AME CET Chemistry Sample Paper-4

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 contains 40% carbon, 6.7% hydrogen, and the rest is oxygen. If its vapour density is 30, what is the molecular formula of the compound?

(A) CH_2O

(B) $C_2H_4O_2$

(C) $C_3H_6O_3$

(D) $C_4H_8O_4$

Q2. Which of the following molecules exhibits a square pyramidal geometry according to VSEPR theory?

(A) BrF_5

(B) PCl_5

(C) SF_6

(D) XeF_4

Q3. The major product obtained when 2-bromobutane is treated with alcoholic KOH is:

(A) 1-butene

(B) trans-2-butene

(C) cis-2-butene

(D) 2-butanol

Q4. In a coordination compound $[Co(NH_3)_5Cl]Cl_2$, the secondary valence and primary valence of the central metal ion are respectively:

(A) 5 and 3

(B) 6 and 2

(C) 6 and 3

(D) 5 and 2

Q5. For the reaction $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$, what is the relationship between K_p and K_c?

(A) $K_p = K_c(RT)$

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

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

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

Q6. Which of the following elements has the highest tendency to show the maximum number of oxidation states?

(A) Cr

(B) Mn

(C) Fe

(D) V

Q7. The standard reduction potentials of three metals A, B, and C are $+0.5$ V, -3.0 V, and -1.2 V respectively. The reducing power of these metals follows the order:

(A) B > C > A

(B) A > C > B

(C) C > B > A

(D) A > B > C

Q8. Which of the following is an example of an electrophilic substitution reaction?

(A) Nitration of benzene

(B) Alkaline hydrolysis of ethyl bromide

(C) Addition of HBr to propene

(D) Dehydration of ethanol to ethene

Q9. The hybridization of atomic orbitals of nitrogen in NO_2^+, NO_3^-, and NH_4^+ are respectively:

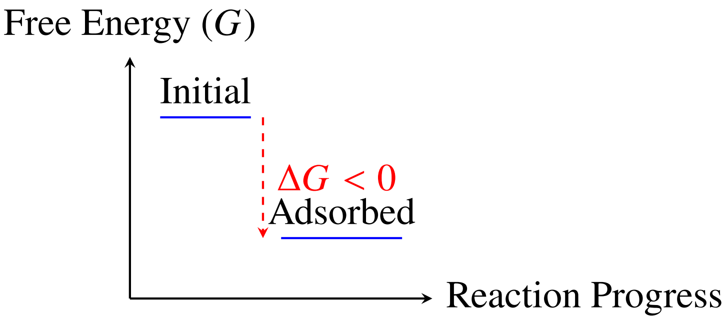
(A) sp, sp^2, sp^3

(B) sp^2, sp, sp^3

(C) sp^3, sp^2, sp

(D) sp^2, sp^3, sp

Q10. Adsorption of a gas on a solid surface is generally exothermic because of the thermodynamic balance represented below:



Which statement correctly explains this process?

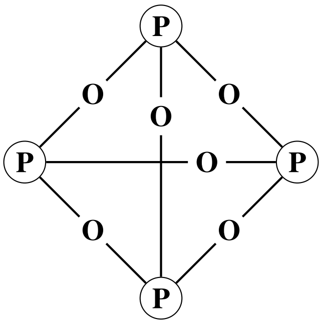
(A) Entropy increases during the process

(B) Enthalpy decrease overcomes the entropy decrease ($\Delta G < 0$)

(C) Surface energy increases

(D) Chemical bonds are always broken during adsorption

Q11. The core structure of P_4O_{10} contains a specific framework of alternating phosphorus and oxygen atoms. Consider the schematic connectivity diagram below:



How many bridging P – O – P bonds are present in total within the structure?

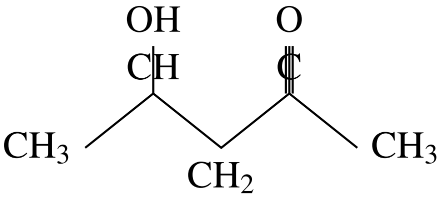
(A) 4

(B) 5

(C) 6

(D) 8

Q12. What is the correct IUPAC name of the compound shown below?



(A) 2-Hydroxypentan-4-one

(B) 4-Hydroxypentan-2-one

(C) 1-Methyl-3-hydroxybutan-1-one

(D) Pentan-2-one-4-ol

Q13. In which of the following arrangements, the sequence is not strictly according to the property written against it?

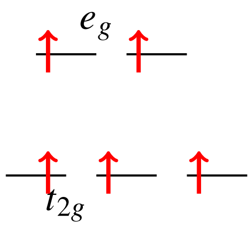
(A) HF < HCl < HBr < HI (Increasing acid strength)

(B) $NH_3 < PH_3 < AsH_3 < SbH_3$ (Increasing basic strength)

(C) B < C < O < N (Increasing first ionization enthalpy)

(D) I < Br < F < Cl (Increasing electron gain enthalpy with negative sign)

Q14. The magnetic moment of a coordination complex is found to be 4.90 BM. The configuration of the d-electrons can be represented across the energy levels shown below:



The central metal ion in this spin-free complex could be:

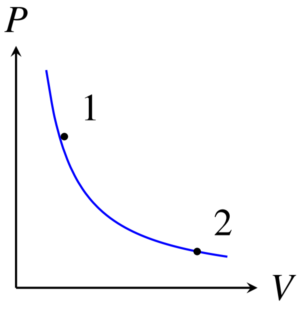
(A) Cr^{3+}

(B) Fe^{2+}

(C) Mn^{2+}

(D) Cu^{2+}

Q15. For an ideal gas expanding isothermally and reversibly into a vacuum, the thermodynamic state transitions can be tracked on a $P-V$ grid:



What are the values of w and ΔU for this process?

(A) $w = 0, \Delta U \neq 0$

(B) $w \neq 0, \Delta U = 0$

(C) $w = 0, \Delta U = 0$

(D) $w \neq 0, \Delta U \neq 0$

Q16. Which of the following compounds will give a positive Iodoform test?

(A) Pentan-3-one

(B) Benzyl alcohol

(C) Pentan-2-one

(D) Methanol

Q17. The molar conductivity of a 0.05 M solution of an electrolyte is 120 $\Omega^{-1}\,\text{cm}^2\,\text{mol}^{-1}$. What is its specific conductivity (κ)?

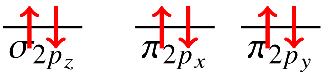
(A) 0.006 S cm^{-1}

(B) 0.06 S cm^{-1}

(C) 0.6 S cm^{-1}

(D) 6.0 S cm^{-1}

Q18. 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^+

Q19. Which of the following forms a stable carbocation intermediate most easily upon protonation?

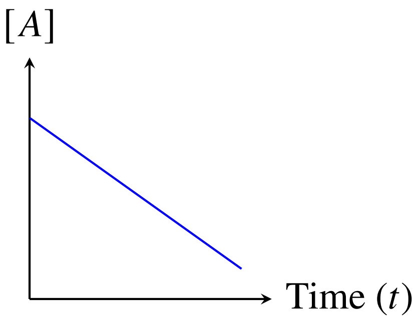
(A) Propene

(B) 2-Methylpropene

(C) Ethene

(D) But-1-ene

Q20. For a zero-order reaction, a profile tracking the concentration of the reactant over time is shown below:



The slope of the plot of concentration of reactant vs time is equal to:

(A) $-k$

(B) $+k$

(C) $-k/2.303$

(D) $k/2.303$

Detailed Solutions

Q1.

Solution

Concept: The molecular formula of a compound can be determined by finding its empirical formula from the mass percentages of its constituent elements, calculating the empirical formula mass, and then using the vapour density to find the molecular mass via the relationship: Molecular Mass = 2 × Vapour Density.

Solution: Step 1: Determine the percentage of oxygen in the organic compound. Given that the compound contains 40% carbon and 6.7% hydrogen, the remaining percentage belongs to oxygen. Thus, Percentage of Oxygen = 100% − (40% + 6.7%) = 53.3%.

Step 2: Calculate the relative number of moles of each element by dividing their respective percentages by their atomic masses (C = 12, H = 1, O = 16).
Moles of C = 40/12 = 3.33
Moles of H = 6.7/1 = 6.70
Moles of O = 53.3/16 = 3.33

Step 3: Determine the simplest molar ratio by dividing each value by the smallest number of moles obtained, which is 3.33.
Ratio of C = 3.33/3.33 = 1
Ratio of H = 6.70/3.33 = 2
Ratio of O = 3.33/3.33 = 1
Therefore, the empirical formula of the organic compound is CH_2O.

Step 4: Calculate the empirical formula mass.
Empirical Formula Mass = 12 + (2 × 1) + 16 = 30 g/mol.

Step 5: Determine the molecular mass of the compound from its given vapour density.
Molecular Mass = 2 × Vapour Density = 2 × 30 = 60 g/mol.

Step 6: Find the multiplying factor n by dividing the molecular mass by the empirical formula mass.
$n = \frac{\text{Molecular Mass}}{\text{Empirical Formula Mass}} = \frac{60}{30} = 2$.
Multiplying the empirical formula by 2 gives the molecular formula: $(CH_2O) \times 2 = C_2H_4O_2$.

Final Answer: $\boxed{C_2H_4O_2}$

Answer: (B)

Go Back to Question 1

Q2.

Solution

Concept: According to the Valence Shell Electron Pair Repulsion (VSEPR) theory, the geometry of a molecule depends entirely on the total number of valence shell electron pairs (both bonding pairs and lone pairs) surrounding the central atom. The steric number is calculated to determine the hybridization and spatial layout.

Solution: Step 1: Analyze the central atom in BrF_5. Bromine belongs to group 17 and possesses 7 valence electrons. It forms 5 single covalent bonds with five fluorine atoms, utilizing 5 of its valence electrons.

Step 2: Determine the remaining non-bonding electrons on bromine. Out of 7 valence electrons, 5 are shared in bonds, leaving 2 unshared electrons, which constitute exactly 1 lone pair.

Step 3: Calculate the total steric number for the bromine central atom.
Steric Number = Number of bond pairs + Number of lone pairs = 5 + 1 = 6.

Step 4: Establish the hybridization and ideal geometry. A steric number of 6 corresponds to sp^3d^2 hybridization, which possesses an octahedral geometry.

Step 5: Deduce the actual molecular shape. Due to the presence of 1 lone pair occupying one of the positions to minimize electron repulsion, the octahedral geometry becomes distorted into a square pyramidal molecular shape.

Step 6: Examine the other options for comparison. PCl_5 has 5 bond pairs and 0 lone pairs (trigonal bipyramidal). SF_6 has 6 bond pairs and 0 lone pairs (octahedral). XeF_4 has 4 bond pairs and 2 lone pairs (square planar). Thus, only BrF_5 is square pyramidal.

Final Answer: $\boxed{BrF_5}$

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

Go Back to Question 2

Q3.

Solution

Concept: The reaction of an alkyl halide with alcoholic KOH undergoes a dehydrohalogenation process via an E2 elimination mechanism. The regioselectivity of this elimination reaction is governed by Saytzeff's rule, which states that the highly substituted, more stable alkene will be formed as the major product.

Solution: Step 1: Identify the structure of the substrate. The given compound is 2-bromobutane, which can be represented structurally as $CH_3 - CH(Br) - CH_2 - CH_3$.

Step 2: Identify the adjacent beta-carbons from which hydrogen abstraction can occur. The carbon bearing the bromine atom (α-carbon) is adjacent to two distinct positions: a primary β_1-carbon (CH_3) on the left and a secondary β_2-carbon (CH_2) on the right.

Step 3: Analyze the removal of a proton from the β_1-carbon. If the base abstracts a proton from the primary β_1-carbon, the resulting double bond forms at the terminal position, yielding 1-butene. This product has fewer alkyl substituents around the double bond.

Step 4: Analyze the removal of a proton from the β_2-carbon. If the base abstracts a proton from the secondary β_2-carbon, the double bond forms internally, yielding 2-butene. This alkene contains more alkyl substituents and is more stable due to hyperconjugation.

Step 5: Apply Saytzeff's rule to determine the major product. The internal alkene, 2-butene, is favored. Between its two geometric isomers, trans-2-butene is less sterically hindered and lower in energy than cis-2-butene, making trans-2-butene the absolute major product of the reaction.

Final Answer: $\boxed{\text{trans-2-butene}}$

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

Go Back to Question 3

Q4.

Solution

Concept: According to Werner's coordination theory, central metal atoms in coordination complexes exhibit two distinct types of valencies: primary valency and secondary valency. The primary valency corresponds directly to the oxidation state of the metal ion, while the secondary valency corresponds to its coordination number.

Solution: Step 1: Determine the secondary valency of Cobalt in the complex $[Co(NH_3)_5Cl]Cl_2$. The secondary valency is defined as the total number of donor atoms directly bonded to the central metal ion inside the coordination sphere.

Step 2: Count the ligands coordinated to Cobalt. There are 5 neutral ammine (NH_3) ligands and 1 anionic chlorido (Cl^-) ligand inside the square brackets. Both are monodentate ligands. Thus, Secondary Valency $= 5 + 1 = 6$.

Step 3: Determine the primary valency of Cobalt. The primary valency corresponds to the overall oxidation number of Cobalt required to balance the charge of the complex.

Step 4: Set up the algebraic equation for the oxidation state. Let the oxidation state of Cobalt be x. The ammine ligands are neutral (0), the inner chlorine has a charge of -1, and the two counter-ions outside the brackets have a combined charge of $2 \times (-1) = -2$.
$x + 5(0) + 1(-1) + 2(-1) = 0$
$x - 1 - 2 = 0$
$x = +3$
Hence, the primary valency is 3. Combining both values, the secondary and primary valencies are 6 and 3 respectively.

Final Answer: $\boxed{\text{6 and 3}}$

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

Go Back to Question 4

Q5.

Solution

Concept: The equilibrium constant expressed in terms of partial pressures (K_p) is related to the equilibrium constant expressed in terms of molar concentrations (K_c) by the ideal gas derivation: $K_p = K_c(RT)^{\Delta n_g}$, where Δn_g represents the change in the number of moles of gaseous products and reactants.

Solution: Step 1: Write down the balanced chemical equation for the synthesis of ammonia.
$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

Step 2: Identify and calculate the total number of moles of gaseous products. Looking at the right side of the reaction equation, there are 2 moles of $NH_3(g)$. Thus, Moles of products = 2.

Step 3: Identify and calculate the total number of moles of gaseous reactants. Looking at the left side of the reaction equation, there is 1 mole of $N_2(g)$ and 3 moles of $H_2(g)$. Thus, Moles of reactants = 1 + 3 = 4.

Step 4: Compute the value of Δn_g, which is the difference between the gaseous product moles and gaseous reactant moles.
$\Delta n_g = 2 - 4 = -2$.

Step 5: Substitute the value of Δn_g into the standard mathematical formula relating the two constants.
$K_p = K_c(RT)^{\Delta n_g}$
$K_p = K_c(RT)^{-2}$
This matches option B.

Final Answer: $\boxed{K_p = K_c(RT)^{-2}}$

Answer: (B)

Go Back to Question 5

Q6.

Solution

Concept: In the first transition series ($3d$ series) of d-block elements, the capability to display a wide variety of oxidation states peaks near the middle of the series. This variation occurs because elements near the middle possess the maximum number of unpaired electrons in both the $3d$ and $4s$ subshells available for bonding.

Solution: Step 1: Examine the valence shell electronic configuration of the given transition metals.
Vanadium (V, $Z = 23$): $[Ar]\, 3d^3\, 4s^2$
Chromium (Cr, $Z = 24$): $[Ar]\, 3d^5\, 4s^1$
Manganese (Mn, $Z = 25$): $[Ar]\, 3d^5\, 4s^2$
Iron (Fe, $Z = 26$): $[Ar]\, 3d^6\, 4s^2$

Step 2: Count the maximum possible number of electrons that can participate in chemical bonding for each element. Manganese has 5 unpaired electrons in its $3d$ orbital and 2 electrons in its $4s$ orbital, giving a total of 7 available valence electrons.

Step 3: Determine the range of oxidation states shown by Manganese. Because it can step-wise lose or share all 7 electrons, it exhibits the maximum number of stable oxidation states ranging continuously from +2 to +7 (e.g., in $KMnO_4$).

Step 4: Compare with the other elements. Vanadium goes up to +5, Chromium goes up to +6, and Iron primarily exhibits +2 and +3 oxidation states with less stability in higher states. Hence, Manganese exhibits the highest variety.

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

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

Go Back to Question 6

Q7.

Solution

Concept: The reducing power of a metal denotes its ability to act as a reducing agent by losing electrons (undergoing oxidation). In terms of electrochemistry, a lower (more negative) standard reduction potential value implies that the species releases electrons more readily, making it a stronger reducing agent.

Solution: Step 1: List the given standard reduction potential (E°) values for the three metals.
Metal A: $E^\circ = +0.5\,\text{V}$
Metal B: $E^\circ = -3.0\,\text{V}$
Metal C: $E^\circ = -1.2\,\text{V}$

Step 2: Understand the fundamental electrochemical rule. The lower or more negative the standard reduction potential, the greater the tendency of the element to get oxidized, and consequently, the higher its reducing capability.

Step 3: Arrange the reduction potentials in ascending mathematical order.
$-3.0\,\text{V} < -1.2\,\text{V} < +0.5\,\text{V}$

Step 4: Correlate the values back to the corresponding metals. Metal B has the lowest potential ($-3.0\,\text{V}$), followed by Metal C ($-1.2\,\text{V}$), and Metal A has the highest value ($+0.5\,\text{V}$).

Step 5: Invert the order to represent the descending strength of reducing power. Metal B is the strongest reducing agent because it has the most negative value, followed by C, and then A. Thus, the correct sequence is B > C > A.

Final Answer: $\boxed{\text{B > C > A}}$

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

Go Back to Question 7

Q8.

Solution

Concept: An electrophilic substitution reaction is a chemical process where an electrophile (an electron-deficient species) replaces a functional group or a hydrogen atom integrated into an aromatic ring system, which possesses high electron density due to delocalized pi-electrons.

Solution: Step 1: Analyze option A: Nitration of benzene. Benzene contains a stable, cloud of six delocalized pi-electrons. During nitration, a strong nitronium ion electrophile (NO_2^+) is generated. This ion attacks the benzene ring, substituting a hydrogen atom. This is a classic example of aromatic electrophilic substitution.

Step 2: Analyze option B: Alkaline hydrolysis of ethyl bromide. Here, the hydroxide ion (OH^-) acts as an electron-rich nucleophile that attacks the saturated carbon atom to displace the bromide ion. This represents a nucleophilic substitution reaction (S_N2).

Step 3: Analyze option C: Addition of HBr to propene. This involves the attack of an electrophile (H^+) across a carbon-carbon double bond, followed by a nucleophilic attack, classified as an electrophilic addition reaction.

Step 4: Analyze option D: Dehydration of ethanol to ethene. This reaction is an elimination reaction (E1) driven by an acid catalyst. Thus, only option A falls under electrophilic substitution.

Final Answer: $\boxed{\text{Nitration of benzene}}$

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

Go Back to Question 8

Q9.

Solution

Concept: The hybridization state of a central atom in polyatomic ions can be predicted by determining its steric number, which is equal to the sum of the number of sigma bonds formed and the number of lone pairs residing on that central atom.

Solution: Step 1: Determine the hybridization of Nitrogen in NO_2^+. Nitrogen originally has 5 valence electrons. The +1 charge indicates the loss of 1 electron, leaving 4 valence electrons. It forms two double bonds with two oxygen atoms (2 sigma bonds and 2 pi bonds) and has zero lone pairs.
Steric Number $= 2\,\sigma\,\text{bonds} + 0\,\text{lone pairs} = 2$. Therefore, the hybridization is sp.

Step 2: Determine the hybridization of Nitrogen in NO_3^-. The nitrogen atom has 5 valence electrons, and the -1 charge adds 1 electron, giving 6 bonding electrons. It forms bonds with three oxygen atoms (3 sigma bonds and 1 pi bond) with no remaining lone pairs.
Steric Number $= 3\,\sigma\,\text{bonds} + 0\,\text{lone pairs} = 3$. Therefore, the hybridization is sp^2.

Step 3: Determine the hybridization of Nitrogen in NH_4^+. Nitrogen has 5 valence electrons minus 1 electron due to the positive charge, leaving 4 electrons. It forms single sigma bonds with four hydrogen atoms.
Steric Number $= 4\,\sigma\,\text{bonds} + 0\,\text{lone pairs} = 4$. Therefore, the hybridization is sp^3.
The sequential order is sp, sp^2, and sp^3.

Final Answer: $\boxed{sp,\ sp^2,\ sp^3}$

Answer: (A)

Go Back to Question 9

Q10.

Solution

Concept: Adsorption is a surface phenomenon where gas molecules adhere to a solid surface. The thermodynamic spontaneity of any process is dictated by the Gibbs free energy equation: $\Delta G = \Delta H - T\Delta S$. For a process to occur spontaneously, ΔG must be negative.

Solution: Step 1: Analyze the change in entropy (ΔS) during the adsorption of a gas. When gas molecules are collected on a solid surface, their freedom of movement is restricted. This restriction causes a decrease in randomness, meaning that ΔS is negative ($\Delta S < 0$).

Step 2: Examine the Gibbs free energy condition for spontaneity. For adsorption to happen spontaneously, the change in Gibbs free energy must be negative ($\Delta G < 0$).

Step 3: Relate these factors using the thermodynamic equation: $\Delta G = \Delta H - T\Delta S$. Since ΔS is negative, the term $-T\Delta S$ becomes a positive value.

Step 4: Conclude the sign of the enthalpy change (ΔH). For ΔG to maintain a negative value, the enthalpy change (ΔH) must be negative and large enough to overcome the positive $-T\Delta S$ term. A negative ΔH indicates that the process is exothermic. Therefore, the decrease in enthalpy overcomes the decrease in entropy.

Final Answer: $\boxed{\text{Enthalpy decrease overcomes the entropy decrease } (\Delta G < 0)}$

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

Go Back to Question 10

Q11.

Solution

Concept: Tetraphosphorus decoxide (P_4O_{10}) is a chemical compound formed by the oxidation of phosphorus. Its cage-like structure is derived from the tetrahedral geometry of the P_4 molecule, where oxygen atoms are inserted along the edges and vertices of the cage framework.

Solution: Step 1: Recall the basic structural arrangement of P_4O_{10}. The molecule contains four phosphorus atoms arranged at the corners of a regular tetrahedron.

Step 2: Categorize the two types of oxygen atoms present in the structure. The ten oxygen atoms are divided into bridging oxygens ($P - O - P$) and terminal oxygens ($P = O$).

Step 3: Count the terminal oxygen atoms. Each of the four phosphorus atoms forms one coordinate or double bond with a single terminal oxygen atom at the vertices. This accounts for 4 terminal oxygen atoms.

Step 4: Count the bridging oxygen atoms. The remaining oxygen atoms are inserted directly along the edges of the phosphorus tetrahedron. A tetrahedron has exactly 6 edges. Therefore, there are 6 bridging oxygen atoms, each forming a $P - O - P$ bond linkage. Thus, the total number of bridging $P - O - P$ bonds is 6.

Final Answer: $\boxed{6}$

Answer: (C)

Go Back to Question 11

Q12.

Solution

Concept: According to the IUPAC rules for naming polyfunctional organic compounds, when a molecule contains more than one functional group, a principal functional group is selected based on a priority hierarchy. The longest continuous carbon chain containing the principal functional group is numbered to give it the lowest possible locant.

Solution: Step 1: Identify the functional groups present in the given compound. The compound $CH_3-CH(OH)-CH_2-CO-CH_3$ contains both a hydroxyl group ($-OH$) and a keto carbonyl group ($-CO-$).

Step 2: Determine the priority order between the functional groups. According to IUPAC guidelines, ketones have higher priority than alcohols. Therefore, the keto group serves as the principal functional group, adding the suffix "-one", while the hydroxyl group is treated as a substituent with the prefix "hydroxy-".

Step 3: Find the longest carbon chain. The continuous chain contains 5 carbon atoms, making the parent alkane pentane.

Step 4: Number the carbon chain to give the principal functional group the lowest possible locant. Numbering from right-to-left gives the ketone position 2:
$C_5(H_3)-C_4H(OH)-C_3H_2-C_2O-C_1H_3$.

Step 5: Identify the position of the substituent. The hydroxy group is attached to carbon-4. Combining these terms yields the name 4-hydroxypentan-2-one.

Final Answer: $\boxed{\text{4-Hydroxypentan-2-one}}$

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

Go Back to Question 12

Q13.

Solution

Concept: Periodic properties and chemical trends within groups and periods follow specific rules. Anomalies often occur due to factors such as hydrogen bonding, electron-electron repulsions in compact shells, or changes in shielding effects down a group.

Solution: Step 1: Analyze trend A. For hydrides of group 17 (HF < HCl < HBr < HI), bond dissociation enthalpy decreases down the group as halogen size increases. This makes it easier to release a proton, meaning acid strength increases correctly as listed.

Step 2: Analyze trend B. For hydrides of group 15, basic strength depends on the electron density of the lone pair on the central atom. As the atomic size increases from N to Sb, the lone pair is delocalized over a larger volume, reducing its capability to donate protons. Thus, basic strength actually decreases: $NH_3 > PH_3 > AsH_3 > SbH_3$. The given sequence shows the inverse trend and is incorrect.

Step 3: Analyze trend C. The ionization enthalpy across a period generally increases, but Nitrogen ($1s^2\,2s^2\,2p^3$) has a stable, half-filled p-subshell, making it harder to remove an electron than from Oxygen ($1s^2\,2s^2\,2p^4$). The trend B < C < O < N is correct.

Step 4: Analyze trend D. Chlorine has a higher negative electron gain enthalpy than Fluorine due to less electron-electron repulsion in its larger $3p$ orbital compared to Fluorine's compact $2p$ orbital. The trend is correct. Thus, option B is the incorrect sequence.

Final Answer: $\boxed{NH_3 < PH_3 < AsH_3 < SbH_3 \text{ (Increasing basic strength)}}$

Answer: (B)

Go Back to Question 13

Q14.

Solution

Concept: The spin-only magnetic moment (μ) of a transition metal complex depends on the number of unpaired electrons (n) present in its d-orbitals. It is calculated using the formula: $\mu = \sqrt{n(n+2)}$ BM.

Solution: Step 1: Use the given spin-only magnetic moment value ($\mu = 4.90$ BM) to determine the number of unpaired electrons (n). Based on the formula $\sqrt{n(n+2)} = 4.90$, squaring both sides gives $n(n+2) = 24$. Solving this shows that $n = 4$. Thus, the metal ion must contain exactly 4 unpaired electrons.

Step 2: Examine the electronic configurations of the given ions in their ground states.
Cr^{3+} ($Z = 24$, loss of 3 electrons): $3d^3 \longrightarrow$ 3 unpaired electrons.
Fe^{2+} ($Z = 26$, loss of 2 electrons): $3d^6 \longrightarrow$ 4 unpaired electrons (in a high-spin/spin-free state).
Mn^{2+} ($Z = 25$, loss of 2 electrons): $3d^5 \longrightarrow$ 5 unpaired electrons.
Cu^{2+} ($Z = 29$, loss of 2 electrons): $3d^9 \longrightarrow$ 1 unpaired electron.

Step 3: Correlate the configurations with the calculated value of n. Only the Fe^{2+} ion in its high-spin state matches the requirement of having exactly 4 unpaired electrons. Thus, the complex ion is Fe^{2+}.

Final Answer: $\boxed{Fe^{2+}}$

Answer: (B)

Go Back to Question 14

Q15.

Solution

Concept: The first law of thermodynamics states that $\Delta U = q + w$. For an ideal gas, the internal energy (U) is a function of temperature alone. In an isothermal expansion process, the temperature remains constant, meaning that the change in internal energy (ΔU) is zero.

Solution: Step 1: Evaluate the internal energy change (ΔU) for an isothermal process involving an ideal gas. Since internal energy depends only on temperature, and $\Delta T = 0$ in an isothermal process, the change in internal energy must equal zero ($\Delta U = 0$).

Step 2: Evaluate the work done (w) during expansion into a vacuum. Expansion into a vacuum is known as free expansion.

Step 3: Apply the work formula for expansion against an external pressure.
$w = -P_{\text{ext}} \cdot \Delta V$

Step 4: Substitute the conditions of a vacuum. A vacuum exerts no external pressure, meaning $P_{\text{ext}} = 0$. Substituting this value into the equation yields:
$w = -0 \cdot \Delta V = 0$.
Therefore, for an ideal gas expanding isothermally into a vacuum, both $w = 0$ and $\Delta U = 0$.

Final Answer: $\boxed{w = 0, \Delta U = 0}$

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

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Q16.

Solution

Concept: The iodoform test is a diagnostic organic reaction used to identify the presence of either a methyl ketone group ($CH_3 - CO-$) or a secondary methyl carbinol group ($CH_3 - CH(OH)-$) in a given chemical structure. When treated with iodine and sodium hydroxide, these compounds form a yellow precipitate of iodoform (CHI_3).

Solution: Step 1: Analyze the structural formula of option A: Pentan-3-one. Its structure is $CH_3 - CH_2 - CO - CH_2 - CH_3$. It lacks a terminal methyl group directly adjacent to the carbonyl carbon, meaning it does not give a positive iodoform test.

Step 2: Analyze the structural formula of option B: Benzyl alcohol. Its structure is $C_6H_5 - CH_2 - OH$. It does not possess the required $CH_3 - CH(OH)-$ group, so it yields a negative result.

Step 3: Analyze the structural formula of option C: Pentan-2-one. Its structure is $CH_3 - CO - CH_2 - CH_2 - CH_3$. This molecule contains the distinct $CH_3 - CO-$ methyl ketone group on one side of the carbonyl carbon, satisfying the structural condition to yield a positive iodoform test.

Step 4: Analyze option D: Methanol ($CH_3 - OH$). It contains only one carbon atom and cannot form the necessary intermediates, resulting in a negative test. Thus, Pentan-2-one is the correct choice.

Final Answer: $\boxed{\text{Pentan-2-one}}$

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

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Q17.

Solution

Concept: Molar conductivity (Λ_m) is related to specific conductivity (κ) and the molar concentration (M) of an electrolytic solution by the standard formula: $\Lambda_m = \frac{\kappa \times 1000}{M}$, where Λ_m is in $\Omega^{-1}\,\text{cm}^2\,\text{mol}^{-1}$ and κ is in S cm^{-1}.

Solution: Step 1: Identify the given values from the problem statement.
Molar concentration (M) = 0.05 M = 0.05 mol/L
Molar conductivity (Λ_m) = $120\,\Omega^{-1}\,\text{cm}^2\,\text{mol}^{-1}$

Step 2: Rearrange the standard mathematical formula to solve for specific conductivity (κ).
$\Lambda_m = \frac{\kappa \times 1000}{M} \implies \kappa = \frac{\Lambda_m \times M}{1000}$

Step 3: Substitute the given values into the rearranged equation.
$\kappa = \frac{120 \times 0.05}{1000}$

Step 4: Complete the arithmetic operations step-by-step.
$120 \times 0.05 = 6$
$\kappa = \frac{6}{1000} = 0.006\,\text{S cm}^{-1}$
Thus, the specific conductivity of the solution is $0.006\,\text{S cm}^{-1}$.

Final Answer: $\boxed{0.006\,\text{S cm}^{-1}}$

Answer: (A)

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Q18.

Solution

Concept: According to Molecular Orbital (MO) Theory, the bond order of a diatomic molecule is calculated using the formula: Bond Order $= \frac{N_b - N_a}{2}$, where N_b is the number of bonding electrons and N_a is the number of antibonding electrons. A species is diamagnetic if all its electrons are paired.

Solution: Step 1: Write the molecular orbital electronic configuration for N_2 (total of 14 electrons).
$\sigma^2_{1s}\,\sigma^{*2}_{1s}\,\sigma^2_{2s}\,\sigma^{*2}_{2s}\,\pi^2_{2p_x} = \pi^2_{2p_y}\,\sigma^2_{2p_z}$

Step 2: Count the bonding (N_b) and antibonding (N_a) electrons for N_2.
$N_b = 2 + 2 + 2 + 2 + 2 = 10$
$N_a = 2 + 2 = 4$

Step 3: Calculate the bond order of N_2.
Bond Order $= \frac{10-4}{2} = 3$.

Step 4: Determine the magnetic property of N_2. Since every electron in the molecular orbitals is paired, N_2 is diamagnetic.

Step 5: Compare with other options. O_2 has a bond order of 2 and is paramagnetic. O_2^{2-} has a bond order of 1. N_2^+ has 13 electrons, leaving an unpaired electron, which makes it paramagnetic with a bond order of 2.5. Therefore, N_2 is the correct choice.

Final Answer: $\boxed{N_2}$

Answer: (B)

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Q19.

Solution

Concept: The ease of protonation of an alkene depends directly on the stability of the carbocation intermediate formed during the electrophilic addition step. According to thermodynamic stability trends, carbocation stability increases in the order: primary (1°) < secondary (2°) < tertiary (3°), driven by inductive effects and hyperconjugation.

Solution: Step 1: Analyze the protonation of option A (Propene: $CH_3 - CH = CH_2$). Protonation yields a secondary (2°) carbocation, $CH_3 - CH^+ - CH_3$, which has 6 hyperconjugative hydrogens.

Step 2: Analyze the protonation of option B (2-Methylpropene: $(CH_3)_2C = CH_2$). When a proton attacks the terminal carbon, it forms a tertiary (3°) carbocation: $(CH_3)_3C^+$. This tertiary butyl carbocation is highly stable due to the $+I$ inductive effect of three methyl groups and 9 hyperconjugative hydrogen atoms.

Step 3: Analyze the protonation of option C (Ethene: $CH_2 = CH_2$). Protonation yields a primary (1°) carbocation, $CH_3 - CH_2^+$, which is highly unstable.

Step 4: Analyze the protonation of option D (But-1-ene: $CH_3 - CH_2 - CH = CH_2$). Protonation creates a secondary (2°) carbocation, $CH_3 - CH_2 - CH^+ - CH_3$, which is less stable than a tertiary carbocation. Therefore, 2-methylpropene undergoes protonation most easily because it forms the highly stable tertiary carbocation.

Final Answer: $\boxed{\text{2-Methylpropene}}$

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

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Q20.

Solution

Concept: The integrated rate equation for a zero-order chemical reaction is expressed as: $[A]_t = -kt + [A]_0$, where $[A]_t$ represents the concentration of the reactant at time t, k is the reaction rate constant, and $[A]_0$ is the initial concentration of the reactant.

Solution: Step 1: Write down the linear concentration relationship derived for zero-order kinetics.
$[A]_t = -kt + [A]_0$

Step 2: Compare this mathematical expression with the standard equation of a straight line.
$y = mx + c$

Step 3: Map the variables from the kinetics equation onto the coordinate line framework. Here, the variable plotted on the vertical y-axis is the concentration $[A]_t$, and the variable on the horizontal x-axis is the elapsed time t.

Step 4: Identify the corresponding values for the intercept and the slope. The y-intercept (c) corresponds directly to the initial concentration value, $[A]_0$. The slope of the line (m) corresponds directly to the coefficient of time, which is $-k$.

Step 5: Conclude the value of the slope. The negative slope reflects a linear decrease in the concentration of the reactant over time. Therefore, the slope of a plot of concentration versus time for a zero-order reaction is exactly equal to $-k$.

Final Answer: $\boxed{-k}$

Answer: (A)

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Answer Key

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