KIITEE Chemistry Sample Paper – 11

Duration: 50 Minutes **Maximum Marks: 160**

Instructions

- This paper contains **40** Multiple Choice Questions (Single Correct Answer), modelled on the Chemistry portion of **KIITEE** entrance.
- Each correct answer carries **+4 marks**. There is -1 **mark per wrong answer;** unattempted questions score **0**
- Only **one** option is correct. Choose carefully.
- Syllabus level: **Class 11 & 12 (10+2) Chemistry — Organic Chemistry, Physical Chemistry,Inorganic Chemistry and Environmental Chemistry, Polymers & Biomolecules**
- The test is computer based. Personal calculators, log tables, mobile phones, and other electronic gadgets are strictly prohibited.

Q1. An organic compound contains 40% carbon, 6.7% hydrogen, and the rest oxygen. If the vapour density of the compound is 30, what is its molecular formula?

(A) CH_2O

(B) $C_2H_4O_2$

(C) $C_3H_6O_3$

(D) C_2H_6O

Q2. Which of the following arrangements represents the correct order of increasing fundamental periodic property as per the modern periodic law?

(A) O < N < F < Ne (by electron gain enthalpy with negative sign)

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

(C) I < Br < F < Cl (by electron affinity)

(D) Li < Na < K < Rb (by metallic radius)

Q3. For the reaction $A(g) + 2B(g) \rightleftharpoons 2C(g)$, the equilibrium partial pressures are $P_A = 0.20$ atm, $P_B = 0.30$ atm, and $P_C = 0.60$ atm. What is the value of K_p for this reaction?

(A) $3.33\ \text{atm}^{-1}$

(B) $10.0\ \text{atm}^{-1}$

(C) $20.0\ \text{atm}^{-1}$

(D) $0.05\ \text{atm}^{-1}$

Q4. Identify the major product obtained when 2-bromobutane is treated with alcoholic KOH under heating conditions.

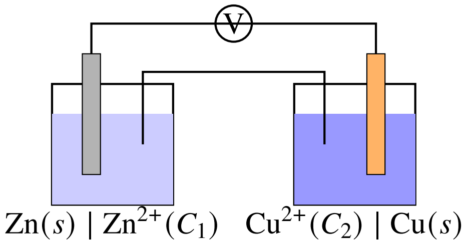
(A) Butan-1-ol

(B) Butan-2-ol

(C) But-1-ene

(D) trans-But-2-ene

Q5. Which of the following standard conditions will yield the highest cell potential for the given galvanic cell at 298 K?



(A) $C_1 = 1.0$ M, $C_2 = 1.0$ M

(B) $C_1 = 0.1$ M, $C_2 = 1.0$ M

(C) $C_1 = 1.0$ M, $C_2 = 0.1$ M

(D) $C_1 = 0.0$ M, $C_2 = 0.0$ M

Q6. Phenol on treatment with chloroform in the presence of aqueous NaOH followed by acidification yields salicylaldehyde. What is the active electrophile involved in this reaction?

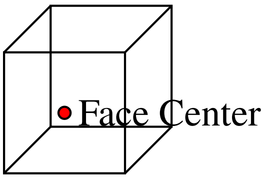
(A) Cl^-

(B) CCl_3^-

(C) $:CCl_2$

(D) ^+CHO

Q7. In a face-centered cubic (fcc) lattice, an atom at the face-center is shared equally by how many unit cells?



(A) 1 unit cell

(B) 2 unit cells

(C) 4 unit cells

(D) 8 unit cells

Q8. Which one of the following species has a square pyramidal geometry according to VSEPR theory?

(A) ClF_3

(B) XeF_4

(C) BrF_5

(D) SF_4

Q9. Equal masses of methane and oxygen gas are mixed in an empty container at 25°C. What fraction of the total pressure is exerted by oxygen gas?

(A) 1/2

(B) 1/3

(C) 2/3

(D) 1/4

Q10. An aqueous solution of a non-volatile solute boils at 100.156°C. What is the freezing point of this solution? (Given: $K_b = 0.52$ K kg mol^{-1}, $K_f = 1.86$ K kg mol^{-1} for water)

(A) −0.558°C

(B) −0.156°C

(C) −0.432°C

(D) −0.744°C

Q11. The secondary structure of a protein refers primarily to which of the following spatial arrangements?

(A) The linear sequence of amino acids joined by peptide bonds.

(B) The three-dimensional folding of the entire polypeptide chain.

(C) Regular folding patterns like α-helices and β-pleated sheets stabilized by hydrogen bonds.

(D) The spatial arrangement of multiple polypeptide subunits relative to each other.

Q12. What is the correct order of decreasing acid strength for the following substituted benzoic acids?

I. p-nitrobenzoic acid
II. p-methoxybenzoic acid
III. benzoic acid

(A) I > II > III

(B) I > III > II

(C) II > III > I

(D) III > I > II

Q13. Among the following pairs of coordination compounds, which pair exhibits ionization isomerism?

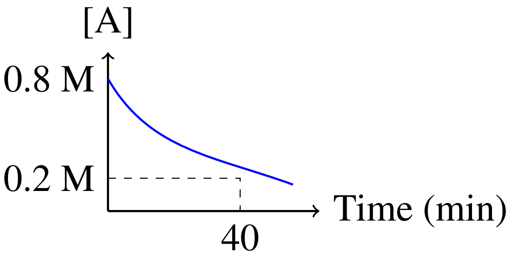
(A) $[Co(NH_3)_5Br]SO_4$ and $[Co(NH_3)_5SO_4]Br$

(B) $[Cr(H_2O)_6]Cl_3$ and $[Cr(H_2O)_5Cl]Cl_2 \cdot H_2O$

(C) $[Co(NH_3)_6][Cr(CN)_6]$ and $[Cr(NH_3)_6][Co(CN)_6]$

(D) $[Pt(NH_3)_2Cl_2]$ cis- and trans- forms

Q14. For a first-order reaction, if the concentration of the reactant drops from 0.8 M to 0.2 M in 40 minutes, what is the rate constant of the reaction?



(A) 0.0346 min^{-1}

(B) 0.0173 min^{-1}

(C) 0.0693 min^{-1}

(D) 0.0521 min^{-1}

Q15. Which of the following polymers is classified as a biodegradable polyamide?

(A) Nylon-6,6

(B) Nylon-2-nylon-6

(C) Buna-N

(D) Terylene

Q16. What is the total number of unpaired electrons in the high-spin complex $[CoF_6]^{3-}$? (Atomic number of Co = 27)

(A) 0

(B) 2

(C) 4

(D) 5

Q17. The correct IUPAC name of the compound $CH_3 - CH(OH) - CH_2 - CO - CH_3$ is:

(A) 4-hydroxypentan-2-one

(B) 2-hydroxypentan-4-one

(C) 4-oxopentan-2-ol

(D) 2-oxopentan-4-ol

Q18. Which of the following oxides is amphoteric in nature?

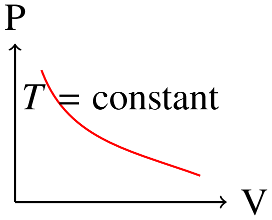
(A) N_2O_3

(B) ZnO

(C) CaO

(D) Cl_2O_7

Q19. For the ideal gas expansion process carried out isothermally and reversibly against an external pressure, which statement holds true?



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

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

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

(D) $\Delta H \neq 0, \Delta U = 0$

Q20. When D-glucose is treated with an excess of phenylhydrazine, it forms an osazone. Which carbon atoms of the glucose molecule are involved in this reaction?

(A) C_1 and C_2

(B) C_2 and C_3

(C) C_1 and C_4

(D) C_5 and C_6

Q21. According to the molecular orbital theory, which of the following species is expected to be diamagnetic?

(A) O_2

(B) O_2^-

(C) N_2

(D) B_2

Q22. In the extraction of copper from its sulphide ore, the copper metal is finally formed by the reduction of cuprous oxide with which substance?

(A) Iron sulphide (FeS)

(B) Carbon monoxide (CO)

(C) Cuprous sulphide (Cu_2S)

(D) Sulfur dioxide (SO_2)

Q23. Which of the following carbocations is the most stable?

(A) $(CH_3)_3C^+$

(B) $(C_6H_5)_3C^+$

(C) $CH_2 = CH - CH_2^+$

(D) $CH_3 - CH_2 - CH_2^+$

Q24. A 0.01 M aqueous solution of a weak monoacidic base is 2% ionized at 298 K. What is the pH of this solution?

(A) 3.7

(B) 10.3

(C) 4.3

(D) 9.7

Q25. What is the major organic product formed when aniline reacts with nitrous acid ($NaNO_2 + HCl$) at 0°C – 5°C?

(A) Chlorobenzene

(B) Phenol

(C) Benzene diazonium chloride

(D) Nitrobenzene

Q26. Which of the following alkali metal chlorides forms a dihydrate crystal ($MCl \cdot 2H_2O$) due to its exceptionally high hydration enthalpy?

(A) NaCl

(B) KCl

(C) LiCl

(D) CsCl

Q27. The rate of a chemical reaction triples when the temperature changes from 27°C to 37°C. What is the activation energy (E_a) of the reaction in kJ mol^{-1}? ($R = 8.314\ J\ K^{-1} mol^{-1}$, $\ln 3 = 1.1$)

(A) 42.1

(B) 84.2

(C) 53.6

(D) 26.8

Q28. Which of the following compounds will not undergo an aldol condensation reaction when treated with dilute NaOH?

(A) Acetaldehyde

(B) Propananal

(C) Benzaldehyde

(D) Acetone

Q29. What is the total number of stereoisomers possible for 2,3-dichlorobutane?

(A) 2

(B) 3

(C) 4

(D) 6

Q30. Which of the following elements exhibits the maximum number of stable oxidation states due to the presence of partly filled d-orbitals?

(A) Sc

(B) Mn

(C) Zn

(D) Fe

Q31. The standard reduction potentials of three metals X, Y, and Z are -1.2 V, $+0.5$ V, and -3.0 V respectively. What is the correct order of their reducing power?

(A) $X > Y > Z$

(B) $Z > X > Y$

(C) $Y > X > Z$

(D) $Z > Y > X$

Q32. In the qualitative analysis of group II cations, why is H_2S gas passed in the presence of dilute HCl?

(A) To increase the sulfide ion concentration by common ion effect.

(B) To decrease the sulfide ion concentration so that only group II sulfides precipitate.

(C) To act as an oxidizing agent.

(D) To maintain a completely neutral pH.

Q33. What is the product obtained when propene reacts with HBr in the presence of organic peroxides?

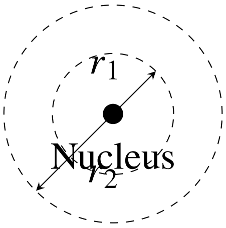
(A) 2-Bromopropane

(B) 1-Bromopropane

(C) 1,2-Dibromopropane

(D) 2-Bromopropan-2-ol

Q34. According to Bohr's theory, what is the ratio of the radius of the second orbit of He^+ ion to the third orbit of Li^{2+} ion?



(A) 4 : 9

(B) 8 : 27

(C) 2 : 3

(D) 4 : 3

Q35. Which of the following sets of quantum numbers is not permissible for an electron in an atom?

(A) $n = 3, l = 2, m_l = -2, m_s = +1/2$

(B) $n = 4, l = 0, m_l = 0, m_s = -1/2$

(C) $n = 3, l = 3, m_l = 1, m_s = +1/2$

(D) $n = 2, l = 1, m_l = 0, m_s = -1/2$

Q36. When ethylamine is warmed with chloroform and alcoholic KOH, a foul-smelling compound is formed. What is the structure of this foul-smelling substance?

(A) C_2H_5NC

(B) C_2H_5CN

(C) C_2H_5Cl

(D) CH_3NC

Q37. Which of the following oxoacids of phosphorus contains a direct P – P bond along with a +4 oxidation state for phosphorus?

(A) $H_4P_2O_7$

(B) $H_4P_2O_6$

(C) H_3PO_3

(D) $H_4P_2O_5$

Q38. For a reversible process in an isolated system, what are the conditions for ΔS_{system} and $\Delta S_{\text{surroundings}}$ at equilibrium?

(A) $\Delta S_{\text{system}} > 0, \Delta S_{\text{surroundings}} = 0$

(B) $\Delta S_{\text{system}} = 0, \Delta S_{\text{surroundings}} = 0$

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

(D) $\Delta S_{\text{system}} + \Delta S_{\text{surroundings}} > 0$

Q39. What is the major product when bromobenzene is heated with sodium metal in dry ether?

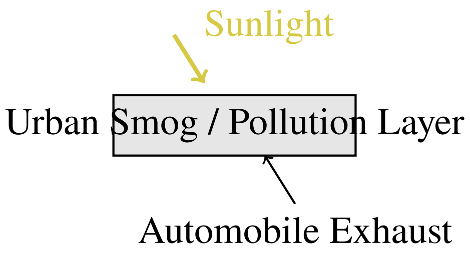
(A) Benzene

(B) Toluene

(C) Diphenyl

(D) Chlorobenzene

Q40. Photochemical smog is a consistent problem in congested urban areas. Which of the following components is NOT a primary or secondary constituent of photochemical smog?



(A) Ozone (O_3)

(B) Peroxyacetyl nitrate (PAN)

(C) Nitric oxide (NO)

(D) Chlorofluorocarbons (CFCs)

Detailed Solutions

Q1.

Solution

Concept: The molecular formula is determined by finding the empirical formula from mass percentages, then multiplying it by the ratio of molecular weight (derived from vapour density) to empirical formula mass.

Solution: Step 1: Find the mass percentage of Oxygen:

$$\text{Percentage of O} = 100 - (40\%\ \text{C} + 6.7\%\ \text{H}) = 53.3\%$$

Step 2: Calculate the relative number of moles for each element:

$$\text{Moles of C} = \frac{40}{12} = 3.33, \quad \text{Moles of H} = \frac{6.7}{1} = 6.70, \quad \text{Moles of O} = \frac{53.3}{16} = 3.33$$

Step 3: Determine the simplest atomic ratio by dividing by the smallest value (3.33):

$$\text{C} = \frac{3.33}{3.33} = 1, \quad \text{H} = \frac{6.70}{3.33} \approx 2, \quad \text{O} = \frac{3.33}{3.33} = 1 \implies \text{Empirical Formula} = \text{CH}_2\text{O}$$

Step 4: Compute the empirical formula mass and molecular weight:

$$\text{Empirical Mass} = 12 + (2 \times 1) + 16 = 30\ \text{g mol}^{-1}$$

$$\text{Molecular Weight} = 2 \times \text{Vapour Density} = 2 \times 30 = 60\ \text{g mol}^{-1}$$

Step 5: Find the multiplier n and determine the final molecular formula:

$$n = \frac{\text{Molecular Weight}}{\text{Empirical Mass}} = \frac{60}{30} = 2$$

$$\text{Molecular Formula} = 2 \times (\text{CH}_2\text{O}) = \text{C}_2\text{H}_4\text{O}_2$$

Final Answer: $\boxed{\text{C}_2\text{H}_4\text{O}_2}$

Answer: (B)

Go Back to Question 1

Q2.

Solution

Concept: Ionization enthalpy generally increases across a period due to an increase in effective nuclear charge.
However, anomalous behavior occurs when an element possesses an exceptionally stable half-filled or completely filled electronic configuration.

Solution: Step 1: Write down the general electronic configurations for the second-period elements involved (B, C, O, N):

$$\text{B} : 1s^2 2s^2 2p^1$$

$$\text{C} : 1s^2 2s^2 2p^2$$

$$\text{O} : 1s^2 2s^2 2p^4$$

$$\text{N} : 1s^2 2s^2 2p^3$$

Step 2: Analyze the configuration of Nitrogen (N). The $2p$ subshell is exactly half-filled ($2p^3$), which confers extra exchange energy and symmetrical distribution stability.

Step 3: Analyze Oxygen (O). Removing an electron from Oxygen leads to a stable half-filled $2p^3$ configuration, making it easier to lose an electron compared to Nitrogen.

Step 4: Therefore, the first ionization energy of Nitrogen is higher than that of Oxygen, breaking the regular left-to-right increasing trend across the period.

Step 5: Compare the remaining elements. Boron has the lowest effective nuclear charge among them, followed by Carbon. Thus, the actual correct order of increasing first ionization enthalpy is B < C < O < N.

Final Answer: $\boxed{\text{B} < \text{C} < \text{O} < \text{N (by first ionization enthalpy)}}$

Answer: (B)

Go Back to Question 2

Q3.

Solution

Concept: The equilibrium constant expressed in terms of partial pressures (K_p) is calculated by taking the ratio of the product of partial pressures of products to that of the reactants, with each term raised to the power of its stoichiometric coefficient.

Solution: Step 1: Write the expression for the equilibrium constant K_p for the given gaseous phase chemical reaction:

$$\mathrm{A}(g) + 2\mathrm{B}(g) \rightleftharpoons 2\mathrm{C}(g)$$

$$K_p = \frac{(P_\mathrm{C})^2}{(P_\mathrm{A}) \times (P_\mathrm{B})^2}$$

Step 2: Identify the given equilibrium partial pressures from the text statement:

$$P_\mathrm{A} = 0.20 \text{ atm}$$

$$P_\mathrm{B} = 0.30 \text{ atm}$$

$$P_\mathrm{C} = 0.60 \text{ atm}$$

Step 3: Substitute these values directly into the formulated mathematical expression:

$$K_p = \frac{(0.60)^2}{(0.20) \times (0.30)^2}$$

Step 4: Solve the arithmetic operations systematically:

$$(0.60)^2 = 0.36$$

$$(0.30)^2 = 0.09$$

$$\text{Denominator} = 0.20 \times 0.09 = 0.018$$

$$K_p = \frac{0.36}{0.018} = 20.0 \text{ atm}^{-1}$$

Final Answer: $\boxed{20.0 \text{ atm}^{-1}}$

Answer: (C)

Go Back to Question 3

Q4.

Solution

Concept: The dehydrohalogenation of alkyl halides using a strong, bulky base like alcoholic KOH proceeds via an E2 elimination mechanism.
The regioselectivity of this elimination reaction is governed by Zaitsev's rule, which states that the highly substituted, more stable alkene will be formed as the major product.

Solution: Step 1: Write down the structural formula of the starting material, 2-bromobutane:

$$CH_3 - CH(Br) - CH_2 - CH_3$$

Step 2: Identify the β-hydrogens available for elimination. There are two distinct types of β-carbons:
- The β_1 carbon on the terminal methyl group (-CH_3).
- The β_2 carbon on the internal methylene group (-CH_2-).

Step 3: Analyze path A (β_1 elimination): Removal of a hydrogen from the terminal methyl group yields But-1-ene, which is a monosubstituted alkene.

Step 4: Analyze path B (β_2 elimination): Removal of a hydrogen from the internal methylene group yields But-2-ene, which is a disubstituted alkene.

Step 5: According to chemical stability, disubstituted alkenes are thermodynamically more stable than monosubstituted ones due to hyperconjugation. Furthermore, trans-But-2-ene experiences minimal steric hindrance compared to cis-But-2-ene, rendering it the dominant major product.
Final Answer: $\boxed{\text{trans-But-2-ene}}$

Answer: (D)

Go Back to Question 4

Q5.

Solution

Concept: The cell potential of a non-standard galvanic cell is computed using the Nernst equation, which correlates the cell electromotive force (EMF) with the concentration of the active ionic species in the respective half-cells.

Solution: Step 1: Write down the net cell reaction taking place inside the given galvanic cell:

$$\mathrm{Zn}(s) + \mathrm{Cu}^{2+}(aq) \rightarrow \mathrm{Zn}^{2+}(aq) + \mathrm{Cu}(s)$$

Step 2: Formulate the Nernst equation at standard room temperature (298 K):

$$E_{\text{cell}} = E^{\circ}_{\text{cell}} - \frac{0.0591}{n} \log\left(\frac{[\mathrm{Zn}^{2+}]}{[\mathrm{Cu}^{2+}]}\right)$$

Here, the total number of exchanged electrons is $n = 2$.

Step 3: Substitute the concentrations C_1 and C_2 into the relationship:

$$E_{\text{cell}} = E^{\circ}_{\text{cell}} - \frac{0.0591}{2} \log\left(\frac{C_1}{C_2}\right)$$

Step 4: To maximize the final calculated value of E_{cell}, the logarithmic term must be minimized or made highly negative. This requires the ratio $\frac{C_1}{C_2}$ to be as small as possible.

Step 5: Evaluate the choices. Setting $C_1 = 0.1$ M and $C_2 = 1.0$ M gives a ratio of 0.1.

$$\log(0.1) = -1$$

$$E_{\text{cell}} = E^{\circ}_{\text{cell}} + \frac{0.0591}{2} > E^{\circ}_{\text{cell}}$$

Thus, option B yields the maximum potential.

Final Answer: $\boxed{C_1 = 0.1 \text{ M}, C_2 = 1.0 \text{ M}}$

Answer: (B)

Go Back to Question 5

Q6.

Solution

Concept: The formulation of salicylaldehyde from phenol using chloroform and base is known as the Reimer-Tiemann reaction.
This reaction proceeds via an organic mechanism involving alpha-elimination to generate a highly reactive, neutral electrophilic intermediate.

Solution: Step 1: Analyze the interaction between chloroform ($CHCl_3$) and the strong hydroxide base (OH^-).

Step 2: Hydroxide ions deprotonate chloroform by removing the acidic alpha-hydrogen atom:

$$CHCl_3 + OH^- \rightleftharpoons : CCl_3^- + H_2O$$

Step 3: The trichloromethyl anion ($: CCl_3^-$) is unstable and spontaneously eliminates a chloride leaving group (Cl^-) via alpha-elimination:

$$: CCl_3^- \rightarrow : CCl_2 + Cl^-$$

Step 4: The resulting chemical intermediate is dichlorocarbene ($: CCl_2$). Despite having a lone pair, the carbon atom contains only six valence electrons, making it a neutral, powerful electrophile.

Step 5: This dichlorocarbene species is subsequently attacked by the electron-rich phenoxide ring at the ortho position, eventually resulting in the formation of salicylaldehyde.
Final Answer: $\boxed{: CCl_2}$

Answer: (C)

Go Back to Question 6

Q7.

Solution

Concept: In solid-state chemistry, the contribution and spatial sharing of an atom situated at a specific position inside a crystal unit cell depends on how many surrounding unit cells share that exact position.

Solution: Step 1: Visualize a three-dimensional crystal lattice composed of adjacent repeating cubic unit cells.

Step 2: Identify the location of a face-centered atom. A face-centered position lies flat on one of the outer flat boundary surfaces of a cube.

Step 3: Observe how cubes stack together in space to form a continuous lattice. Any given flat square face is a shared boundary between exactly two touching adjacent cubic unit cells.

Step 4: Since only two unit cells meet at any single face, the atom located precisely at the center of that face is sliced and shared equally between those 2 cells.

Step 5: Consequently, the fractional contribution of a face-centered atom to a single individual unit cell is exactly $1/2$. Thus, it is shared equally by 2 unit cells.

Final Answer: $\boxed{\text{2 unit cells}}$

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

Go Back to Question 7

Q8.

Solution

Concept: The molecular geometry of a covalent molecule can be predicted using Valence Shell Electron Pair Repulsion (VSEPR) theory by calculating its steric number, which is the sum of bonding pairs and lone pairs around the central atom.

Solution: Step 1: Determine the valence electrons of the central atom Bromine (Br) in BrF_5. Bromine is a halogen belonging to group 17, so it has 7 valence electrons.

Step 2: Count the number of monovalent fluorine ligands attached. There are 5 fluorine atoms, which form 5 single covalent σ-bonds with Bromine.

Step 3: Calculate the remaining non-bonding valence electrons on Bromine:

$$\text{Remaining electrons} = 7 - 5 = 2 \text{ electrons}$$

Two non-bonding electrons constitute exactly 1 lone pair.

Step 4: Determine the total steric number (SN):

$$\text{SN} = \text{Bond Pairs} + \text{Lone Pairs} = 5 + 1 = 6$$

Step 5: A steric number of 6 corresponds to an octahedral electronic geometry layout. With 5 bonding pairs and 1 lone pair occupying one of the axial positions, the resulting spatial shape minimizes repulsion by adopting a square pyramidal molecular geometry.

Final Answer: $\boxed{BrF_5}$

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

Go Back to Question 8

Q9.

Solution

Concept: According to Dalton's Law of Partial Pressures, the partial pressure exerted by an individual gas in an ideal gaseous mixture is directly proportional to its mole fraction in that mixture.

Solution: Step 1: Let the mass of both methane (CH_4) and oxygen (O_2) gas mixed in the container be equal to m grams.

Step 2: Calculate the molar masses of both gases:

$$\text{Molar mass of CH}_4 = 12 + (4 \times 1) = 16\ \text{g mol}^{-1}$$

$$\text{Molar mass of O}_2 = 2 \times 16 = 32\ \text{g mol}^{-1}$$

Step 3: Express the number of moles of each gas in terms of the mass m:

$$\text{Moles of methane } (n_{\text{CH}_4}) = \frac{m}{16}$$

$$\text{Moles of oxygen } (n_{\text{O}_2}) = \frac{m}{32}$$

Step 4: Calculate the total number of moles present in the gaseous mixture:

$$n_{\text{total}} = \frac{m}{16} + \frac{m}{32} = \frac{2m + m}{32} = \frac{3m}{32}$$

Step 5: Compute the mole fraction of oxygen gas (χ_{O_2}):

$$\chi_{\text{O}_2} = \frac{n_{\text{O}_2}}{n_{\text{total}}} = \frac{\frac{m}{32}}{\frac{3m}{32}} = \frac{1}{3}$$

Since the partial pressure fraction equals the mole fraction, the fraction is $1/3$.

Final Answer: $\boxed{1/3}$

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

Go Back to Question 9

Q10.

Solution

Concept: Colligative properties, such as elevation in boiling point (ΔT_b) and depression in freezing point (ΔT_f), depend on the molality of the non-volatile solute in the solution.

Solution: Step 1: Calculate the elevation in boiling point (ΔT_b) from the given boiling point of the solution:

$$\Delta T_b = T_b - T_b^\circ = 100.156^\circ\text{C} - 100.000^\circ\text{C} = 0.156^\circ\text{C}$$

Step 2: Relate the boiling point elevation to the molality (m) of the solution:

$$\Delta T_b = K_b \times m$$

$$0.156 = 0.52 \times m$$

$$m = \frac{0.156}{0.52} = 0.3 \text{ mol kg}^{-1}$$

Step 3: Use the calculated molality value to find the depression in freezing point (ΔT_f):

$$\Delta T_f = K_f \times m$$

$$\Delta T_f = 1.86 \times 0.3 = 0.558^\circ\text{C}$$

Step 4: Determine the final freezing point of the aqueous solution (T_f):

$$T_f = T_f^\circ - \Delta T_f = 0.000^\circ\text{C} - 0.558^\circ\text{C} = -0.558^\circ\text{C}$$

Final Answer: $\boxed{-0.558^\circ\text{C}}$

Answer: (A)

Go Back to Question 10

Q11.

Solution

Concept: The structural organization of proteins is categorized into primary, secondary, tertiary, and quaternary levels based on the complexity of the polypeptide chain folding.

Solution: Step 1: Define the primary structure. It is the linear amino acid sequence held together purely by strong covalent peptide bonds.

Step 2: Evaluate the secondary structure. It arises from regular, localized conformation choices of the polypeptide backbone.

Step 3: Identify the stabilization forces. The secondary structures are stabilized by highly ordered hydrogen bonds formed between the carbonyl oxygen ($C = O$) and the amide hydrogen ($N - H$) groups of the peptide backbone.

Step 4: Recognize the classic structural motifs. The two most prominent secondary structures found widely in nature are the rigid α-helix conformation and the extended sheet-like β-pleated sheets.

Step 5: Conclude that option C perfectly captures the exact scientific description of the protein secondary structure.

Final Answer: $\boxed{\text{Regular folding patterns like } \alpha\text{-helices and } \beta\text{-pleated sheets stabilized by hydrogen bonds.}}$

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

Go Back to Question 11

Q12.

Solution

Concept: The acidity of carboxylic acids depends on the stability of the conjugate carboxylate anion formed after deprotonation. Electron-withdrawing groups stabilize the negative charge, whereas electron-donating groups destabilize it.

Solution: Step 1: Analyze the structural electronic effects of the substituent groups on the benzene ring at the para position.

Step 2: Examine compound I (p-nitrobenzoic acid). The nitro group ($-NO_2$) acts as a strong electron-withdrawing group via both powerful resonant electronic withdrawal ($-M$ effect) and inductive withdrawal ($-I$ effect). This significantly stabilizes the carboxylate anion, increasing its acidity.

Step 3: Examine compound III (benzoic acid). It features a neutral hydrogen atom as the reference point with no additional electronic pushing or pulling effects.

Step 4: Examine compound II (p-methoxybenzoic acid). The methoxy group ($-OCH_3$) acts as an electron-donating group due to lone pair resonance ($+M$ effect), which increases the electron density on the ring and destabilizes the conjugate base, making it less acidic.

Step 5: Arrange them in order of decreasing acid strength: I > III > II.

Final Answer: $\boxed{\text{I > III > II}}$

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

Go Back to Question 12

Q13.

Solution

Concept: Ionization isomerism occurs in coordination chemistry when a ligand bound directly inside the inner coordination sphere exchanges positions with a counter-ion present outside in the outer ionization sphere.

Solution: Step 1: Understand the prerequisite for ionization isomerism. The isomers must dissolve in water to release completely different ions into the aqueous medium.

Step 2: Analyze pair A: $[Co(NH_3)_5Br]SO_4$ and $[Co(NH_3)_5SO_4]Br$.

Step 3: Dissolve the first complex in water:

$$[Co(NH_3)_5Br]SO_4 \rightarrow [Co(NH_3)_5Br]^{2+} + SO_4^{2-}$$

This solution yields a white precipitate when treated with barium chloride ($BaCl_2$).

Step 4: Dissolve the second complex in water:

$$[Co(NH_3)_5SO_4]Br \rightarrow [Co(NH_3)_5SO_4]^{+} + Br^{-}$$

This solution yields a light-yellow precipitate when treated with silver nitrate ($AgNO_3$).

Step 5: Since they have the same molecular formula but generate different ions in solution, they are classified as ionization isomers.

Final Answer: $\boxed{[Co(NH_3)_5Br]SO_4 \text{ and } [Co(NH_3)_5SO_4]Br}$

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

Go Back to Question 13

Q14.

Solution

Concept: The rate constant (k) for a first-order chemical kinetic reaction can be calculated using its integrated rate law equation, which links time with initial and final reactant concentrations.

Solution: Step 1: Recall the integrated rate equation for a first-order reaction:

$$k = \frac{2.303}{t} \log\left(\frac{[A]_0}{[A]_t}\right)$$

Step 2: Identify the given values from the problem statement:
Initial concentration, $[A]_0 = 0.8$ M
Final concentration at time t, $[A]_t = 0.2$ M
Time elapsed, $t = 40$ minutes

Step 3: Substitute the parameters into the integrated formula:

$$k = \frac{2.303}{40} \log\left(\frac{0.8}{0.2}\right)$$

Step 4: Simplify the concentration ratio inside the logarithm:

$$\frac{0.8}{0.2} = 4$$

$$\log(4) = 2\log(2) \approx 2 \times 0.3010 = 0.6020$$

Step 5: Complete the arithmetic calculation:

$$k = \frac{2.303 \times 0.6020}{40} = \frac{1.3864}{40} = 0.0346 \text{ min}^{-1}$$

Final Answer: $\boxed{0.0346 \text{ min}^{-1}}$

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

Go Back to Question 14

Q15.

Solution

Concept: Biodegradable polymers can be broken down by environmental microorganisms over time. Polyamides are polymers that feature repeating amide linkages (-CO-NH-).

Solution: Step 1: Analyze option A (Nylon-6,6). It is a synthetic polyamide made from adipic acid and hexamethylenediamine, but it is non-biodegradable.

Step 2: Analyze option B (Nylon-2-nylon-6). It is an alternating polyamide copolymer synthesized from two amino acids: glycine ($H_2N\text{-}CH_2\text{-}COOH$, a 2-carbon system) and amino caproic acid ($H_2N\text{-}(CH_2)_5\text{-}COOH$, a 6-carbon system).

Step 3: Because of its specific structural linkages mimicking natural proteins, Nylon-2-nylon-6 can be easily broken down by microbial enzymes, classifying it as a biodegradable polyamide.

Step 4: Review options C and D. Buna-N is a synthetic rubber, and Terylene is a polyester, so neither fits the criteria.
Final Answer: $\boxed{\text{Nylon-2-nylon-6}}$

$\boxed{\textbf{Answer: (B)}}$
Go Back to Question 15

Q16.

Solution

Concept: The number of unpaired electrons in a coordination complex is determined by the oxidation state of the central metal ion and the field strength of the surrounding ligands according to Crystal Field Theory (CFT).

Solution: Step 1: Determine the oxidation state of Cobalt (Co) in the complex $[CoF_6]^{3-}$:

$$x + 6(-1) = -3 \implies x = +3$$

Thus, Cobalt exists as a Co^{3+} ion.

Step 2: Write the electronic configuration for a neutral Cobalt atom ($Z = 27$):

$$\text{Co} = [\text{Ar}]3d^7 4s^2$$

Step 3: Write the electronic configuration for the Co^{3+} ion by removing three electrons:

$$\text{Co}^{3+} = [\text{Ar}]3d^6$$

Step 4: Assess the ligand field strength. Fluoride (F^-) is classified as a weak-field ligand in the spectrochemical series. It cannot cause electron pairing in the $3d$ orbitals.

Step 5: Distribute the 6 electrons across the five $3d$ orbitals following Hund's rule: four orbitals get 1 electron each, and one orbital gets paired. This leaves exactly 4 unpaired electrons.

Final Answer: $\boxed{4}$

Answer: (C)

Go Back to Question 16

Q17.

Solution

Concept: According to IUPAC nomenclature rules for polyfunctional organic compounds, the principal functional group must be selected based on the priority order, and the carbon chain is numbered to give it the lowest possible locant.

Solution: Step 1: Identify the functional groups present in the given structural formula:

$$CH_3 - CH(OH) - CH_2 - CO - CH_3$$

The two functional groups are a hydroxyl group (-OH) and a carbonyl ketone group (-CO-).

Step 2: Determine the priority order between a ketone and an alcohol. Ketones have a higher priority than hydroxyl groups. Therefore, the suffix of the compound name will be "-one" and the alcohol group will be treated as a prefix substituent named "hydroxy".

Step 3: Number the five-carbon chain from the end that gives the ketone the lowest 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 4: Identify the position of the substituent. The hydroxy group is located at carbon-4.

Step 5: Combine these elements into the final IUPAC name: 4-hydroxypentan-2-one.
Final Answer: $\boxed{\text{4-hydroxypentan-2-one}}$

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

Go Back to Question 17

Q18.

Solution

Concept: Oxides are classified as acidic, basic, neutral, or amphoteric depending on their chemical reactivity with both acids and bases. Amphoteric oxides react with both to form salt and water.

Solution: Step 1: Evaluate option A (N_2O_3). It is a non-metal oxide, which exhibits purely acidic properties when dissolved in water.

Step 2: Evaluate option B (ZnO). Zinc oxide is a metallic oxide that can dissolve in strong acids (like HCl) to form zinc chloride and also dissolves in strong bases (like NaOH) to form sodium zincate:

$$\mathrm{ZnO} + 2\mathrm{HCl} \rightarrow \mathrm{ZnCl_2} + \mathrm{H_2O}$$

$$\mathrm{ZnO} + 2\mathrm{NaOH} \rightarrow \mathrm{Na_2ZnO_2} + \mathrm{H_2O}$$

This dual reactivity classifies ZnO as amphoteric.

Step 3: Evaluate option C (CaO). Calcium oxide is an alkaline earth metal oxide, which is strongly basic.

Step 4: Evaluate option D (Cl_2O_7). It is a non-metal oxide in a high oxidation state, making it strongly acidic.

Final Answer: $\boxed{\mathrm{ZnO}}$

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

Go Back to Question 18

Q19.

Solution

Concept: For an ideal gas, internal energy (U) is a function of temperature only. Therefore, in any isothermal process where temperature remains constant, the change in internal energy (ΔU) is zero.

Solution: Step 1: Identify the characteristics of the given process: it is an isothermal expansion of an ideal gas.

Step 2: State the thermodynamic consequence of an isothermal process for an ideal gas:

$$\Delta T = 0 \implies \Delta U = 0$$

Step 3: Recall the First Law of Thermodynamics expression:

$$\Delta U = q + w$$

Step 4: Substitute $\Delta U = 0$ into the First Law formula:

$$0 = q + w \implies q = -w$$

Step 5: This result indicates that all the heat absorbed (q) by the ideal gas system from the surroundings is entirely converted into work (w) done by the gas during its expansion. Therefore, the conditions $\Delta U = 0$ and $q = -w$ must hold true.
Final Answer: $\boxed{\Delta U = 0, q = -w}$

Answer: (C)

Go Back to Question 19

Q20.

Solution

Concept: Osazone formation is a characteristic reaction of reducing carbohydrates containing a carbonyl group adjacent to a hydroxyl group when treated with an excess of phenylhydrazine.

Solution: Step 1: Understand the structural reaction of D-glucose with phenylhydrazine. D-glucose is an aldohexose with an aldehyde group at the C_1 position.

Step 2: In the first step of the reaction, one molecule of phenylhydrazine reacts with the aldehyde group at C_1 to form a phenylhydrazone intermediate.

Step 3: In the second step, a second molecule of phenylhydrazine oxidizes the adjacent secondary alcohol group at the C_2 position into a ketone group.

Step 4: In the final step, a third molecule of phenylhydrazine reacts with this newly formed C_2 ketone group, resulting in a crystalline compound called glucosazone.

Step 5: Since the chemical modifications are strictly restricted to the C_1 and C_2 positions, carbohydrates that differ only at these two carbons (like glucose and fructose) yield the exact same osazone.

Final Answer: $\boxed{C_1 \text{ and } C_2}$

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

Go Back to Question 20

Q21.

Solution

Concept: According to Molecular Orbital (MO) theory, a species is classified as diamagnetic if all the electrons in its molecular orbitals are completely paired up. If any unpaired electrons exist, it is paramagnetic.

Solution: Step 1: Determine the total number of electrons for N_2. Each nitrogen atom contributes 7 electrons, so N_2 has 14 total electrons.

Step 2: Write down the molecular orbital electronic configuration for a 14-electron homonuclear diatomic system:

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

Step 3: Analyze the filling of the valence orbitals. The bonding π_{2p} and σ_{2p_z} orbitals are completely filled with pairs of electrons. There are no half-filled or unpaired electrons.

Step 4: Since all 14 electrons are paired, N_2 exhibits diamagnetism. In contrast, species like O_2 have unpaired electrons in their antibonding π^* orbitals, making them paramagnetic.

Final Answer: $\boxed{N_2}$

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

Go Back to Question 21

Q22.

Solution

Concept: The metallurgy of copper involves a self-reduction or auto-reduction process inside a Bessemer converter, where the partially roasted sulphide ore reacts directly with the remaining unreacted ore without adding an external reducing agent.

Solution: Step 1: During the initial partial roasting stage of copper extraction, cuprous sulphide (Cu_2S) is partially oxidized by heating in air to form cuprous oxide (Cu_2O):

$$2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$$

Step 2: When the supply of oxygen is cut off, the newly formed cuprous oxide (Cu_2O) undergoes a self-reduction reaction with the remaining unreacted cuprous sulphide (Cu_2S) present in the furnace.

Step 3: Write down the balanced chemical equation for this auto-reduction process:

$$2Cu_2O + Cu_2S \rightarrow 6Cu + SO_2$$

Step 4: The solidified copper obtained this way has a blistered appearance due to the evolution of SO_2 bubbles, and is called blister copper. The reducing agent is cuprous sulphide.
Final Answer: $\boxed{\text{Cuprous sulphide } (Cu_2S)}$

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

Go Back to Question 22

Q23.

Solution

Concept: The thermodynamic stability of carbocations is enhanced by factors that delocalize the positive charge, such as resonance, hyperconjugation, and inductive effects.

Solution: Step 1: Evaluate option A, the tert-butyl carbocation $(CH_3)_3C^+$. It is stabilized by 9 hyperconjugative α-hydrogens and the $+I$ effect of three methyl groups.

Step 2: Evaluate option B, the triphenylmethyl carbocation $(C_6H_5)_3C^+$. Here, the carbon bearing the positive charge is directly attached to three aromatic phenyl rings.

Step 3: Analyze the resonance delocalization in $(C_6H_5)_3C^+$. The positive charge can be completely delocalized into the ortho and para positions of all three phenyl rings. This extensive resonance over multiple canonical forms provides exceptional stability.

Step 4: Compare resonance versus hyperconjugation. Resonance delocalization is a significantly stronger stabilizing factor than hyperconjugation. Therefore, the triphenylmethyl carbocation is far more stable than the tert-butyl carbocation.

Final Answer: $\boxed{(C_6H_5)_3C^+}$

Answer: (B)

Go Back to Question 23

Q24.

Solution

Concept: The hydroxide ion concentration $[OH^-]$ of a weak monoacidic base can be calculated from its molar concentration (C) and degree of ionization (α). The pH is then derived using the water autoionization constant relationship.

Solution: Step 1: Extract the given quantitative parameters:
Concentration of the weak base, $C = 0.01\text{ M} = 10^{-2}\text{ M}$
Degree of ionization, $\alpha = 2\% = 0.02 = 2 \times 10^{-2}$

Step 2: Calculate the concentration of hydroxide ions $[OH^-]$ in the solution:

$$[OH^-] = C \times \alpha = (10^{-2}) \times (2 \times 10^{-2}) = 2 \times 10^{-4}\text{ M}$$

Step 3: Calculate the pOH of the solution by taking the negative logarithm:

$$\text{pOH} = -\log[OH^-] = -\log(2 \times 10^{-4})$$

$$\text{pOH} = 4 - \log(2) = 4 - 0.3010 = 3.699 \approx 3.7$$

Step 4: Calculate the pH of the solution using the standard relationship at 298 K:

$$\text{pH} + \text{pOH} = 14$$

$$\text{pH} = 14 - 3.7 = 10.3$$

Final Answer: $\boxed{10.3}$

Answer: (B)

Go Back to Question 24

Q25.

Solution

Concept: The reaction of primary aromatic amines with nitrous acid at low temperatures (0°C – 5°C) is known as diazotization, which forms stable diazonium salts.

Solution: Step 1: Identify the starting material and reagents. Aniline ($C_6H_5NH_2$) is a primary aromatic amine. Nitrous acid (HNO_2) is prepared in situ using sodium nitrite ($NaNO_2$) and excess hydrochloric acid (HCl).

Step 2: At low temperatures (273 K – 278 K), aniline reacts with the nitrous acid mixture to form a diazonium cation.

Step 3: Write out the balanced equation for this conversion:

$$C_6H_5NH_2 + NaNO_2 + 2HCl \xrightarrow{0-5^\circ C} C_6H_5N_2^+Cl^- + NaCl + 2H_2O$$

Step 4: The resulting organic product is benzene diazonium chloride. This salt is relatively stable at cold temperatures due to the resonance delocalization of the positive charge into the aromatic ring, making it a valuable intermediate in synthetic organic chemistry.

Final Answer: $\boxed{\text{Benzene diazonium chloride}}$

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

Go Back to Question 25

Q26.

Solution

Concept: Hydration enthalpy depends inversely on the ionic radius of the cation. A smaller ion size results in a higher charge density, allowing it to attract water molecules more strongly.

Solution: Step 1: Analyze the periodic trends for group 1 alkali metal cations (Li^+, Na^+, K^+, Cs^+). Ionic size increases down the group:

$$Li^+ < Na^+ < K^+ < Cs^+$$

Step 2: Determine the charge-to-size ratio layout. The Lithium cation (Li^+) has the smallest ionic radius in its group, giving it an exceptionally high charge density.

Step 3: Correlate charge density with hydration behavior. Because of this high charge density, Li^+ exerts a strong electrostatic attraction on the dipoles of surrounding water molecules, resulting in the highest hydration enthalpy among the alkali metals.

Step 4: As a consequence of this intense hydration, Lithium chloride crystallizes from aqueous solutions as a dihydrate compound, $LiCl \cdot 2H_2O$, whereas the other alkali chlorides remain anhydrous.

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

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

Go Back to Question 26

Q27.

Solution

Concept: The dependence of a reaction's rate constant on temperature is quantitatively described by the Arrhenius equation, which can be rearranged into a logarithmic form to calculate the activation energy (E_a).

Solution: Step 1: Write down the logarithmic version of the Arrhenius equation for two different temperatures:

$$\ln\left(\frac{k_2}{k_1}\right) = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right) = \frac{E_a}{R}\left(\frac{T_2 - T_1}{T_1 T_2}\right)$$

Step 2: Convert the given temperatures from Celsius to Kelvin:

$$T_1 = 27 + 273 = 300 \text{ K}$$

$$T_2 = 37 + 273 = 310 \text{ K}$$

Step 3: Substitute the given values into the equation ($\frac{k_2}{k_1} = 3$, $R = 8.314 \text{ J K}^{-1}\text{mol}^{-1}$, $\ln 3 = 1.1$):

$$1.1 = \frac{E_a}{8.314}\left(\frac{310 - 300}{300 \times 310}\right)$$

$$1.1 = \frac{E_a}{8.314}\left(\frac{10}{93000}\right)$$

Step 4: Isolate and solve for the activation energy E_a:

$$E_a = \frac{1.1 \times 8.314 \times 93000}{10} = 1.1 \times 8.314 \times 9300 = 85052 \text{ J mol}^{-1}$$

$$E_a \approx 53.6 \text{ kJ mol}^{-1}$$

Final Answer: $\boxed{53.6 \text{ kJ mol}^{-1}}$

Answer: (C)

Go Back to Question 27

Q28.

Solution

Concept: For an aldehyde or ketone to undergo a self-aldol condensation reaction in the presence of a dilute base, it must possess at least one acidic α-hydrogen atom attached to the carbon adjacent to the carbonyl group.

Solution: Step 1: Examine the chemical structures of the choices to check for the presence of α-hydrogens.

Step 2: Analyze option A (Acetaldehyde, CH_3CHO). It has three α-hydrogens on its methyl group, so it readily undergoes the aldol reaction.

Step 3: Analyze option B (Propanal, CH_3CH_2CHO). It contains two α-hydrogens on its central methylene carbon, making it reactive.

Step 4: Analyze option D (Acetone, CH_3COCH_3). It contains six equivalent α-hydrogens, allowing it to undergo base-catalyzed condensation.

Step 5: Analyze option C (Benzaldehyde, C_6H_5CHO). The carbonyl group is directly attached to the sp2 hybridized benzene ring carbon, which lacks any hydrogen atoms. Lacking α-hydrogens, benzaldehyde cannot undergo self-aldol condensation; instead, it undergoes the Cannizzaro reaction.

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

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

Go Back to Question 28

Q29.

Solution

Concept: The total number of stereoisomers for a molecule with multiple chiral centers is determined by its structural symmetry. Symmetrical molecules contain an internal plane of symmetry that makes the meso form optically inactive.

Solution: Step 1: Draw out the structural formula of 2,3-dichlorobutane:

$$CH_3 - CH(Cl) - CH(Cl) - CH_3$$

The molecule contains two identical chiral carbons (C_2 and C_3).

Step 2: Identify the stereochemical configurations. Since the molecule is symmetrical, we use the modified stereoisomer formulas for a system with an even number of identical chiral centers ($n = 2$).

Step 3: Calculate the number of optically active enantiomeric forms (a):

$$a = 2^{n-1} = 2^{2-1} = 2^1 = 2 \text{ forms (one } d \text{ and one } l \text{ form)}$$

Step 4: Calculate the number of meso forms (m):

$$m = 2^{(n/2)-1} = 2^{(2/2)-1} = 2^0 = 1 \text{ form}$$

Step 5: Add these values together to find the total number of stereoisomers:

$$\text{Total Stereoisomers} = a + m = 2 + 1 = 3$$

Final Answer: $\boxed{3}$

Answer: (B)

Go Back to Question 29

Q30.

Solution

Concept: Transition metals display a wide variety of oxidation states because their valence electrons occupy both the outer $4s$ and inner $3d$ subshells, which are close in energy.

Solution: Step 1: Write down the ground-state valence electronic configurations for the transition elements provided in the choices:

$$\text{Sc } (Z = 21) = 3d^1 4s^2$$

$$\text{Mn } (Z = 25) = 3d^5 4s^2$$

$$\text{Fe } (Z = 26) = 3d^6 4s^2$$

$$\text{Zn } (Z = 30) = 3d^{10} 4s^2$$

Step 2: Analyze Manganese (Mn). It has the maximum number of unpaired electrons in its d-orbitals ($3d^5$) along with two electrons in the $4s$ orbital.

Step 3: Determine the available oxidation states. Because the energy gap between the $3d$ and $4s$ subshells is very small, Manganese can involve anywhere from 2 to all 7 valence electrons in bonding.

Step 4: Consequently, Manganese exhibits a wide range of stable oxidation states, spanning +2, +3, +4, +5, +6, and +7. This is the largest number of oxidation states shown by any element in the $3d$ transition series.

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

Answer: (B)

Go Back to Question 30

Q31.

Solution

Concept: The reducing power of a metal refers to its ability to act as a reducing agent by losing electrons (undergoing oxidation). A lower or more negative standard reduction potential indicates a stronger reducing power.

Solution: Step 1: List the given standard reduction potentials (E°) for the three metals:

$$E^\circ_{\text{X}} = -1.2\text{ V}$$

$$E^\circ_{\text{Y}} = +0.5\text{ V}$$

$$E^\circ_{\text{Z}} = -3.0\text{ V}$$

Step 2: Understand the electrochemical relationship: a more negative reduction potential means the species has a strong tendency to lose electrons, making it a powerful reducing agent.

Step 3: Compare the values to find the most negative potential. Metal Z has the lowest reduction potential (−3.0 V), giving it the strongest reducing power.

Step 4: Compare the remaining values. Metal X (−1.2 V) is moderately negative, while metal Y (+0.5 V) is positive, meaning Y prefers to be reduced rather than oxidize.

Step 5: Arrange the metals in order of decreasing reducing power: Z > X > Y.

Final Answer: $\boxed{\text{Z} > \text{X} > \text{Y}}$

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

Go Back to Question 31

Q32.

Solution

Concept: In inorganic qualitative analysis, selective precipitation of cations into specific groups is achieved by controlling the concentration of the precipitating reagent using equilibrium principles like the common ion effect.

Solution: Step 1: Understand the chemistry of Group II and Group III cation precipitation. Group II cations precipitate as sulfides (MS) because they have low solubility products (K_{sp}).

Step 2: Analyze the dissociation equilibrium of the weak electrolyte hydrogen sulfide gas (H_2S):

$$H_2S(aq) \rightleftharpoons 2H^+(aq) + S^{2-}(aq)$$

Step 3: Analyze the effect of adding hydrochloric acid (HCl), a strong acid that dissociates completely:

$$HCl(aq) \longrightarrow H^+(aq) + Cl^-(aq)$$

Step 4: The high concentration of H^+ ions from HCl shifts the H_2S dissociation equilibrium to the left according to Le Chatelier's principle. This common ion effect lowers the concentration of sulfide ions (S^{2-}).

Step 5: This low sulfide concentration is sufficient to exceed the low K_{sp} of Group II sulfides, but is too low to precipitate Group III cations, ensuring selective separation.

Final Answer: $\boxed{\text{To decrease the sulfide ion concentration so that only group II sulfides precipitate.}}$

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

Go Back to Question 32

Q33.

Solution

Concept: The addition of hydrogen bromide (HBr) to unsymmetrical alkenes in the presence of organic peroxides proceeds via a free-radical mechanism that follows anti-Markovnikov regioselectivity.

Solution: Step 1: Identify the starting material and conditions. Propene ($CH_3 - CH = CH_2$) is an unsymmetrical alkene, reacting with HBr in the presence of peroxides.

Step 2: In the presence of peroxides, the reaction initiates via homolytic cleavage to generate a bromine free radical ($Br^\bullet$).

Step 3: The $Br^\bullet$ radical attacks the alkene double bond. It adds to the terminal carbon to form a more stable secondary carbon radical rather than a primary one:

$$CH_3 - CH = CH_2 + Br^\bullet \rightarrow CH_3 - CH^\bullet - CH_2Br$$

Step 4: This stable secondary radical then abstracts a hydrogen atom from another HBr molecule to yield the final saturated organic product:

$$CH_3 - CH^\bullet - CH_2Br + HBr \rightarrow CH_3 - CH_2 - CH_2Br + Br^\bullet$$

Step 5: The final product is 1-bromopropane, confirming the anti-Markovnikov addition.
Final Answer: $\boxed{\text{1-Bromopropane}}$

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

Go Back to Question 33

Q34.

Solution

Concept: According to the Bohr atomic model, the radius (r) of an orbit for a single-electron hydrogen-like species is directly proportional to the square of the principal quantum number (n^2) and inversely proportional to the atomic number (Z).

Solution: Step 1: State the mathematical formula for the Bohr radius of an orbit:

$$r \propto \frac{n^2}{Z}$$

Step 2: Calculate the orbital radius relationship for the He^+ ion.
For He^+, the atomic number is $Z_1 = 2$, and we are looking at the second orbit, so $n_1 = 2$.

$$r_{He^+} \propto \frac{(2)^2}{2} = \frac{4}{2} = 2$$

Step 3: Calculate the orbital radius relationship for the Li^{2+} ion.
For Li^{2+}, the atomic number is $Z_2 = 3$, and we are looking at the third orbit, so $n_2 = 3$.

$$r_{Li^{2+}} \propto \frac{(3)^2}{3} = \frac{9}{3} = 3$$

Step 4: Find the ratio of the two calculated values:

$$\text{Ratio} = \frac{r_{He^+}}{r_{Li^{2+}}} = \frac{2}{3} = 2:3$$

Final Answer: $\boxed{2:3}$

Answer: (C)

Go Back to Question 34

Q35.

Solution

Concept: The quantum numbers that describe the state of an electron must follow strict mathematical boundary rules derived from the wave equations of atomic structure.

Solution: Step 1: Review the fundamental boundary rules for the four quantum numbers:
- Principal quantum number, n, must be a positive integer $(1, 2, 3, \ldots)$.
- Azimuthal quantum number, l, can have integer values ranging from 0 to $(n - 1)$.
- Magnetic quantum number, m_l, ranges from $-l$ to $+l$, including zero.
- Spin quantum number, m_s, must be either $+1/2$ or $-1/2$.

Step 2: Evaluate choice C: $n = 3, l = 3, m_l = 1, m_s = +1/2$.

Step 3: Apply the rule for l. Since $n = 3$, the permissible values for l are restricted to:

$$l = 0, 1, \text{ or } 2$$

Step 4: Because the maximum allowed value of l is $(n - 1)$, l can never be equal to n. Therefore, having $l = 3$ when $n = 3$ is mathematically impossible and forbidden.

Final Answer: $\boxed{n = 3, l = 3, m_l = 1, m_s = +1/2}$

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

Go Back to Question 35

Q36.

Solution

Concept: Primary aliphatic and aromatic amines react with chloroform and alcoholic potassium hydroxide to undergo the carbylamine reaction (also known as the Hofmann isocyanide test).

Solution: Step 1: Identify the nature of the reactant. Ethylamine ($C_2H_5NH_2$) is a primary aliphatic amine.

Step 2: Recall the chemical behavior of primary amines in the carbylamine reaction. When heated with chloroform ($CHCl_3$) and alcoholic KOH, the amine group undergoes a condensation reaction to form an isocyanide compound.

Step 3: Write out the balanced equation for this specific chemical reaction:

$$C_2H_5NH_2 + CHCl_3 + 3KOH \rightarrow C_2H_5NC + 3KCl + 3H_2O$$

Step 4: Characterize the product. The resulting molecule is ethyl isocyanide (C_2H_5NC), which has an extremely foul, characteristic choking smell. This reaction serves as a definitive qualitative test for primary amines, as secondary and tertiary amines do not react.

Final Answer: $\boxed{C_2H_5NC}$

Answer: (A)

Go Back to Question 36

Q37.

Solution

Concept: The oxidation state of phosphorus in its oxoacids is determined from its structural bonding layout, where each constituent atom satisfies its common chemical valency.

Solution: Step 1: Analyze option B, hypophosphoric acid ($H_4P_2O_6$).

Step 2: Determine its structural configuration. Hypophosphoric acid contains a symmetrical layout where two phosphorus atoms are linked together directly by a single covalent $P-P$ bond. Each phosphorus is also bonded to two hydroxyl groups (-OH) and double-bonded to one oxygen atom (=O).

Step 3: Calculate the formal oxidation state (x) of phosphorus using its molecular formula:

$$4(+1)+2(x)+6(-2)=0$$

$$4+2x-12=0$$

$$2x-8=0 \implies 2x=8 \implies x=+4$$

Step 4: This confirms that hypophosphoric acid satisfies both criteria: it contains a direct $P-P$ bond and phosphorus exists in a +4 oxidation state.

Final Answer: $\boxed{H_4P_2O_6}$

Answer: (B)

Go Back to Question 37

Q38.

Solution

Concept: An isolated system does not exchange mass or energy with its surroundings. For any thermodynamic process taking place inside an isolated system, the change in entropy of the surroundings ($\Delta S_{\text{surroundings}}$) is zero.

Solution: Step 1: Analyze the properties of the system. In an isolated system, there is no thermal or physical interaction with the external environment, which means:

$$\Delta S_{\text{surroundings}} = 0$$

Step 2: Consider the nature of a reversible process. For any thermodynamically reversible process, the total change in entropy of the universe is zero:

$$\Delta S_{\text{universe}} = \Delta S_{\text{system}} + \Delta S_{\text{surroundings}} = 0$$

Step 3: Substitute the condition for the isolated surroundings ($\Delta S_{\text{surroundings}} = 0$) into the universe equation:

$$\Delta S_{\text{system}} + 0 = 0 \implies \Delta S_{\text{system}} = 0$$

Step 4: Therefore, at thermodynamic equilibrium for a reversible process inside an isolated system, both the system and surroundings undergo no net change in entropy, meaning $\Delta S_{\text{system}} = 0$ and $\Delta S_{\text{surroundings}} = 0$.

Final Answer: $\boxed{\Delta S_{\text{system}} = 0, \Delta S_{\text{surroundings}} = 0}$

Answer: (B)

Go Back to Question 38

Q39.

Solution

Concept: The coupling reaction of aryl halides with an alkali metal in the presence of a dry ether solvent is known as the Fittig reaction, which synthesizes symmetrical biaryl compounds.

Solution: Step 1: Identify the starting material and reaction conditions. Bromobenzene (C_6H_5Br) is treated with metallic sodium in dry ether.

Step 2: This process follows a free-radical coupling mechanism. Sodium atoms lose electrons to form sodium cations (Na^+), while transferring an electron to the halobenzene to break the $C-Br$ bond.

Step 3: This cleavage generates highly reactive phenyl free radicals ($C_6H_5^\bullet$) along with sodium bromide as a byproduct:

$$2C_6H_5Br + 2Na \xrightarrow{\text{dry ether}} 2C_6H_5^\bullet + 2NaBr$$

Step 4: Two of these phenyl free radicals spontaneously combine to form a new carbon-carbon single bond:

$$C_6H_5^\bullet + C_6H_5^\bullet \rightarrow C_6H_5 - C_6H_5$$

Step 5: The resulting coupled product is diphenyl (also known as biphenyl).

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

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

Go Back to Question 39

Q40.

Solution

Concept: Photochemical smog is a secondary air pollution phenomenon that occurs in warm, sunny urban areas due to the action of solar ultraviolet radiation on primary pollutants like nitrogen oxides and unburned hydrocarbons.

Solution: Step 1: Analyze the origin and composition of photochemical smog. It is initiated by internal combustion engine emissions that release primary pollutants like nitric oxide (NO) and hydrocarbons into the air.

Step 2: Under sunlight, nitric oxide converts into nitrogen dioxide (NO_2), which undergoes photolysis to yield nascent oxygen, forming ozone (O_3).

Step 3: The ozone and nitrogen oxides react with unburned hydrocarbons to produce powerful secondary lacrimatory compounds like peroxyacetyl nitrate (PAN) and acrolein.

Step 4: Evaluate option D, chlorofluorocarbons (CFCs). CFCs are highly stable synthetic compounds used in refrigeration that migrate to the stratosphere to cause ozone layer depletion. They do not participate in the lower atmospheric chemistry that forms photochemical smog.
Final Answer: $\boxed{\text{Chlorofluorocarbons (CFCs)}}$

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

Go Back to Question 40

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	B	3	C	4	D	5	B
6	C	7	B	8	C	9	B	10	A
11	C	12	B	13	A	14	A	15	B
16	C	17	A	18	B	19	C	20	A
21	C	22	C	23	B	24	B	25	C
26	C	27	C	28	C	29	B	30	B
31	B	32	B	33	B	34	C	35	C
36	A	37	B	38	B	39	C	40	D