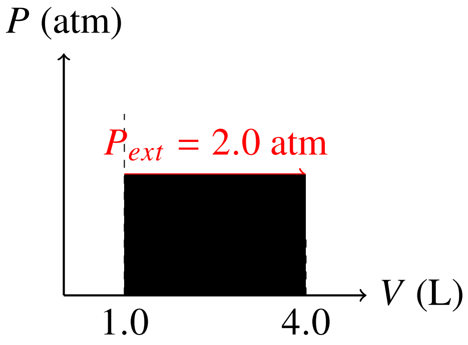
(A) Trigonall planar, sp^2

(B) T-shaped, sp^3d

(C) Trigonal bipyramidal, sp^3d

(D) See-saw, sp^3d

Q17. A sample of gas expands isothermally against a constant external pressure of 2.0 atm from an initial volume of 1.0 L to a final volume of 4.0 L as illustrated in the P-V indicator transition graph:



The work done (w) by the gas on the surroundings is: (Given: 1 L·atm = 101.3 J)

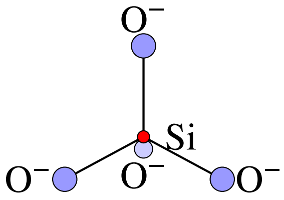
(A) −607.8 J

(B) +607.8 J

(C) −6.0 J

(D) −303.9 J

Q18. The basic structural unit of all silicates can be represented by the tetrahedral schematic below:



The structural configuration is:

(A) SiO_3^{2-} chain

(B) SiO_4^{4-} tetrahedron

(C) SiO_2 network

(D) $Si_2O_7^{6-}$ dimer

Q19. When phenol is treated with chloroform ($CHCl_3$) in the presence of aqueous sodium hydroxide (NaOH) followed by acidification, salicylaldehyde is formed. This synthetic transformation is widely known as the:

(A) Kolbe's reaction

(B) Reimer-Tiemann reaction

(C) Rosenmund reduction

(D) Friedel-Crafts acylation

Q20. An organic compound 'X' having the molecular formula C_3H_6O forms a yellow precipitate with iodine and sodium hydroxide solution, but it does not reduce Tollens' reagent. The structural formula of 'X' is:

(A) CH_3CH_2CHO

(B) CH_3COCH_3

(C) $CH_2 = CH - CH_2OH$

(D) $CH_3CH_2CH_2OH$

Detailed Solutions

Q1.

Solution

Concept: Molarity (M) measures solute concentration in a solution. It represents the number of moles of solute dissolved per liter of solution.

Solution: Step 1: Write down the given variables from the question. The molar mass of sodium carbonate (Na_2CO_3) is given as 106 g mol^{-1}. The target volume of the solution is 250 mL, and the required molarity of the solution is 0.1 M.

Step 2: Convert the volume of the solution from milliliters to liters because the standard formula for molarity requires volume in liters.

$$V = \frac{250 \text{ mL}}{1000 \text{ mL L}^{-1}} = 0.25 \text{ L}$$

Step 3: State the foundational formula for calculating molarity. Molarity (M) is calculated by dividing the number of moles of solute (n) by the volume of the solution in liters (V).

$$M = \frac{n}{V}$$

Step 4: Rearrange this formula to express the number of moles needed in terms of molarity and volume. Substitute the given values into the equation.

$$n = M \times V = 0.1 \text{ mol L}^{-1} \times 0.25 \text{ L} = 0.025 \text{ moles}$$

Step 5: Relate the number of moles to the total mass (W) of the substance using its molar mass (M_m). The mass of the solute is found by multiplying the number of moles by the molar mass.

$$W = n \times M_m = 0.025 \text{ mol} \times 106 \text{ g mol}^{-1} = 2.65 \text{ g}$$

Thus, exactly 2.65 g of sodium carbonate is necessary to prepare the specified solution.

Final Answer: $\boxed{2.65 \text{ g}}$

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

Go Back to Question 1

Q2.

Solution

Concept: The rate of a nucleophilic substitution (S_N1) reaction depends directly on the thermodynamic stability of the carbocation intermediate formed during the rate-determining step.

Solution: Step 1: Analyze the structural mechanism of an S_N1 pathway. The reaction proceeds through a two-step mechanism where the first, rate-limiting step involves the heterolytic cleavage of the carbon-halogen bond to generate a reactive carbocation intermediate.

Step 2: Identify and characterize the nature of the carbocations that would form from each of the given alkyl halide options upon ionization.
Option (A): $CH_3CH_2CH_2Cl$ ionizes to form a primary (1°) carbocation, $CH_3CH_2CH_2^+$.
Option (B): $(CH_3)_3CCl$ ionizes to form a tertiary (3°) carbocation, $(CH_3)_3C^+$.
Option (C): $(CH_3)_2CHCl$ ionizes to form a secondary (2°) carbocation, $(CH_3)_2CH^+$.
Option (D): CH_3Cl ionizes to form a highly unstable methyl carbocation, CH_3^+.

Step 3: Compare the electronic stabilities of these carbocations based on inductive effects and hyperconjugation. Alkyl groups are electron-donating groups via positive inductive effect ($+I$) and stabilize adjacent positive charges by hyperconjugation involving adjacent C-H bonds.

Step 4: Establish the definitive stability order for carbocations. The structural stabilization follows the trend: tertiary (3°) > secondary (2°) > primary (1°) > methyl.

Step 5: Match the stability trend to the options. Because the tert-butyl carbocation has nine stabilizing hyperconjugative hydrogens and three $+I$ groups, it forms exceptionally fast, causing tert-butyl chloride to react most readily.

Final Answer: $\boxed{(CH_3)_3CCl}$

Answer: (B)

Go Back to Question 2

Q3.

Solution

Concept: Molecular Orbital (MO) Theory describes the distribution of electrons in molecules and allows us to predict bond order, magnetic behavior, and electronic configurations.

Solution: Step 1: Recall the molecular orbital electronic configuration sequence for homonuclear diatomic molecules of the second period containing 14 or fewer electrons, and those containing more than 14 electrons.

Step 2: Examine Nitrogen (N_2), which contains a total of 14 electrons. The ground state molecular orbital configuration for a 14-electron system is written as follows:

$$\sigma_{1s}^2\ \sigma_{1s}^{*2}\ \sigma_{2s}^2\ \sigma_{2s}^{*2}\ \pi_{2p_x}^2\ \pi_{2p_y}^2\ \sigma_{2p_z}^2$$

Step 3: Analyze the magnetic properties by looking for the presence of unpaired electrons in the configuration. All electrons in the molecular orbitals of N_2 are paired. Because there are zero unpaired electrons, the molecule exhibits diamagnetism.

Step 4: Calculate the bond order using the standard formula, which states that bond order is equal to half the difference between the number of bonding electrons (N_b) and antibonding electrons (N_a).

$$\text{Bond Order} = \frac{N_b - N_a}{2}$$

Step 5: Count the electrons in the configuration. The total number of bonding electrons is 10, and the total number of antibonding electrons is 4. Substitute these counts into the formula:

$$\text{Bond Order} = \frac{10-4}{2} = \frac{6}{2} = 3$$

Step 6: Evaluate the other options to confirm the uniqueness of the answer. O_2 is paramagnetic with a bond order of 2, O_2^{2-} is diamagnetic but has a bond order of 1, and N_2^+ is paramagnetic with a bond order of 2.5. Hence, nitrogen perfectly satisfies both conditions.

Final Answer: $\boxed{N_2}$

Answer: (B)

Go Back to Question 3

Q4.

Solution

Concept: IUPAC nomenclature for coordination compounds follows a strict hierarchical order: ligands are named alphabetically first, followed by the central metal atom with its formal oxidation state denoted in Roman numerals.

Solution: Step 1: Identify the component parts of the coordination complex formula $[Co(NH_3)_5(CO_3)]Cl$. The complex consists of a cationic coordination sphere $[Co(NH_3)_5(CO_3)]^+$ and an external chloride counter-anion Cl^-.

Step 2: Determine the formal charges of all constituent ligands inside the coordination sphere to compute the oxidation state of the central metal. The ammine ligand (NH_3) is a neutral molecule with a charge of 0. The carbonato ligand (CO_3^{2-}) carries a charge of -2. The outer chloride ion (Cl^-) has a charge of -1.

Step 3: Set up an algebraic equation to solve for the unknown oxidation state (x) of the Cobalt (Co) atom, keeping in mind that the net charge of the entire coordination compound is completely neutral.

$$x + 5(0) + 1(-2) + 1(-1) = 0$$

$$x - 2 - 1 = 0 \implies x = +3$$

Thus, Cobalt exists in the +3 oxidation state, which must be represented as (III).

Step 4: Arrange the names of the ligands in alphabetical order. The neutral ligand NH_3 is named 'ammine' and has a prefix of 'penta' because five are present. The anionic ligand CO_3^{2-} is named 'carbonato'. Alphabetically, 'ammine' precedes 'carbonato'.

Step 5: Combine the ligand names with the name of the central metal. Because the coordination sphere is a cation, the metal retains its common name 'cobalt'. Conclude the full name by adding the counter-ion at the end, separated by a space. The complete valid name is pentaaminecarbonatocobalt(III) chloride.

Final Answer: $\boxed{\text{Pentaaminecarbonatocobalt(III) chloride}}$

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

Go Back to Question 4

Q5.

Solution

Concept: The standard electromotive force (E°_{cell}) of an electrochemical cell is fundamentally linked to its thermodynamic equilibrium constant (K_c) via the Nernst equation evaluated at standard state equilibrium conditions.

Solution: Step 1: State the specialized expression derived from the Nernst equation for a chemical system that has achieved equilibrium at a temperature of 298 K.

$$E^\circ_{\text{cell}} = \frac{2.303RT}{nF}\log_{10} K_c$$

Step 2: Identify the given numerical values from the problem statement. The standard cell potential E°_{cell} is equal to 0.295 V, the number of transferred electrons (n) is equal to 2, and the combined constant term $\frac{2.303RT}{F}$ is given as 0.059 V. Step 3: Substitute these parameters directly into the mathematical relationship to isolate the logarithmic term of the equilibrium constant.

$$0.295 = \frac{0.059}{2}\log_{10} K_c$$

Step 4: Solve the algebraic equation by multiplying both sides by 2 and then dividing by 0.059.

$$0.295 \times 2 = 0.059\log_{10} K_c$$

$$0.590 = 0.059\log_{10} K_c$$

$$\log_{10} K_c = \frac{0.590}{0.059} = 10$$

Step 5: Convert the expression from logarithmic form to exponential form by taking the antilogarithm of both sides to discover the definitive value of K_c.

$$K_c = 10^{10} = 1 \times 10^{10}$$

This demonstrates that the forward reaction is highly thermodynamically favored.

Final Answer: $\boxed{1 \times 10^{10}}$

Answer: (A)

Go Back to Question 5

Q6.

Solution

Concept: Physical adsorption (physisorption) involves weak, non-specific Van der Waals forces acting between an adsorbate gas and a solid adsorbent surface, making the process highly dependent on system temperature.

Solution: Step 1: Understand the thermodynamic properties of physical adsorption. The binding interaction between gas molecules and the solid surface releases energy, which means physisorption is inherently an exothermic process. The general chemical equation can be modeled as:

$$\text{Gas (Adsorbate)} + \text{Solid (Adsorbent)} \rightleftharpoons \text{Adsorption} + \text{Heat}$$

Step 2: Apply Le Chatelier's principle to this exothermic equilibrium system. According to the principle, if a stress such as an increase in temperature is applied to a system at equilibrium, the system will shift in the direction that absorbs the added heat.

Step 3: Deduce the direction of the shift. Increasing the temperature forces the equilibrium to shift in the backward direction, which favors desorption rather than adsorption. Consequently, the extent of physical adsorption (x/m) must decrease as the temperature rises.

Step 4: Analyze the provided tikz graph. The graph illustrates a continuous, smooth downward curve from left to right, validating that as temperature (T) increases along the horizontal axis, the extent of adsorption (x/m) drops on the vertical axis.

Step 5: Review the options against these core concepts. While chemisorption initially increases with temperature due to activation energy, physisorption lacks an activation energy barrier and decreases across the entire temperature scale. This directly correlates with Option (D).

Final Answer: $\boxed{\text{decreases with an increase in temperature.}}$

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

Go Back to Question 6

Q7.

Solution

Concept: The inert pair effect refers to the increasing thermodynamic stability of oxidation states that are two units lower than the group valence shell maximum for heavy post-transition elements of the p-block.

Solution: Step 1: Examine the group classification and valence electron configuration of the elements provided in the choices. Carbon (C), Silicon (Si), Tin (Sn), and Lead (Pb) all belong to Group 14 of the periodic table, possessing an outer shell electronic configuration of ns^2np^2.

Step 2: Comprehend the physical origin of the inert pair effect. As we descend down a p-block group, the intervening d and f orbitals fill up. These inner d and f electrons provide poor electrostatic shielding of the outermost valence s electrons from the increasing nuclear charge.

Step 3: Analyze the consequences of poor shielding on the valence s subshell. The outer ns^2 electron pair experiences a stronger effective nuclear charge, drawing it closer to the nucleus and holding it tightly. As a result, this s-orbital electron pair becomes chemically inert and resists taking part in bonding.

Step 4: Determine the preferred oxidation states down Group 14. For the lighter elements like Carbon and Silicon, all four valence electrons (ns^2np^2) readily participate, making +4 the dominant state. Tin shows both +2 and +4 states.

Step 5: Identify the trend for the heaviest element. For Lead ($_{82}$Pb), the $6s^2$ electrons are exceptionally inert. Thus, it loses only its two $6p$ electrons, causing the +2 oxidation state to be significantly more stable and dominant than the +4 oxidation state.

Final Answer: $\boxed{\text{Lead}}$

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

Go Back to Question 7

Q8.

Solution

Concept: The equilibrium constant (K_{eq}) of a chemical reaction is a fundamental thermodynamic constant that depends solely on the temperature of the system and the structural identity of the chemical species involved.

Solution: Step 1: Define what an equilibrium constant represents mathematically for a general reversible reaction:

$$\mathrm{A + B \rightleftharpoons C + D}$$

$$K_{eq} = \frac{[\mathrm{C}][\mathrm{D}]}{[\mathrm{A}][\mathrm{B}]}$$

Step 2: Understand the difference between the reaction quotient (Q) and the equilibrium constant (K_{eq}). When the concentrations of the reactants are suddenly doubled, the instantaneous reaction quotient changes, throwing the chemical system temporarily out of equilibrium.

Step 3: Analyze how the system responds according to Le Chatelier's principle. The system will naturally react to consume the excess reactants by shifting the reaction forward, producing more products until a new state of equilibrium is established.

Step 4: Examine the mathematical ratio at this new equilibrium. At the new equilibrium position, the concentrations of both the reactants and products will have adjusted such that their ratio yields the exact same numerical constant as before.

Step 5: Identify the single variable capable of shifting the actual value of K_{eq}. According to the Van 't Hoff equation, the equilibrium constant is only modified by varying the system temperature. Changing initial concentrations alters the equilibrium positions but leaves the value of K_{eq} completely unchanged.

Final Answer: $\boxed{\text{remain unchanged.}}$

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

Go Back to Question 8

Q9.

Solution

Concept: The addition of hydrogen halides to unsymmetrical alkenes follows anti-Markovnikov regioselectivity exclusively when the reaction is conducted in the presence of organic peroxides. This phenomenon is known as the peroxide effect or Kharasch effect.

Solution: Step 1: Write out the structures of the chemical reactants. Propene is an unsymmetrical alkene with the formula $CH_3CH = CH_2$. The reagent is hydrogen bromide (HBr), and the reaction conditions include benzoyl peroxide.

Step 2: Understand the free-radical mechanism driven by the peroxide catalyst. Peroxides readily undergo homolytic cleavage to generate alkoxy or phenyl radicals, which abstract a hydrogen atom from HBr to produce a highly reactive bromine radical ($Br^\bullet$).

Step 3: Analyze the addition of the bromine radical to the double bond of propene. The bromine radical can attack either Carbon-1 or Carbon-2 to form a new carbon-radical intermediate:
Attack at C_1: $CH_3C^\bullet H - CH_2Br$ (a secondary 2° free radical).
Attack at C_2: $CH_3CHBr - C^\bullet H_2$ (a primary 1° free radical).

Step 4: Compare the stabilities of the free radicals. Just like carbocations, secondary carbon free radicals are significantly more stable than primary free radicals due to hyperconjugation and inductive stabilization. Therefore, the reaction proceeds exclusively via the 2° radical pathway.

Step 5: Complete the final step of the propagation mechanism. The stable secondary radical abstracts a hydrogen atom from another HBr molecule to yield the final product, which is 1-bromopropane ($CH_3CH_2CH_2Br$). This is the reverse of standard Markovnikov addition.
Final Answer: 1-bromopropane

Answer: (B)

Go Back to Question 9

Q10.

Solution

Concept: The net dipole moment (μ) of a polyatomic molecule is the vector sum of its individual bond dipoles, which is strictly governed by the overall three-dimensional molecular geometry of the molecule.

Solution: Step 1: Evaluate the molecular structure and symmetry of each compound listed across the options to see if individual bond dipoles cancel out or reinforce one another.

Step 2: Analyze Water (H_2O) and Ammonia (NH_3) as depicted in the descriptive diagrams.
For H_2O: The central oxygen atom has two bonding pairs and two lone pairs, creating a bent V-shaped geometry. The individual polar $O-H$ bond dipoles and the lone pair dipoles point in the same general direction, reinforcing each other to produce a large net dipole moment ($\mu \neq 0$).
For NH_3: The nitrogen atom has three bonding pairs and one lone pair, yielding a trigonal pyramidal geometry. The highly electronegative nitrogen pulls electron density up from the three hydrogens, and this combined vector aligns with the lone pair dipole, leading to a net dipole moment greater than zero ($\mu \neq 0$).

Step 3: Analyze the highly symmetric molecules found in the other options.
CO_2: Linear geometry ($O = C = O$) where two equal and opposite $C = O$ bond vectors cancel each other out perfectly ($\mu = 0$).
BF_3: Symmetrical trigonal planar geometry where three equatorial $B - F$ bonds cancel out completely ($\mu = 0$).
CH_4: Perfectly symmetrical tetrahedral structure where the four $C - H$ dipoles sum to zero ($\mu = 0$).

Step 4: Conclude that among the combinations offered, only the pair consisting of water and ammonia contains two non-zero dipoles.
Final Answer: $\boxed{H_2O \text{ and } NH_3}$

Answer: (C)

Go Back to Question 10

Q11.

Solution

Concept: The spontaneity of a chemical reaction is governed by the Gibbs free energy change (ΔG), which is defined by the Gibbs-Helmholtz equation: $\Delta G = \Delta H - T\Delta S$. A reaction is spontaneous if and only if $\Delta G < 0$.

Solution: Step 1: List the given thermodynamic variables. The enthalpy change (ΔH) is -92.4 kJ mol^{-1} = -92400 J mol^{-1}. The entropy change (ΔS) is -198.3 J K^{-1} mol^{-1}. Note that both terms are negative.

Step 2: Analyze the signs within the Gibbs equation. Because ΔH is negative, it favors spontaneity. However, because ΔS is negative, the term $-T\Delta S$ becomes a positive quantity, which opposes spontaneity.

Step 3: Determine the condition required to keep ΔG net negative. For ΔG to be less than zero, the magnitude of the favorable enthalpy term must overcome the unfavorable entropy term.

$$|\Delta H| > |T\Delta S| \implies T < \frac{\Delta H}{\Delta S}$$

Step 4: Calculate the threshold temperature (T) at which the system switches between spontaneous and non-spontaneous states by setting $\Delta G = 0$.

$$T = \frac{-92400 \text{ J mol}^{-1}}{-198.3 \text{ J K}^{-1} \text{ mol}^{-1}} \approx 465.96 \text{ K}$$

Step 5: Conclude the final temperature range. Since the temperature must remain below this pivotal equilibrium value to prevent the positive $-T\Delta S$ term from dominating, the reaction will be spontaneous at all temperatures below approximately 466 K.

Final Answer: $\boxed{\text{temperatures below 466 K.}}$

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

Go Back to Question 11

Q12.

Solution

Concept: Ionisation isomerism occurs when coordination compounds with the same empirical formula yield different ions in an aqueous solution because of an exchange of ligands inside the coordination sphere with counter-ions outside.

Solution: Step 1: Examine the structural formulas of the two coordination complexes presented in the problem: $[Co(NH_3)_5(SO_4)]Br$ and $[Co(NH_3)_5(Br)]SO_4$. They have identical chemical compositions but differ in ligand placement.

Step 2: Predict the dissociation behavior of the first complex when dissolved in water. The counter-ion outside the brackets breaks free as a simple hydrated ion.

$$[Co(NH_3)_5(SO_4)]Br \xrightarrow{H_2O} [Co(NH_3)_5(SO_4)]^+ + Br^-$$

This solution will give a positive analytical precipitate test with silver nitrate ($AgNO_3$) due to free bromide ions.

Step 3: Predict the dissociation behavior of the second complex under identical aqueous conditions.

$$[Co(NH_3)_5(Br)]SO_4 \xrightarrow{H_2O} [Co(NH_3)_5(Br)]^{2+} + SO_4^{2-}$$

This solution will give a positive analytical precipitate test with barium chloride ($BaCl_2$) due to free sulfate ions.

Step 4: Classify the isomerism based on these properties. Because the structural difference lies solely in which chemical group acts as the counter-ion versus which acts as an inner-sphere ligand, producing distinct ions upon dissolution, it fits the definition of ionisation isomerism.

Final Answer: $\boxed{\text{Ionisation isomerism}}$

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

Go Back to Question 12

Q13.

Solution

Concept: Potassium dichromate acts as a powerful oxidizing agent in acidic media, undergoing a clear color change as the central chromium atom gets reduced from a higher oxidation state to a lower one.

Solution: Step 1: Determine the starting oxidation state of Chromium in potassium dichromate ($K_2Cr_2O_7$). Potassium has a +1 charge and Oxygen has a −2 charge.

$$2(+1) + 2(x) + 7(-2) = 0 \implies 2 + 2x - 14 = 0 \implies 2x = 12 \implies x = +6$$

Chromium begins in the +6 oxidation state, which displays a bright orange color.

Step 2: Write out the balanced redox chemical equation for the reaction taking place when sulfur dioxide gas (SO_2) is bubbled through the solution. Sulfur dioxide acts as a reducing agent and gets oxidized to sulfate ions.

$$Cr_2O_7^{2-} + 3SO_2 + 2H^+ \rightarrow 2Cr^{3+} + 3SO_4^{2-} + H_2O$$

Step 3: Monitor the change in the oxidation states. The chromium center gains electrons, dropping its oxidation state from +6 down to +3.

Step 4: Relate the oxidation state change to the visual color changes described in the problem and diagram. As illustrated in the scheme, the reduction transition from the higher energy state to the stable lower state converts the orange dichromate ion into hydrated green trivalent chromium (Cr^{3+}) ions.

Final Answer: $\boxed{Cr^{3+}\text{ ions}}$

Answer: (A)

Go Back to Question 13

Q14.

Solution

Concept: Molar conductivity (Λ_m) is defined as the conducting power of all the ions produced by dissolving one mole of an electrolyte in solution, and its behavior varies fundamentally between strong and weak electrolytes upon dilution.

Solution: Step 1: Define dilution in terms of concentration. Dilution means adding more solvent, which systematically decreases the concentration (c) of the solute toward zero.

Step 2: Contrast the ionization of strong versus weak electrolytes. Strong electrolytes are fully ionized at all concentrations. Their molar conductivity increases linearly with the square root of concentration ($\sqrt{c}$) as concentration decreases, which matches the straight blue line on the graph.

Step 3: Analyze the behavior of weak electrolytes. Weak electrolytes have a low degree of dissociation (α) at normal concentrations. According to Ostwald's dilution law, the degree of dissociation is inversely proportional to the square root of concentration:

$$\alpha = \sqrt{\frac{K_a}{c}}$$

Step 4: Trace the graph for a weak electrolyte. As dilution increases ($c \to 0$ or $\sqrt{c} \to 0$), the value of α escalates rapidly. This causes a massive surge in the total number of active conducting ions in solution.

Step 5: Conclude the final trend from the steep red curve on the plot. Near infinite dilution, the curve shoots up almost vertically. This proves that the molar conductivity of a weak electrolyte increases sharply with dilution.

Final Answer: $\boxed{\text{increases sharply with dilution.}}$

Answer: (B)

Go Back to Question 14

Q15.

Solution

Concept: The acid strength of carboxylic acids depends on the stability of the conjugate base carboxylate anion formed after deprotonation, which is enhanced by electron-withdrawing groups via the negative inductive effect ($-I$).

Solution: Step 1: Write down the chemical formulas for the four compounds being compared: acetic acid (CH_3COOH), monochloroacetic acid ($ClCH_2COOH$), dichloroacetic acid ($Cl_2CHCOOH$), and trichloroacetic acid (Cl_3CCOOH).

Step 2: Identify the electronic effect of the substituents attached to the carboxylic carbon. Chlorine (Cl) is highly electronegative and exerts a powerful electron-withdrawing negative inductive effect ($-I$).

Step 3: Analyze how the $-I$ effect alters the stability of the carboxylate anion ($RCOO^-$). Electron-withdrawing groups pull negative charge away from the carboxylate group, delocalizing and dispersing the negative charge, which stabilizes the anion.

Step 4: Relate the number of chlorine atoms to the magnitude of the $-I$ effect. Increasing the number of chlorine atoms increases electron withdrawal, which stabilizes the conjugate base and makes the parent acid stronger.

$$Cl_3C-\ \text{(three } -I \text{ groups)} > Cl_2CH- > ClCH_2- > CH_3-\ \text{(electron donating } +I \text{ group)}$$

Step 5: Arrange the compounds in decreasing order of acid strength based on this electronic stabilization trend. The correct order is: $Cl_3CCOOH > Cl_2CHCOOH > ClCH_2COOH > CH_3COOH$.

Final Answer: $\boxed{Cl_3CCOOH > Cl_2CHCOOH > ClCH_2COOH > CH_3COOH}$

Answer: (B)

Go Back to Question 15

Q16.

Solution

Concept: Valence Shell Electron Pair Repulsion (VSEPR) theory allows us to determine the geometric arrangement of a molecule by calculating the steric number of the central atom.

Solution: Step 1: Identify the central atom in chlorine trifluoride (ClF_3), which is Chlorine (Cl). Chlorine belongs to Group 17 and possesses 7 valence electrons in its outer shell.

Step 2: Count the total number of electrons around the central atom contributed by bonding. Chlorine forms 3 single covalent bonds with 3 monovalent fluorine atoms, sharing 3 electrons.

Step 3: Calculate the remaining unbonded valence electrons to determine the number of lone pairs.

$$\text{Unbonded electrons} = 7 - 3 = 4 \text{ electrons} = 2 \text{ lone pairs}$$

Step 4: Calculate the steric number by adding the number of bonded atoms (sigma bonds) to the number of lone pairs.

$$\text{Steric Number} = 3 \text{ sigma bonds} + 2 \text{ lone pairs} = 5$$

Step 5: Assign the hybridisation state and baseline electronic geometry corresponding to a steric number of 5. A steric number of 5 requires sp^3d hybridisation, which yields a trigonal bipyramidal electronic geometry.

Step 6: Determine the actual molecular shape by placing the lone pairs to minimize electron repulsion. Following VSEPR rules, lone pairs occupy the less crowded equatorial positions. As shown in the diagram, with 2 equatorial lone pairs and 3 bonding positions, the physical shape of the atoms forms a distinct T-shape configuration.

Final Answer: $\boxed{\text{T-shaped, } sp^3d}$

Answer: (B)

Go Back to Question 16

Q17.

Solution

Concept: During an irreversible gas expansion against a constant external pressure (P_{ext}), the mechanical work (w) performed by the system is calculated by integrating pressure over the change in volume.

Solution: Step 1: Identify the given values from the problem description. The constant external opposition pressure P_{ext} is 2.0 atm. The initial volume V_i is 1.0 L, and the final volume V_f is 4.0 L.

Step 2: State the standard thermodynamic formula used to compute expansion work.

$$w = -P_{ext}\Delta V = -P_{ext}(V_f - V_i)$$

The negative sign follows the sign convention where work done by the system on its surroundings is negative.

Step 3: Substitute the volumes into the equation to calculate the change in volume (ΔV).

$$\Delta V = 4.0\ \text{L} - 1.0\ \text{L} = 3.0\ \text{L}$$

Step 4: Compute the work done in units of liter-atmospheres ($\text{L} \cdot \text{atm}$). This corresponds to the shaded rectangular area on the provided P-V graph.

$$w = -2.0\ \text{atm} \times 3.0\ \text{L} = -6.0\ \text{L} \cdot \text{atm}$$

Step 5: Convert the work value from $\text{L} \cdot \text{atm}$ to Joules (J) using the provided conversion factor ($1\ \text{L} \cdot \text{atm} = 101.3\ \text{J}$).

$$w = -6.0\ \text{L} \cdot \text{atm} \times 101.3\ \text{J}\ (\text{L} \cdot \text{atm})^{-1} = -607.8\ \text{J}$$

The negative sign confirms that the gas loses energy while expanding against the surroundings.
Final Answer: $\boxed{-607.8\ \text{J}}$

Answer: (A)

Go Back to Question 17

Q18.

Solution

Concept: Silicates are a vast class of minerals whose structural chemistry is built entirely upon a single repeating fundamental anionic silicon-oxygen building block.

Solution: Step 1: Examine the electronic properties of Silicon (Si) and Oxygen (O). Silicon belongs to Group 14 and has 4 valence electrons, which allows it to form 4 covalent bonds.

Step 2: Analyze the coordinated geometry around the central silicon atom. Silicon undergoes sp^3 hybridisation, causing it to bond with four separate oxygen atoms located at the corners of a regular three-dimensional tetrahedron.

Step 3: Determine the net formal chemical charge of this basic unit. The central silicon atom has an oxidation state of +4. Each of the four surrounding oxygen atoms accepts an electron to complete its octet, carrying a charge of −2 when unshared.

$$\text{Net Charge} = (+4) + 4(-2) = 4 - 8 = -4$$

Step 4: Write out the resulting chemical formula for this basic building block, which is SiO_4^{4-}.

Step 5: Match this with the provided diagram. The diagram illustrates a central silicon atom bonded to four oxygen corners, forming a regular tetrahedron. This structural unit can exist as isolated ions or link together via shared oxygen corners to build chains, sheets, or complex 3D silicate frameworks.

Final Answer: $\boxed{\text{SiO}_4^{4-}\text{ tetrahedron}}$

Answer: (B)

Go Back to Question 18

Q19.

Solution

Concept: The synthesis of ortho-hydroxybenzaldehyde (salicylaldehyde) from phenol using chloroform and an aqueous base is a classic, named organic formulation reaction driven by a highly reactive carbene intermediate.

Solution: Step 1: Analyze the reaction conditions described in the prompt. Phenol (C_6H_5OH) is reacted with chloroform ($CHCl_3$) in an aqueous sodium hydroxide (NaOH) solution at approximately 340 K, followed by final acidic workup.

Step 2: Understand the initial step where the active electrophile is generated. The strong base NaOH deprotonates chloroform to form a trichloromethanide anion, which quickly loses a chloride ion to generate dichlorocarbene ($: CCl_2$), a neutral but highly electron-deficient electrophile.

Step 3: Analyze the attack on the aromatic ring. The base converts phenol into a highly reactive phenoxide ion. The phenoxide ion directs the electrophilic dichlorocarbene to attack the ortho position, forming an intermediate benzal chloride derivative.

Step 4: Follow the subsequent hydrolysis steps. The alkaline medium hydrolyzes the adjacent chlorine atoms to form an unstable intermediate diol, which spontaneously loses a water molecule to create an aldehyde group ($-CHO$).

Step 5: Identify the name of this organic reaction. This specific sequence that introduces a formyl group ortho to a phenolic hydroxyl group is known as the Reimer-Tiemann reaction.

Final Answer: $\boxed{\text{Reimer-Tiemann reaction}}$

Answer: (B)

Go Back to Question 19

Q20.

Solution

Concept: Functional group identification involves analyzing diagnostic chemical tests like the iodoform reaction and Tollens' reduction test to deduce the precise structure of an organic compound.

Solution: Step 1: Analyze the given molecular formula, which is C_3H_6O. Calculate its Double Bond Equivalent (DBE) or index of hydrogen deficiency to determine structural saturation.

$$\text{DBE} = C + 1 - \frac{H}{2} = 3 + 1 - \frac{6}{2} = 4 - 3 = 1$$

A DBE of 1 indicates the compound contains either one ring or one double bond (such as $C = O$ or $C = C$).

Step 2: Interpret the result of the Tollens' reagent test. The prompt states that compound 'X' does not reduce Tollens' reagent. This negative result proves that 'X' is not an aldehyde, ruling out propanal (CH_3CH_2CHO).

Step 3: Interpret the positive iodoform test. The compound forms a yellow precipitate when treated with iodine (I_2) and sodium hydroxide (NaOH). This positive test requires the presence of either a methyl ketone group (CH_3CO-) or a secondary alcohol group with a adjacent methyl branch ($CH_3CH(OH)-$).

Step 4: Combine the clues to identify the functional group. Since the compound must contain a carbonyl group but cannot be an aldehyde, it must be a ketone. The only possible ketone structure that fits the three-carbon formula C_3H_6O is propanone (acetone), which contains the required methyl ketone structural unit.

Step 5: Write out the final structural formula for propanone, which is CH_3COCH_3. This structure is perfectly consistent with all the experimental data.

Final Answer: $\boxed{CH_3COCH_3}$

Answer: (B)

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Answer Key

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