MHT-CET Chemistry Sample Paper-7

Duration: 45 Minutes **Maximum Marks: 50**

Instructions

- This paper contains a total of **50** Multiple Choice Questions.
- Each correct answer carries **+1 marks**.
- No negative marking for incorrect questions.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.
- No marks will be deducted for questions that are left unattempted.

Q1. A solution of $CaCl_2$ has a Van't Hoff factor (i) of 2.45. What is the degree of dissociation (α) for this salt?

(A) 0.45

(B) 0.725

(C) 0.85

(D) 0.95

Q2. An element crystallizes in a body-centered cubic (BCC) lattice with a unit cell edge length of 300 pm. If the density is 6.8 g/cm^3, what is the molar mass of the element? ($N_A = 6.022 \times 10^{23}$)

(A) 55.3 g/mol

(B) 27.6 g/mol

(C) 110.6 g/mol

(D) 48.2 g/mol

Q3. For a first-order reaction, the time required for 75% completion is 30 minutes. What is the time required for 93.75% completion?

(A) 45 minutes

(B) 60 minutes

(C) 90 minutes

(D) 120 minutes

Q4. Which of the following complexes is expected to have the highest Crystal Field Splitting Energy (Δ_o)?

(A) $[Co(NH_3)_6]^{3+}$

(B) $[Co(CN)_6]^{3-}$

(C) $[Co(H_2O)_6]^{3+}$

(D) $[CoF_6]^{3-}$

Q5. In the nitration of benzene with concentrated H_2SO_4 and HNO_3, the active electrophile is:

(A) NO_2

(B) NO_2^+

(C) NO_2^-

(D) HNO_3

Q6. Predict the major product when 1-methoxy-4-nitrobenzene is treated with HI.

(A) 4-nitrophenol and methyl iodide

(B) Iodobenzene and methanol

(C) 4-iodonitrobenzene and methanol

(D) Nitrobenzene and methyl iodide

Q7. The standard electrode potential ($E°$) for Sn^{4+}/Sn^{2+} is +0.15 V and for Cr^{3+}/Cr is -0.74 V. What is the standard EMF of the cell $Cr|Cr^{3+}||Sn^{4+}|Sn^{2+}$?

(A) 0.89 V

(B) 0.59 V

(C) -0.59 V

(D) 1.04 V

Q8. Which of the following molecules has a linear shape despite having lone pairs on the central atom?

(A) SO_2

(B) XeF_2

(C) H_2O

(D) ClO_2^-

Q9. The correct order of increasing basic strength for the following in aqueous solution is:

(A) $NH_3 < (C_2H_5)_3N < C_2H_5NH_2 < (C_2H_5)_2NH$

(B) $(C_2H_5)_3N < NH_3 < (C_2H_5)_2NH < C_2H_5NH_2$

(C) $NH_3 < C_2H_5NH_2 < (C_2H_5)_3N < (C_2H_5)_2NH$

(D) $(C_2H_5)_2NH < (C_2H_5)_3N < C_2H_5NH_2 < NH_3$

Q10. A buffer solution is prepared by mixing 0.1 M acetic acid and 0.1 M sodium acetate. If the pK_a of acetic acid is 4.76, what is the pH after adding 0.01 moles of HCl to 1 liter of this buffer?

(A) 4.67

(B) 4.85

(C) 4.76

(D) 5.01

Q11. Which of the following will show the highest magnetic moment?

(A) Ti^{3+}

(B) Cr^{3+}

(C) Fe^{3+}

(D) Cu^{2+}

Q12. The polymer “Dacron” is classified as a:

(A) Polyamide

(B) Polyurethane

(C) Polyester

(D) Polyolefin

Q13. In the conversion of $R-CN$ to $R-CHO$, the reagent used is:

(A) $LiAlH_4$

(B) $SnCl_2/HCl$ followed by H_3O^+

(C) $NaBH_4$

(D) $KMnO_4/H^+$

Q14. The solubility of $AgCl$ in 0.1 M $NaCl$ solution is (K_{sp} for $AgCl = 1.2\times10^{-10}$):

(A) 1.2×10^{-11} M

(B) 1.2×10^{-9} M

(C) 1.1×10^{-5} M

(D) 1.2×10^{-10} M

Q15. Which of the following is an example of an extensive property?

(A) Molar enthalpy

(B) Density

(C) Internal energy

(D) Temperature

Q16. The correct IUPAC name of $HOOC-CH_2-CH(NH_2)-COOH$ is:

(A) 2-aminobutanedioic acid

(B) 3-aminobutanedioic acid

(C) 2-aminobutanoic acid

(D) Aspartic acid

Q17. The transition element that shows only the +3 oxidation state is:

(A) Scandium (Sc)

(B) Zinc (Zn)

(C) Manganese (Mn)

(D) Iron (Fe)

Q18. According to the Arrhenius equation, a plot of $\ln k$ versus $1/T$ gives a straight line with a slope equal to:

(A) $-E_a/R$

(B) E_a/R

(C) $-E_a/2.303R$

(D) A/R

Q19. Which of the following shows the lowest boiling point?

(A) PH_3

(B) NH_3

(C) AsH_3

(D) SbH_3

Q20. When Phenol is treated with Br_2 in CS_2 at low temperature, the major product is:

(A) $2,4,6$-tribromophenol

(B) p-bromophenol

(C) o-bromophenol

(D) m-bromophenol

Q21. The coordination number of Carbon in diamond is:

(A) 4

(B) 6

(C) 8

(D) 12

Q22. Which among the following is a “high-spin” complex?

(A) $[Co(CN)_6]^{3-}$

(B) $[Fe(CN)_6]^{4-}$

(C) $[Fe(H_2O)_6]^{3+}$

(D) $[Co(en)_3]^{3+}$

Q23. The product formed when Benzaldehyde reacts with Ethylene glycol in the presence of dry HCl gas is:

(A) Cyclic acetal

(B) Hemi-acetal

(C) Cyanohydrin

(D) Benzyl alcohol

Q24. In the extraction of Gold, the role of $NaCN$ is to:

(A) Oxidize Gold

(B) Reduce Gold

(C) Form a soluble complex

(D) Act as a flux

Q25. Which of the following aqueous solutions will have the highest boiling point?

(A) 1.0 M Glucose

(B) 1.0 M $NaCl$

(C) 1.0 M $CaCl_2$

(D) 1.0 M $AlCl_3$

Q26. The half-life of a zero-order reaction is proportional to:

(A) Initial concentration

(B) Square of initial concentration

(C) Inverse of initial concentration

(D) Independent of initial concentration

Q27. The most basic oxide among the following is:

(A) Al_2O_3

(B) SiO_2

(C) Na_2O

(D) SO_3

Q28. In the reaction $CH_3CH_2OH + PCl_5 \rightarrow X$, the product X is:

(A) CH_3CH_2Cl

(B) $CH_3CH_2OCH_2CH_3$

(C) $CH_2 = CH_2$

(D) CH_3Cl

Q29. What is the formal charge on the central Oxygen atom in Ozone (O_3)?

(A) 0

(B) +1

(C) -1

(D) +2

Q30. Which vitamin deficiency causes Pernicious Anemia?

(A) Vitamin B_1

(B) Vitamin B_2

(C) Vitamin B_{12}

(D) Vitamin K

Q31. The standard molar entropy is highest for:

(A) $H_2(g)$

(B) $C(\text{graphite})$

(C) $H_2O(l)$

(D) $I_2(s)$

Q32. In the reaction of toluene with Cl_2 in the presence of $FeCl_3$, the product is:

(A) Benzyl chloride

(B) Benzal chloride

(C) o/p-chlorotoluene

(D) Chlorobenzene

Q33. The relationship between C_p and C_v for an ideal gas is:

(A) $C_p - C_v = R$

(B) $C_v - C_p = R$

(C) $C_p/C_v = R$

(D) $C_p + C_v = R$

Q34. Which of the following is a thermosetting polymer?

(A) Polystyrene

(B) PVC

(C) Bakelite

(D) Nylon-6

Q35. The hybridization of phosphorus in PCl_5 is:

(A) sp^3

(B) sp^3d

(C) sp^3d^2

(D) dsp^2

Q36. When CH_3MgBr reacts with CO_2 followed by hydrolysis, the product is:

(A) Acetaldehyde

(B) Acetic acid

(C) Acetone

(D) Methane

Q37. An aqueous solution of $FeCl_3$ is:

(A) Acidic

(B) Basic

(C) Neutral

(D) Amphoteric

Q38. The unit of the rate constant for a second-order reaction is:

(A) s^{-1}

(B) $mol\ L^{-1}\ s^{-1}$

(C) $L\ mol^{-1}\ s^{-1}$

(D) $L^2\ mol^{-2}\ s^{-1}$

Q39. Identify the "Meso" form among the following:

(A) 2, 3-dichlorobutane (non-identical centers)

(B) 2, 3-pentanediol

(C) Tartaric acid with a plane of symmetry

(D) 1-chloroethanol

Q40. The catalyst used in the "Hydrogenation of oils" is:

(A) V_2O_5

(B) Fe

(C) Ni

(D) Pt

Q41. Which of the following contains an O-O linkage?

(A) $H_2S_2O_7$

(B) $H_2S_2O_8$

(C) H_2SO_4

(D) $H_2S_2O_3$

Q42. The product of the Reimer-Tiemann reaction is:

(A) Salicylic acid

(B) Salicylaldehyde

(C) Benzoic acid

(D) Phthalic acid

Q43. In a Face-Centered Cubic (FCC) lattice, the empty space is:

(A) 26%

(B) 32%

(C) 48%

(D) 52%

Q44. Glucose on prolonged heating with HI gives:

(A) n-Hexane

(B) Gluconic acid

(C) Saccharic acid

(D) Hexanoic acid

Q45. The work done in an isothermal reversible expansion of an ideal gas is:

(A) $-nRT\ln(V_2/V_1)$

(B) $P\Delta V$

(C) $q+\Delta U$

(D) 0

Q46. The strongest oxidizing agent among the halogens is:

(A) F_2

(B) Cl_2

(C) Br_2

(D) I_2

Q47. Monomer of “Teflon” is:

(A) Vinyl chloride

(B) Tetrafluoroethene

(C) Isoprene

(D) Styrene

Q48. The pH of 10^{-8} M HCl is:

(A) 8

(B) 6

(C) Between 6.9 and 7

(D) 7

Q49. Linkage isomerism is shown by ligands like:

(A) H_2O

(B) NH_3

(C) SCN^-

(D) Cl^-

Q50. The oxidation number of Oxygen in OF_2 is:

(A) -2

(B) -1

(C) $+1$

(D) $+2$

Detailed Solutions

Q1.

Solution

Concept:

The Van't Hoff factor (i) represents the ratio of the actual concentration of particles produced when the substance is dissolved to the concentration of the substance as calculated from its mass. For a salt that dissociates into n ions, the relationship between i and the degree of dissociation (α) is given by the formula:

$$i = 1 + \alpha(n - 1)$$

Solution:

1. Identify the dissociation of Calcium Chloride ($CaCl_2$):

$$CaCl_2 \longrightarrow Ca^{2+} + 2Cl^-$$

The total number of ions produced per formula unit (n) is 1 + 2 = 3.

2. Set up the equation using the given Van't Hoff factor ($i = 2.45$):

$$2.45 = 1 + \alpha(3 - 1)$$

3. Simplify and solve for α:

$$2.45 = 1 + 2\alpha$$

$$1.45 = 2\alpha$$

$$\alpha = \frac{1.45}{2}$$

$$\alpha = 0.725$$

4. The degree of dissociation is 0.725, which corresponds to 72.5% dissociation.

Final Answer: The degree of dissociation for the salt is 0.725.

Answer: (B)

Q2.

Solution

Concept:

The density (ρ) of a cubic crystal system is related to the unit cell parameters by the formula:

$$\rho = \frac{Z \times M}{a^3 \times N_A}$$

Where: - Z is the number of atoms per unit cell. - M is the molar mass of the element. - a is the edge length of the unit cell. - N_A is Avogadro's number (6.022×10^{23} mol^{-1}).

Solution:

1. Identify the given values and convert units: - For a body-centered cubic (BCC) lattice, $Z = 2$. - Density (ρ) = 6.8 g/cm^3. - Edge length (a) = 300 pm = 300×10^{-10} cm = 3×10^{-8} cm. - Avogadro's number (N_A) = 6.022×10^{23} mol^{-1}.

2. Rearrange the density formula to solve for Molar Mass (M):

$$M = \frac{\rho \times a^3 \times N_A}{Z}$$

3. Substitute the values into the equation:

$$M = \frac{6.8 \times (3 \times 10^{-8})^3 \times 6.022 \times 10^{23}}{2}$$

$$M = \frac{6.8 \times 27 \times 10^{-24} \times 6.022 \times 10^{23}}{2}$$

4. Perform the calculation:

$$M = \frac{6.8 \times 27 \times 0.6022}{2}$$

$$M = \frac{110.56}{2}$$

$$M \approx 55.28 \text{ g/mol}$$

5. Comparing the result with the given options, the value is approximately 55.3 g/mol.

Final Answer: The molar mass of the element is 55.3 g/mol.

Answer: (A)

Q3.

Solution

Concept:

For a first-order reaction, the time required for a specific percentage of completion can be related to the half-life ($t_{1/2}$). A key property of first-order kinetics is that the time taken for the concentration to reduce by half is constant. We can use the relation:

$$[A] = [A]_0 \left(\frac{1}{2}\right)^n$$

where n is the number of half-lives ($n = \frac{t}{t_{1/2}}$).

Solution:

1. Analyze the first condition (75% completion): - 75% completion means 25% of the reactant remains. - Remaining amount = $\frac{1}{4}$ of initial = $\left(\frac{1}{2}\right)^2$ of initial. - This represents 2 half-lives. - Given $t_{75\%} = 30$ minutes, then $2 \times t_{1/2} = 30$ minutes. - Therefore, $t_{1/2} = 15$ minutes.

2. Analyze the second condition (93.75% completion): - 93.75% completion means $100 - 93.75 = 6.25\%$ of the reactant remains. - Express 6.25% as a fraction: $\frac{6.25}{100} = \frac{1}{16}$. - Since $\frac{1}{16} = \left(\frac{1}{2}\right)^4$, this represents 4 half-lives.

3. Calculate the total time required: - $t_{93.75\%} = 4 \times t_{1/2}$ - $t_{93.75\%} = 4 \times 15$ minutes - $t_{93.75\%} =$ 60 minutes.

Final Answer: The time required for 93.75% completion is 60 minutes.

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

Q4.

Solution

Concept:

Crystal Field Theory (CFT) and the Spectrochemical Series.

Solution:

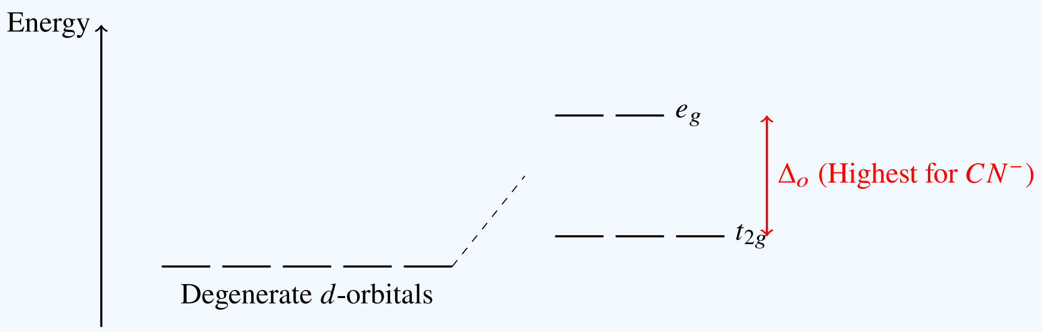
Step 1: The Crystal Field Splitting Energy (Δ_o) in octahedral complexes depends on the nature of the ligand. Strong-field ligands cause greater splitting of d-orbitals than weak-field ligands.

Step 2: According to the spectrochemical series, the field strength of the given ligands follows the order:

$$F^- < H_2O < NH_3 < CN^-$$

Step 3: All the given complexes have the same central metal ion in the same oxidation state (Co^{3+}). Therefore, the splitting energy is determined solely by the ligand strength.

Step 4: Since CN^- is a very strong-field ligand (a π-acceptor), it causes the maximum repulsion with the metal d-orbitals, resulting in the highest Δ_o value.



Crystal Field Splitting in Octahedral Field

Final Answer:

$$\boxed{[Co(CN)_6]^{3-}}$$

Answer: (B)

Q5.

Solution

Concept:
Nitration of benzene is an example of Electrophilic Aromatic Substitution (EAS). In this reaction, a nitrating mixture consisting of concentrated sulfuric acid (H_2SO_4) and concentrated nitric acid (HNO_3) is used. The sulfuric acid acts as a catalyst and a Brønsted acid to protonate the nitric acid, leading to the generation of a powerful electrophile.

Solution:
1. The reaction begins with the protonation of HNO_3 by H_2SO_4:

$$HNO_3 + 2H_2SO_4 \rightleftharpoons NO_2^+ + H_3O^+ + 2HSO_4^-$$

2. In this step, H_2SO_4 (the stronger acid) protonates the OH group of HNO_3. A molecule of water is kemudian eliminated to form the nitronium ion (NO_2^+). 3. The species NO_2^+ is the active electrophile that attacks the electron-rich benzene ring to form a sigma complex (carbocation intermediate). 4. The other options (NO_2, NO_2^-, and HNO_3) do not possess the necessary electrophilic character to effectively break the aromaticity of the benzene ring under these conditions.

Final Answer: The active electrophile is the nitronium ion, NO_2^+.

Answer: (B)

Q6.

Solution

Concept:

The reaction of alkyl aryl ethers with hydrogen halides (like HI) involves the cleavage of the ether bond. In such cases, the bond between the oxygen atom and the aromatic ring (sp^2 carbon) is stronger due to resonance (partial double-bond character) compared to the bond between oxygen and the alkyl group (sp^3 carbon). Consequently, the cleavage always occurs at the alkyl-oxygen bond.

Solution:

1. Identify the structure: 1-methoxy-4-nitrobenzene consists of a benzene ring with a nitro group ($-NO_2$) at the para position and a methoxy group ($-OCH_3$). 2. Protonation: The oxygen atom of the ether is first protonated by HI to form an oxonium ion:

$$Ar - O - CH_3 + H^+ \rightarrow Ar - O^+(H) - CH_3$$

3. Nucleophilic Attack: The iodide ion (I^-) acts as a nucleophile. It attacks the smaller alkyl group (methyl) via an S_N2 mechanism because the $Ar - O$ bond has partial double bond character and the aryl carbon is sterically hindered for back-side attack.

$$I^- + Ar - O^+(H) - CH_3 \rightarrow Ar - OH + CH_3I$$

4. Products formed: The aryl-oxygen bond remains intact, resulting in the formation of 4-nitrophenol (p-nitrophenol) and methyl iodide (CH_3I). 5. Further reaction: Phenols do not react further with HI to form iodobenzene because the $C - OH$ bond in phenol also has partial double-bond character.

Final Answer: The major products are 4-nitrophenol and methyl iodide.

Answer: (A)

Q7.

Solution

Concept:

The standard electromotive force (EMF) of a galvanic cell, E°_{cell}, is calculated using the standard reduction potentials of the cathode and the anode. The formula is:

$$E^\circ_{cell} = E^\circ_{cathode} - E^\circ_{anode}$$

By convention, the cathode is the electrode where reduction occurs (right side of cell notation), and the anode is the electrode where oxidation occurs (left side of cell notation).

Solution:

1. Identify the cathode and anode from the cell notation $Cr|Cr^{3+}||Sn^{4+}|Sn^{2+}$: - Anode (Oxidation): $Cr \longrightarrow Cr^{3+} + 3e^-$ - Cathode (Reduction): $Sn^{4+} + 2e^- \longrightarrow Sn^{2+}$

2. List the given standard reduction potentials: - $E^\circ_{Sn^{4+}/Sn^{2+}} = +0.15$ V (Cathode) - $E^\circ_{Cr^{3+}/Cr} = -0.74$ V (Anode)

3. Substitute the values into the EMF formula:

$$E^\circ_{cell} = E^\circ_{cathode} - E^\circ_{anode}$$

$$E^\circ_{cell} = (+0.15 \text{ V}) - (-0.74 \text{ V})$$

4. Calculate the result:

$$E^\circ_{cell} = 0.15 + 0.74$$

$$E^\circ_{cell} = 0.89 \text{ V}$$

Final Answer: The standard EMF of the cell is 0.89 V.

Answer: (A)

Q8.

Solution

Concept:
The shape of a molecule is determined by the Valence Shell Electron Pair Repulsion (VSEPR) theory. According to this theory, electron pairs (both bonding and lone pairs) around a central atom arrange themselves to minimize repulsion. While the electron geometry accounts for all electron pairs, the molecular shape (geometry) refers only to the positions of the atoms.

Solution:
1. Analyze each option using the VSEPR model: - SO_2: Sulfur has 6 valence electrons. It forms 2 double bonds with Oxygen and has 1 lone pair (AX_2E type). The shape is **Bent** (V-shaped). - XeF_2: Xenon has 8 valence electrons. It forms 2 single bonds with Fluorine and has 3 lone pairs (AX_2E_3 type). - H_2O: Oxygen has 6 valence electrons. It forms 2 single bonds with Hydrogen and has 2 lone pairs (AX_2E_2 type). The shape is **Bent**. - ClO_2^-: Chlorine has 7 valence electrons +1 from the charge = 8. It forms 2 bonds and has 2 lone pairs (AX_2E_2 type). The shape is **Bent**.
2. Focus on XeF_2: - The electron geometry is **Trigonal Bipyramidal** because there are 5 electron pairs (2 bonding + 3 lone). - To minimize repulsion, the 3 lone pairs occupy the **equatorial** positions (120° apart). - The 2 Fluorine atoms occupy the **axial** positions (180° apart). - - Consequently, the atoms $F - Xe - F$ are arranged in a straight line, making the molecular shape **Linear**.

Final Answer: XeF_2 is linear despite having three lone pairs on the central atom.

Answer: (B)

Q9.

Solution

Concept:
The basic strength of amines in aqueous solution is determined by three competing factors: 1. **Inductive effect (+I):** Alkyl groups increase electron density on Nitrogen, increasing basicity ($3^\circ > 2^\circ > 1^\circ$). 2. **Solvation effect:** Hydrogen bonding with water stabilizes the substituted ammonium ion ($1^\circ > 2^\circ > 3^\circ$). 3. **Steric hindrance:** Bulky groups interfere with the protonation and hydration of the nitrogen atom. For ethyl-substituted amines, the combined effect results in a specific order.

Solution:
1. For the ethyl group (C_2H_5), the steric hindrance is significant enough to decrease the basicity of the tertiary amine compared to the secondary and primary amines in water. 2. The experimentally determined order of basic strength for ethylamines in aqueous solution is:

$$(C_2H_5)_2NH > (C_2H_5)_3N > C_2H_5NH_2 > NH_3$$

3. Comparing this to the options: - NH_3 is the weakest because it lacks +I groups. - $(C_2H_5)_2NH$ (Secondary) is the strongest due to the optimal balance of +I effect and solvation. - $(C_2H_5)_3N$ (Tertiary) follows, as steric hindrance reduces its solvation stability compared to the secondary amine. - $C_2H_5NH_2$ (Primary) is stronger than ammonia but weaker than the substituted versions.
Final Answer: The correct increasing order is $NH_3 < C_2H_5NH_2 < (C_2H_5)_3N < (C_2H_5)_2NH$.

Answer: (C)

Q10.

Solution

Concept:

The pH of a buffer solution is calculated using the Henderson-Hasselbalch equation:

$$pH = pK_a + \log \frac{[Salt]}{[Acid]}$$

When a strong acid (HCl) is added, it reacts with the conjugate base (CH_3COO^-) to form more weak acid (CH_3COOH).

Solution:

1. Initial moles in 1 L: - $Acid(CH_3COOH) = 0.1$ mol - $Salt(CH_3COONa) = 0.1$ mol
2. Reaction upon adding 0.01 mol of HCl:

$$CH_3COO^- + H^+ \rightarrow CH_3COOH$$

- New moles of Salt = $0.1 - 0.01 = 0.09$ mol - New moles of Acid = $0.1 + 0.01 = 0.11$ mol

3. Apply the Henderson-Hasselbalch equation:

$$pH = 4.76 + \log \left(\frac{0.09}{0.11} \right)$$

$$pH = 4.76 + \log(0.818)$$

$$pH = 4.76 - 0.087 \approx 4.67$$

Final Answer: The pH of the solution after adding HCl is 4.67.

Answer: (A)

Q11.

Solution

Concept:
The magnetic moment (μ) of transition metal ions is primarily determined by the number of unpaired electrons (n) using the "spin-only" formula:

$$\mu = \sqrt{n(n+2)} \text{ BM}$$

The higher the number of unpaired electrons, the higher the magnetic moment. To find n, we look at the electronic configuration of the ions.
Solution:
1. Determine the electronic configuration and number of unpaired electrons for each ion: - Ti^{3+}: Atomic number 22 ($[Ar]3d^2 4s^2$). Ion is $3d^1$. Unpaired electrons (n) = 1. - Cr^{3+}: Atomic number 24 ($[Ar]3d^5 4s^1$). Ion is $3d^3$. Unpaired electrons (n) = 3. - Fe^{3+}: Atomic number 26 ($[Ar]3d^6 4s^2$). Ion is $3d^5$. Unpaired electrons (n) = 5. - Cu^{2+}: Atomic number 29 ($[Ar]3d^{10} 4s^1$). Ion is $3d^9$. Unpaired electrons (n) = 1.
2. Compare the number of unpaired electrons: - Fe^{3+} has the maximum number of unpaired electrons ($n = 5$).
3. Calculate the magnetic moment for Fe^{3+}:

$$\mu = \sqrt{5(5+2)} = \sqrt{35} \approx 5.92 \text{ BM}$$

This is the highest among the given options.
Final Answer: Fe^{3+} has the highest magnetic moment.

Answer: (C)

Q12.

Solution

Concept:

Polymers are classified based on the type of linkage present in their backbone. Dacron (also known as Terylene) is a condensation polymer formed from the reaction between a diol and a dicarboxylic acid.

Solution:

1. Identify the monomers of Dacron: - Ethylene glycol ($HO - CH_2 - CH_2 - OH$) - Terephthalic acid ($HOOC - C_6H_4 - COOH$)

2. Analyze the polymerization reaction: The hydroxyl group ($-OH$) of the glycol reacts with the carboxyl group ($-COOH$) of the acid, eliminating a water molecule.

3. Identify the functional group formed: The reaction results in the formation of an ester linkage ($-COO-$) between the repeating units.

4. Classification: Because the polymer chain is held together by repeating ester bonds, it is classified as a **Polyester**.

Final Answer: Dacron is classified as a Polyester.

Answer: (C)

Q13.

Solution

Concept:

Stephen Reaction (Reduction of nitriles to aldehydes).

Solution:

Step 1: The conversion of an alkyl nitrile ($R - CN$) to an aldehyde ($R - CHO$) using tin(II) chloride ($SnCl_2$) and hydrochloric acid (HCl), followed by hydrolysis, is known as the **Stephen reduction**.

Step 2: In the first stage, the nitrile is reduced to an imine hydrochloride intermediate by the action of $SnCl_2$ and HCl.

$$R - C \equiv N \xrightarrow{SnCl_2 + HCl} R - CH = NH \cdot HCl$$

Step 3: The imine hydrochloride is subsequently hydrolyzed with warm water (H_3O^+) to yield the corresponding aldehyde.

$$R - CH = NH \cdot HCl \xrightarrow{H_2O} R - CHO + NH_4Cl$$

Step 4: Other reagents like $LiAlH_4$ would reduce nitriles all the way to primary amines ($R - CH_2NH_2$), and $KMnO_4$ is an oxidizing agent.

$$\underset{\text{(Nitrile)}}{R - C \equiv N} \xrightarrow{SnCl_2/HCl} \underset{\text{(Imine)}}{R - CH = NH} \xrightarrow{H_3O^+} \underset{\text{(Aldehyde)}}{R - CHO}$$

Final Answer:

$$\boxed{\text{(B) } SnCl_2/HCl \text{ followed by } H_3O^+}$$

Answer: (B)

Q14.

Solution

Concept:

The solubility of a sparingly soluble salt decreases in the presence of a common ion. This is known as the Common Ion Effect. For the salt $AgCl$, the solubility equilibrium is:

$$AgCl(s) \rightleftharpoons Ag^{+}(aq) + Cl^{-}(aq)$$

The solubility product constant is $K_{sp} = [Ag^{+}][Cl^{-}]$.

Solution:

1. Identify the concentrations in 0.1 M $NaCl$: - $NaCl$ is a strong electrolyte: $[Cl^{-}]_{fromNaCl} = 0.1$ M. - Let s be the solubility of $AgCl$ in this solution. - Total $[Cl^{-}] = s + 0.1$ M.

2. Set up the K_{sp} expression:

$$K_{sp} = [Ag^{+}][Cl^{-}]$$

$$1.2 \times 10^{-10} = (s)(s + 0.1)$$

3. Simplify using the approximation: Since K_{sp} is very small, the value of s will be negligible compared to 0.1 M. Therefore, $s + 0.1 \approx 0.1$.

4. Solve for s:

$$1.2 \times 10^{-10} = s \times 0.1$$

$$s = \frac{1.2 \times 10^{-10}}{0.1}$$

$$s = 1.2 \times 10^{-9} \text{ M}$$

Final Answer: The solubility of $AgCl$ in 0.1 M $NaCl$ is 1.2×10^{-9} M.

Answer: (B)

Q15.

Solution

Concept:

Thermodynamic properties are classified into two categories: 1. **Intensive properties:** These are independent of the amount of substance present in the system (e.g., temperature, pressure, density, molar properties). 2. **Extensive properties:** These depend on the amount of substance present in the system (e.g., mass, volume, total energy).

Solution:

1. **Molar enthalpy:** Although enthalpy is extensive, any "molar" property (value per mole) is intensive because it is a ratio of two extensive properties. 2. **Density:** Density is the ratio of mass to volume ($\rho = m/V$). Since both mass and volume change proportionally with the amount of substance, the ratio remains constant. It is intensive. 3. **Internal energy** (U)**:** The total internal energy of a system is the sum of the energies of all individual particles. If you double the amount of substance, the total internal energy doubles. Therefore, it is extensive. 4. **Temperature** (T)**:** If you divide a system in equilibrium into two parts, the temperature of each part remains the same as the original. It is intensive.

Final Answer: Internal energy is an extensive property.

Answer: (C)

Q16.

Solution

Concept:

To name a dicarboxylic acid according to IUPAC nomenclature: 1. Identify the longest carbon chain containing both carboxyl ($-COOH$) groups. 2. Number the chain from the end that gives the substituent (the amino group, $-NH_2$) the lowest locant number. 3. Use the suffix "-dioic acid" for two carboxyl groups.

Solution:

1. The parent chain has 4 carbon atoms: $HOOC - CH_2 - CH - COOH$. This makes it a **butanedioic acid**. 2. Numbering the chain: - Starting from the right: The carbon with the $-NH_2$ group is at position 2. - Starting from the left: The carbon with the $-NH_2$ group is at position 3. 3. According to the lowest locant rule, we choose the numbering that assigns the amino group to position 2. 4. Combining the parts: The substituent is an "amino" group at position 2. 5. The IUPAC name is **2-aminobutanedioic acid**. Note: While "Aspartic acid" is the common name, the question specifically asks for the IUPAC name.

Final Answer: The correct IUPAC name is 2-aminobutanedioic acid.

Answer: (A)

Q17.

Solution

Concept:
Transition elements (d-block) generally exhibit variable oxidation states due to the participation of both $(n-1)d$ and ns electrons in bond formation. However, the elements at the beginning and the end of the first transition series often show fewer oxidation states due to the stability of empty, half-filled, or fully filled d-subshells.

Solution:
1. Analyze the electronic configurations and common oxidation states: - **Scandium (Sc):** $[Ar]3d^1 4s^2$. By losing all three outer electrons, it achieves the stable noble gas configuration of Argon. It only shows the +3 oxidation state. - **Zinc (Zn):** $[Ar]3d^{10} 4s^2$. It loses two $4s$ electrons to show a +2 oxidation state. It is often not considered a "true" transition element because its d-subshell is full. - **Manganese (Mn):** $[Ar]3d^5 4s^2$. It shows the maximum variety of oxidation states, ranging from +2 to +7. - **Iron (Fe):** $[Ar]3d^6 4s^2$. It commonly shows +2 and +3 oxidation states. 2. Among the options provided, Scandium is the only element that shows exclusively the +3 oxidation state in its compounds.

Final Answer: Scandium (Sc) shows only the +3 oxidation state.

Answer: (A)

Q18.

Solution

Concept:

The Arrhenius equation describes the temperature dependence of reaction rates:

$$k = Ae^{-E_a/RT}$$

Where k is the rate constant, A is the pre-exponential factor, E_a is the activation energy, R is the gas constant, and T is the absolute temperature. To find the slope of a linear plot, we take the natural logarithm of both sides.

Solution:

1. Take the natural log (ln) of the Arrhenius equation:

$$\ln k = \ln(Ae^{-E_a/RT})$$

$$\ln k = \ln A + \ln(e^{-E_a/RT})$$

2. Using the property $\ln(e^x) = x$:

$$\ln k = \ln A - \frac{E_a}{RT}$$

3. Rearrange this into the linear form $y = mx + c$:

$$\ln k = \left(-\frac{E_a}{R}\right)\left(\frac{1}{T}\right) + \ln A$$

4. In this equation: - $y = \ln k$ - $x = 1/T$ - m (slope) = $-E_a/R$ - c (intercept) = $\ln A$

Final Answer: The slope of the plot is $-E_a/R$.

Answer: (A)

Q19.

Solution

Concept:
The boiling points of hydrides of Group 15 elements (NH_3, PH_3, AsH_3, SbH_3) are governed by two types of intermolecular forces: Van der Waals forces (which increase with molecular size and mass) and Hydrogen bonding. Normally, boiling points increase down the group as molecular size increases, but NH_3 is an exception due to strong intermolecular hydrogen bonding.

Solution:
1. Trend due to Van der Waals forces: As we move from PH_3 to AsH_3 to SbH_3, the molecular size and surface area increase, leading to stronger London dispersion forces and higher boiling points ($PH_3 < AsH_3 < SbH_3$). 2. The anomaly of NH_3: Although NH_3 is the smallest, the high electronegativity of Nitrogen allows for hydrogen bonding. This significantly raises its boiling point above PH_3 and AsH_3. 3. Combining the factors: The overall order of boiling points is $PH_3 < AsH_3 < NH_3 < SbH_3$.
4. Therefore, PH_3 (Phosphine) has the lowest boiling point in the series because it lacks hydrogen bonding and has the weakest Van der Waals forces compared to the heavier hydrides.

Final Answer: PH_3 has the lowest boiling point.

Answer: (A)

Q20.

Solution

Concept:
The bromination of phenol is an electrophilic aromatic substitution. The outcome depends heavily on the solvent polarity. In highly polar solvents like water, phenol is highly activated because it exists as the phenoxide ion, leading to trisubstitution. In non-polar solvents like CS_2 or $CHCl_3$, the activation is less pronounced, leading to monosubstitution.

Solution:
1. Effect of the solvent (CS_2): CS_2 is a non-polar solvent. In this medium, the ionization of the $-OH$ group to the phenoxide ion is suppressed. 2. Directing effect: The $-OH$ group is strongly ortho- and para-directing. At low temperatures in a non-polar solvent, bromination occurs only once. 3. Regioselectivity: Both o-bromophenol and p-bromophenol are formed. However, due to steric hindrance between the hydroxyl group and the bromine atom at the ortho position, the para-isomer is the major product.
4. Comparison: If water were used as the solvent, the product would be $2, 4, 6$-tribromophenol (a white precipitate). Since CS_2 is used, we get the monosubstituted p-bromophenol as the major product.

Final Answer: The major product is p-bromophenol.

Answer: (B)

Q21.

Solution

Concept:
The coordination number refers to the number of atoms directly bonded to a central atom in a crystal lattice or molecule. In the case of allotropes of carbon like diamond and graphite, the hybridization of the carbon atoms determines the number of nearest neighbors and the resulting geometry.

Solution:
1. In a diamond crystal, each carbon atom is sp^3 hybridized. 2. Each carbon atom forms four strong covalent bonds (sigma bonds) with four other carbon atoms. 3. These four neighbors are arranged at the corners of a regular tetrahedron around the central carbon atom. 4. This three-dimensional network continues throughout the crystal, giving diamond its extreme hardness. 5. Since each carbon atom is directly surrounded by four other carbon atoms, its coordination number is 4.

Final Answer: The coordination number of Carbon in diamond is 4.

Answer: (A)

Q22.

Solution

Concept:

Crystal Field Theory (CFT) and High-Spin vs. Low-Spin complexes based on the Spectrochemical Series.

Solution:

Step 1: Determine the oxidation state and d-electron configuration of the central metal ions:

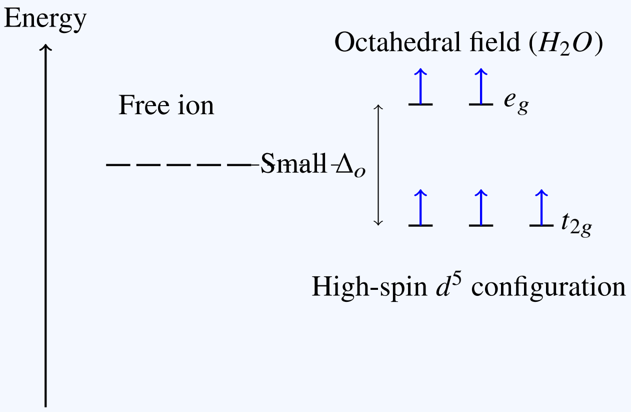
- (A) $[Co(CN)_6]^{3-}$: $Co^{3+}(d^6)$
- (B) $[Fe(CN)_6]^{4-}$: $Fe^{2+}(d^6)$
- (C) $[Fe(H_2O)_6]^{3+}$: $Fe^{3+}(d^5)$
- (D) $[Co(en)_3]^{3+}$: $Co^{3+}(d^6)$

Step 2: Identify the field strength of the ligands. Strong-field ligands (CN^-, en) cause large splitting ($\Delta_o > P$), leading to electron pairing and **low-spin** complexes. Weak-field ligands (H_2O, F^-) cause small splitting ($\Delta_o < P$), resulting in **high-spin** complexes.

Step 3: Analyze each complex:

- $[Co(CN)_6]^{3-}$, $[Fe(CN)_6]^{4-}$, and $[Co(en)_3]^{3+}$ involve strong-field ligands, making them low-spin.
- In $[Fe(H_2O)_6]^{3+}$, H_2O is a weak-field ligand. For $Fe^{3+}(d^5)$, the five electrons fill the t_{2g} and e_g orbitals singly before pairing ($t_{2g}^3 e_g^2$).

Step 4: Because $[Fe(H_2O)_6]^{3+}$ has the maximum number of unpaired electrons due to weak ligand field splitting, it is a high-spin complex.



Final Answer:

$$\boxed{[Fe(H_2O)_6]^{3+}}$$

Answer: (C)

Q23.

Solution

Concept:

Aldehydes react with alcohols in the presence of an acid catalyst (like dry HCl gas) to form acetals. When a 1,2-diol (like ethylene glycol) is used, the two hydroxyl groups react with the carbonyl group of the aldehyde to form a stable five-membered ring structure.

Solution:

1. Benzaldehyde (C_6H_5CHO) reacts with one molecule of ethylene glycol ($HO-CH_2-CH_2-OH$).
2. The reaction involves the nucleophilic attack of the glycol hydroxyl groups on the carbonyl carbon of benzaldehyde. 3. Under acidic conditions (dry HCl), water is eliminated (1 mole of water per mole of aldehyde). 4. Because both hydroxyl groups of the glycol are part of the same molecule, the resulting acetal is a cyclic structure known as a 1,3-dioxolane derivative.
5. This reaction is often used in organic synthesis to protect carbonyl groups because the cyclic acetal is stable to bases and nucleophiles but can be easily hydrolyzed back to the aldehyde with dilute aqueous acid.

Final Answer: The product formed is a cyclic acetal.

Answer: (A)

Q24.

Solution

Concept:

The extraction of gold and silver typically employs the MacArther-Forrest cyanide process. This process relies on the ability of cyanide ions to form highly stable, water-soluble coordination complexes with noble metals in the presence of air (oxygen) and water.

Solution:

1. Gold (Au) is chemically inert and does not dissolve in ordinary acids. 2. In the presence of $NaCN$ and atmospheric oxygen, gold undergoes an oxidative leaching process. 3. The chemical equation for this process is:

$$4Au + 8NaCN + 2H_2O + O_2 \rightarrow 4Na[Au(CN)_2] + 4NaOH$$

4. The role of $NaCN$ is to provide the cyanide ligand (CN^-) which coordinates with the gold to form the dicyanoaurate(I) ion, $[Au(CN)_2]^-$. 5. This complex is soluble in water, allowing the gold to be separated from the insoluble gangue (rock and impurities). The gold is later recovered from the solution by displacement with a more reactive metal like Zinc.

Final Answer: The role of $NaCN$ is to form a soluble complex.

Answer: (C)

Q25.

Solution

Concept:

Boiling point elevation is a colligative property, meaning it depends on the total number of solute particles in the solution rather than their identity. The elevation in boiling point (ΔT_b) is given by:

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

Where i is the Van't Hoff factor (the number of particles produced per formula unit), K_b is the ebullioscopic constant, and m is the molality. For solutions with the same molarity, the one with the highest Van't Hoff factor (i) will have the highest boiling point.

Solution:

1. Determine the Van't Hoff factor (i) for each solute, assuming complete dissociation: - **Glucose:** A non-electrolyte; it does not dissociate. $i = 1$. - $NaCl$**:** Dissociates into Na^+ and Cl^-. $i = 2$. - $CaCl_2$**:** Dissociates into Ca^{2+} and $2Cl^-$. $i = 3$. - $AlCl_3$**:** Dissociates into Al^{3+} and $3Cl^-$. $i = 4$.
2. Compare the total particle concentration ($i \times M$): - Glucose: $1 \times 1.0 = 1.0$ M - $NaCl$: $2 \times 1.0 = 2.0$ M - $CaCl_2$: $3 \times 1.0 = 3.0$ M - $AlCl_3$: $4 \times 1.0 = 4.0$ M
3. Since $AlCl_3$ produces the greatest number of particles in solution, it will cause the maximum elevation in boiling point.

Final Answer: 1.0 M $AlCl_3$ will have the highest boiling point.

Answer: (D)

Q26.

Solution

Concept:
For a zero-order reaction, the rate of reaction is independent of the concentration of the reactants. The integrated rate law for a zero-order reaction is:

$$[A] = [A]_0 - kt$$

The half-life ($t_{1/2}$) is the time required for the concentration of a reactant to decrease to half of its initial value ($[A] = [A]_0/2$).

Solution:
1. Substitute $[A] = \frac{[A]_0}{2}$ into the zero-order rate equation:

$$\frac{[A]_0}{2} = [A]_0 - k \cdot t_{1/2}$$

2. Rearrange the equation to solve for $t_{1/2}$:

$$k \cdot t_{1/2} = [A]_0 - \frac{[A]_0}{2}$$

$$k \cdot t_{1/2} = \frac{[A]_0}{2}$$

$$t_{1/2} = \frac{[A]_0}{2k}$$

3. Analyze the relationship: In the expression $t_{1/2} = \frac{[A]_0}{2k}$, the rate constant k is a constant value. Therefore, $t_{1/2}$ is directly proportional to the initial concentration $[A]_0$.

Final Answer: The half-life of a zero-order reaction is proportional to the initial concentration.

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

Q27.

Solution

Concept:

The acid-base character of oxides follows a periodic trend. As we move across a period from left to right, the electronegativity of the element increases, and the character of its oxide changes from strongly basic to amphoteric and then to increasingly acidic. This is related to the metallic or non-metallic nature of the element.

Solution:

1. Identify the position of the elements in the third period: Sodium (Na), Aluminum (Al), Silicon (Si), and Sulfur (S). 2. Analyze the nature of each oxide: - Na_2O**:** Sodium is a highly electropositive alkali metal. Its oxide reacts with water to form a strong base ($NaOH$). It is **strongly basic**. - Al_2O_3**:** Aluminum is a metal/metalloid transition point. Its oxide reacts with both acids and bases. It is **amphoteric**. - SiO_2**:** Silicon is a non-metal. Its oxide is **weakly acidic**. - SO_3**:** Sulfur is a non-metal. Its oxide reacts with water to form a strong acid (H_2SO_4). It is **strongly acidic**. 3. Following the trend (Basic → Amphoteric → Acidic), the oxide of the element furthest to the left (Na) is the most basic.

Final Answer: Na_2O is the most basic oxide.

Answer: (C)

Q28.

Solution

Concept:

Alcohols react with phosphorus halides (PCl_5, PCl_3) or thionyl chloride ($SOCl_2$) to undergo a substitution reaction. The hydroxyl group ($-OH$) of the alcohol is replaced by a halogen atom (specifically a chlorine atom in this case) to form an alkyl halide.

Solution:

1. Identify the reactants: Ethanol (CH_3CH_2OH) and Phosphorus pentachloride (PCl_5). 2. Analyze the reaction: PCl_5 is a chlorinating agent. The reaction proceeds with the evolution of hydrogen chloride gas and phosphorus oxychloride. 3. Write the chemical equation:

$$CH_3CH_2OH + PCl_5 \rightarrow CH_3CH_2Cl + POCl_3 + HCl$$

4. Identify the organic product (X): The ethyl group remains intact while the $-OH$ is replaced by $-Cl$, resulting in the formation of Chloroethane (ethyl chloride). 5. Other options like ethene ($CH_2 = CH_2$) would require a dehydration catalyst like concentrated H_2SO_4, and diethyl ether would require specific conditions with excess alcohol.

Final Answer: The product X is CH_3CH_2Cl.

Answer: (A)

Q29.

Solution

Concept:
Formal charge is the charge assigned to an atom in a molecule, assuming that electrons in all chemical bonds are shared equally between atoms. The formula to calculate formal charge (FC) is:

$$FC = [V] - [L] - \frac{1}{2}[B]$$

Where: - V is the number of valence electrons of the free atom. - L is the number of electrons in lone pairs. - B is the number of bonding (shared) electrons.

Solution:
1. Draw the Lewis structure of Ozone (O_3): Ozone consists of three oxygen atoms. The central oxygen atom forms a double bond with one terminal oxygen and a single bond with the other. To satisfy the octet rule, the central oxygen must have one lone pair.
2. Identify the values for the central Oxygen atom: - Valence electrons for Oxygen (V) = 6. - The central atom has 1 lone pair, so $L = 2$. - The central atom has 3 bonds (1 double + 1 single), meaning $B = 6$ shared electrons.
3. Calculate the formal charge:

$$FC = 6 - 2 - \frac{1}{2}(6)$$

$$FC = 6 - 2 - 3$$

$$FC = +1$$

4. Verification: The terminal oxygen with the double bond has a formal charge of 0, and the terminal oxygen with the single bond has a formal charge of -1. The sum $(0 + 1 - 1) = 0$, which matches the neutral charge of the O_3 molecule.
Final Answer: The formal charge on the central oxygen atom is +1.

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

Q30.

Solution

Concept:

Pernicious anemia is a specific type of vitamin deficiency anemia. It is characterized by the body's inability to absorb a specific vitamin from the gastrointestinal tract due to the lack of "intrinsic factor," a protein produced in the stomach. This vitamin is essential for the maturation of red blood cells (erythrocytes) and the maintenance of the nervous system.

Solution:

1. Analyze the roles of the given vitamins: - **Vitamin** B_1 **(Thiamine):** Deficiency causes Beri-beri. - **Vitamin** B_2 **(Riboflavin):** Deficiency causes Cheilosis (cracking of lips). - **Vitamin** B_{12} **(Cyanocobalamin):** Deficiency leads to the failure of red blood cells to mature, resulting in Pernicious Anemia. It is unique as it contains the metal ion Cobalt. - **Vitamin K:** Essential for blood clotting; deficiency increases the time required for blood to clot. 2. Pernicious anemia specifically refers to the megaloblastic anemia caused by the malabsorption or lack of Vitamin B_{12}.

Final Answer: Vitamin B_{12} deficiency causes Pernicious Anemia.

Answer: (C)

Q31.

Solution

Concept:

Standard molar entropy (S°) and states of matter.

Solution:

Step 1: Entropy is a measure of the degree of randomness or disorder in a system. For a given substance, entropy depends significantly on its physical state.

Step 2: Generally, the entropy of a substance follows the order:

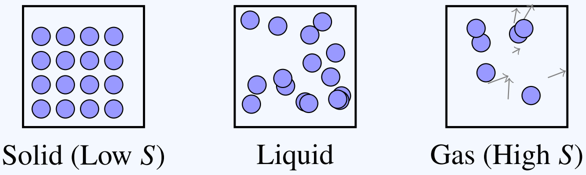
$$S^\circ_{\text{gas}} \gg S^\circ_{\text{liquid}} > S^\circ_{\text{solid}}$$

This is because particles in the gaseous state have much higher translational, rotational, and vibrational freedom compared to liquids and solids.

Step 3: Analyze the given options:

- $H_2(g)$: Gaseous state (highest disorder).
- $C(\text{graphite})$: Solid state (ordered crystal lattice).
- $H_2O(l)$: Liquid state (moderate disorder).
- $I_2(s)$: Solid state (ordered molecular crystal).

Step 4: Since $H_2(g)$ is the only substance in the gaseous state among the choices, it possesses the highest standard molar entropy.



Final Answer:

$$\boxed{H_2(g)}$$

Answer: (A)

Q32.

Solution

Concept:

The reaction between an aromatic hydrocarbon and a halogen depends on the catalyst and conditions. 1. In the presence of a Lewis acid catalyst (like $FeCl_3$ or $AlCl_3$), Electrophilic Aromatic Substitution (EAS) occurs on the ring. 2. In the presence of light ($h\nu$) or heat and without a catalyst, free radical substitution occurs on the side chain (alkyl group).

Solution:

1. Identify the reagents: Toluene (methylbenzene) is treated with Cl_2 in the presence of $FeCl_3$. 2. Role of $FeCl_3$: It acts as a Lewis acid catalyst to generate the chloronium ion (Cl^+), which is a strong electrophile. 3. Directing effect: The methyl group ($-CH_3$) attached to the benzene ring is an electron-donating group. It activates the ring and directs the incoming electrophile to the *ortho* and *para* positions. 4. Reaction outcome: The chlorine atom replaces a hydrogen atom on the benzene ring, not on the methyl side chain. This produces a mixture of *ortho*-chlorotoluene and *para*-chlorotoluene. 5. Comparison: If the reaction were conducted with Cl_2 and UV light/heat, the product would be Benzyl chloride ($C_6H_5CH_2Cl$).

Final Answer: The product is a mixture of o-chlorotoluene and p-chlorotoluene.

Answer: (C)

Q33.

Solution

Concept:

C_p and C_v represent the molar heat capacities of a gas at constant pressure and constant volume, respectively. For an ideal gas, the internal energy depends only on temperature. When heat is added at constant pressure, some energy is used to do expansion work ($P\Delta V$), whereas at constant volume, all heat goes into increasing internal energy. This leads to the relationship known as Mayer's formula.

Solution:

1. Define Enthalpy (H) for an ideal gas:

$$H = U + PV$$

2. For one mole of an ideal gas, $PV = RT$, so:

$$H = U + RT$$

3. Differentiate both sides with respect to temperature (T):

$$\frac{dH}{dT} = \frac{dU}{dT} + \frac{d(RT)}{dT}$$

4. By definition, $C_p = \frac{dH}{dT}$ and $C_v = \frac{dU}{dT}$. 5. Substituting these definitions into the equation:

$$C_p = C_v + R$$

6. Rearranging the terms gives the standard relationship:

$$C_p - C_v = R$$

Final Answer: The relationship is $C_p - C_v = R$.

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

Q34.

Solution

Concept:

Polymers are classified based on their response to heat: 1. **Thermoplastics:** Linear or slightly branched polymers that soften on heating and harden on cooling. They can be remolded multiple times (e.g., Polystyrene, PVC, Nylon). 2. **Thermosetting polymers:** Cross-linked or heavily branched molecules that undergo a chemical change (extensive cross-linking) upon heating and set into an infusible mass. Once set, they cannot be remelted or remolded.

Solution:

1. **Polystyrene:** A thermoplastic used in packaging and disposable cutlery. 2. **PVC (Polyvinyl Chloride):** A common thermoplastic used for pipes and insulation. 3. **Bakelite:** A phenol-formaldehyde resin. It is a heavily cross-linked polymer. When heated, it forms a permanent three-dimensional network structure that does not soften again. Therefore, it is a thermosetting polymer. 4. **Nylon-6:** A fiber-forming thermoplastic polyamide.

Final Answer: Bakelite is a thermosetting polymer.

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

Q35.

Solution

Concept:

The hybridization of an atom is determined by the number of steric units (sigma bonds + lone pairs) surrounding it. - 2 units: sp - 3 units: sp^2 - 4 units: sp^3 - 5 units: sp^3d - 6 units: sp^3d^2

Solution:

1. Identify the central atom: Phosphorus (P), which belongs to Group 15 and has 5 valence electrons. 2. Determine the bonding: In PCl_5, phosphorus forms 5 single (sigma) bonds with 5 chlorine atoms. 3. Check for lone pairs: Phosphorus uses all 5 valence electrons for bonding, so there are 0 lone pairs. 4. Calculate steric number: 5 (sigma bonds) +0 (lone pairs) = 5. 5. Determine hybridization: A steric number of 5 corresponds to sp^3d hybridization. 6. Geometry: The sp^3d orbitals arrange themselves in a **Trigonal Bipyramidal** geometry to minimize electron repulsion.

Final Answer: The hybridization of phosphorus in PCl_5 is sp^3d.

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

Q36.

Solution

Concept:

Grignard reagents ($RMgX$) are powerful nucleophiles that react with carbon dioxide (CO_2) to form salts of carboxylic acids. Upon subsequent acid hydrolysis, these salts are converted into the corresponding carboxylic acids. This reaction is a standard method for increasing a carbon chain by one carbon atom.

Solution:

1. Nucleophilic Attack: The nucleophilic methyl group from methyl magnesium bromide (CH_3MgBr) attacks the electrophilic carbon of CO_2.

$$CH_3 - MgBr + O = C = O \rightarrow CH_3 - COOMgBr$$

2. Formation of Intermediate: This forms a magnesium salt of a carboxylic acid (magnesium bromide ethanoate). 3. Hydrolysis: The addition of water (usually with dilute acid) breaks the $O - MgBr$ bond.

$$CH_3 - COOMgBr + H_2O \rightarrow CH_3 - COOH + Mg(OH)Br$$

4. Identification: The resulting product CH_3COOH is Acetic acid (ethanoic acid).

Final Answer: The product is Acetic acid.

Answer: (B)

Q37.

Solution

Concept:

The pH of an aqueous salt solution is determined by the hydrolysis of its constituent ions. Salts derived from a strong acid and a weak base, or those containing small, highly charged metal cations, undergo hydrolysis to yield acidic solutions.

Solution:

1. Identify the origin of the salt: $FeCl_3$ is formed from the reaction of a weak base ($Fe(OH)_3$) and a strong acid (HCl). 2. Dissociation: In water, $FeCl_3$ dissociates completely:

$$FeCl_3(s) \rightarrow Fe^{3+}(aq) + 3Cl^-(aq)$$

3. Cationic Hydrolysis: The Cl^- ion, being the conjugate base of a strong acid, does not react with water. However, the Fe^{3+} ion is a small, highly charged cation that acts as a Lewis acid. It undergoes hydrolysis by reacting with water molecules:

$$[Fe(H_2O)_6]^{3+} + H_2O \rightleftharpoons [Fe(H_2O)_5(OH)]^{2+} + H_3O^+$$

4. Result: The production of hydronium ions (H_3O^+) increases the concentration of H^+ in the solution, making the solution acidic.

Final Answer: An aqueous solution of $FeCl_3$ is acidic.

Answer: (A)

Q38.

Solution

Concept:

The general unit for the rate constant (k) of a reaction of order n is given by the formula:

$$\text{Unit of } k = (mol\ L^{-1})^{1-n}\ s^{-1}$$

For a second-order reaction, $n = 2$.

Solution:

1. Substitute $n = 2$ into the general formula:

$$\text{Unit} = (mol\ L^{-1})^{1-2}\ s^{-1}$$

$$\text{Unit} = (mol\ L^{-1})^{-1}\ s^{-1}$$

2. Simplify the expression:

$$\text{Unit} = mol^{-1}\ L\ s^{-1} \text{ or } L\ mol^{-1}\ s^{-1}$$

3. Verification using the rate law: For a reaction Rate $= k[A]^2$, the units are:

$$mol\ L^{-1}\ s^{-1} = k \cdot (mol\ L^{-1})^2$$

$$k = \frac{mol\ L^{-1}\ s^{-1}}{mol^2\ L^{-2}} = L\ mol^{-1}\ s^{-1}$$

Final Answer: The unit for a second-order rate constant is $L\ mol^{-1}\ s^{-1}$.

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

Q39.

Solution

Concept:
A "meso" compound is a molecule that contains two or more chiral centers (stereocenters) but is overall achiral (optically inactive) due to the presence of an internal plane of symmetry or a center of inversion.

Solution:
1. **Conditions for Meso:** The molecule must have identical chiral centers and a plane of symmetry that bisects the molecule into two mirror-image halves. 2. **Analysis of Tartaric acid:** Tartaric acid ($HOOC-CH(OH)-CH(OH)-COOH$) has two chiral carbons. 3. In the $(2R,3S)$ configuration, the top half of the molecule is the mirror image of the bottom half. 4. This internal plane of symmetry causes the optical rotation of one half to cancel out the other, making the molecule achiral.

5. Other options: 2, 3-pentanediol cannot be meso because the two chiral centers are not identical (one is attached to an ethyl group, the other to a methyl group).

Final Answer: Tartaric acid with a plane of symmetry is the meso form.

Answer: (C)

Q40.

Solution

Concept:
The hydrogenation of vegetable oils (unsaturated fats) to produce vegetable ghee or vanasparti (saturated fats) is an addition reaction where hydrogen gas is added across the carbon-carbon double bonds in the presence of a finely divided metal catalyst.

Solution:
1. The reaction is a form of heterogeneous catalysis. 2. Finely divided **Nickel (Ni)** is the most commonly used catalyst for this industrial process because it is efficient and cost-effective. 3. The metal surface provides a site for both the H_2 molecules and the unsaturated oil molecules to adsorb, weakening the bonds and allowing the reaction to occur at lower temperatures.

4. Other catalysts: V_2O_5 is used in the Contact process, and Fe is used in the Haber process. While Pt can catalyze hydrogenation, Ni is the standard choice for industrial oil processing.

Final Answer: The catalyst used in the hydrogenation of oils is Ni.

Answer: (C)

Q41.

Solution

Concept:

Structure and bonding in oxoacids of sulfur, specifically identifying the peroxide ($O - O$) linkage in peroxy acids.

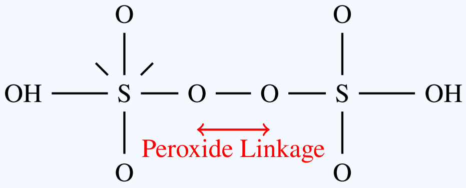
Solution:

Step 1: Analyze the chemical formulas and common names of the given oxoacids:

- $H_2S_2O_7$: Pyrosulfuric acid (Oleum) - Contains an $S - O - S$ linkage.
- $H_2S_2O_8$: Peroxodisulfuric acid (Marshall's acid) - Contains an $O - O$ (peroxide) linkage.
- H_2SO_4: Sulfuric acid - Simple tetrahedral structure with no $O - O$ bond.
- $H_2S_2O_3$: Thiosulfuric acid - Contains an $S = S$ linkage (one oxygen is replaced by sulfur).

Step 2: In $H_2S_2O_8$, the oxidation state of Sulfur appears to be +7 by calculation, but the maximum oxidation state of Sulfur is +6. This discrepancy indicates the presence of a peroxide bond ($O - O$) where two oxygens have an oxidation state of -1.

Step 3: The structure of Marshall's acid consists of two HSO_4 units linked by an oxygen-oxygen bond: $HO - SO_2 - O - O - SO_2 - OH$.



Structure of $H_2S_2O_8$ (Marshall's acid)

Final Answer:

$$\boxed{H_2S_2O_8}$$

Answer: (B)

Q42.

Solution

Concept:
The Reimer-Tiemann reaction is a classic organic reaction used for the ortho-formylation of phenols. It involves the treatment of phenol with chloroform ($CHCl_3$) in the presence of a strong base (like $NaOH$ or KOH).

Solution:
1. **Mechanism:** The reaction proceeds via the generation of a reactive intermediate called dichlorocarbene ($: CCl_2$). 2. The carbene acts as an electrophile and attacks the ortho position of the phenoxide ion (formed by the reaction of phenol with the base). 3. **Intermediate:** An intermediate substituted benzal chloride is formed, which undergoes rapid hydrolysis in the basic medium. 4. **Final Product:** Acidification of the mixture yields 2-hydroxybenzaldehyde, commonly known as **Salicylaldehyde**.
5. **Note:** If carbon tetrachloride (CCl_4) is used instead of chloroform, the major product would be Salicylic acid. However, the standard Reimer-Tiemann reaction refers to the use of chloroform.
Final Answer: The product of the Reimer-Tiemann reaction is Salicylaldehyde.

Answer: (B)

Q43.

Solution

Concept:
The packing efficiency of a crystal lattice is the percentage of total space filled by the constituent particles. The remaining volume is known as the empty space or "void" space.

Solution:
1. In an FCC (or Cubic Close Packed, CCP) lattice, atoms are present at the corners and the centers of all the faces of the cube. 2. The number of atoms per unit cell for FCC is $Z = 4$. 3. The relationship between the edge length (a) and the radius of the atom (r) is:

$$a = 2\sqrt{2}r$$

4. The **Packing Efficiency** is calculated as:

$$\text{Packing Efficiency} = \frac{\text{Volume of 4 spheres}}{\text{Total volume of unit cell}} \times 100$$

$$\text{Packing Efficiency} \approx 74\%$$

5. The **Empty Space** is:

$$\text{Empty Space} = 100\% - 74\% = 26\%$$

Final Answer: The empty space in an FCC lattice is 26%.

Answer: (A)

Q44.

Solution

Concept:

The reaction of a carbohydrate with hydroiodic acid (HI) and red phosphorus is a powerful reduction method used to determine the skeletal structure of the molecule.

Solution:

1. Glucose ($C_6H_{12}O_6$) is a polyhydroxy aldehyde with a six-carbon chain. 2. Prolonged heating with HI acts as a strong reducing agent that removes all oxygen atoms (hydroxyl and aldehyde groups) from the carbon chain. 3. The reaction results in the formation of a straight-chain alkane with six carbon atoms.

$$C_6H_{12}O_6 \xrightarrow[heat]{HI/P_{red}} CH_3 - CH_2 - CH_2 - CH_2 - CH_2 - CH_3$$

4. The formation of **n-hexane** proves that all six carbon atoms in glucose are linked in a straight, unbranched chain.

Final Answer: Glucose on prolonged heating with HI gives n-hexane.

Answer: (A)

Q45.

Solution

Concept:

In an isothermal (constant temperature) reversible process, the gas is in equilibrium with its surroundings at every step. For an ideal gas, the internal energy U depends only on temperature, so $\Delta U = 0$. The work done (w) is the integral of $P \cdot dV$.

Solution:

1. Start with the definition of work for a reversible expansion:

$$w = -\int_{V_1}^{V_2} P_{ext}\, dV$$

2. For a reversible process, $P_{ext} = P_{gas}$. Using the ideal gas law ($PV = nRT$):

$$P = \frac{nRT}{V}$$

3. Substitute P into the integral:

$$w = -\int_{V_1}^{V_2} \frac{nRT}{V}\, dV$$

4. Since n, R, and T are constant, they can be pulled out:

$$w = -nRT \int_{V_1}^{V_2} \frac{1}{V}\, dV = -nRT\,[\ln V]_{V_1}^{V_2}$$

$$w = -nRT \ln\left(\frac{V_2}{V_1}\right)$$

5. **Note:** In thermodynamics, work done *by* the system is negative according to the IUPAC convention.

Final Answer: The work done is $-nRT \ln(V_2/V_1)$.

Answer: (A)

Q46.

Solution

Concept:
The oxidizing power of halogens reflects their ability to accept electrons and be reduced ($X_2+2e^- \rightarrow 2X^-$). This depends on the standard reduction potential, which is influenced by bond dissociation enthalpy, electron gain enthalpy, and hydration enthalpy of the resulting ions.

Solution:
1. **Trend:** Oxidizing power decreases down Group 17 ($F_2 > Cl_2 > Br_2 > I_2$). 2. **Fluorine (F_2):** Although Chlorine has a more negative electron gain enthalpy, Fluorine is the strongest oxidizing agent due to: * The low bond dissociation enthalpy of the $F-F$ bond (due to high inter-electronic repulsion). * The extremely high hydration enthalpy of the small F^- ion. 3. Fluorine can oxidize all other halide ions to their respective halogens in aqueous solution:

$$F_2 + 2X^- \longrightarrow 2F^- + X_2 \quad (X = Cl, Br, I)$$

Final Answer: F_2 is the strongest oxidizing agent.

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

Q47.

Solution

Concept:
Polymers are large molecules formed by the repeated linking of smaller units called monomers. Teflon is a well-known synthetic fluoropolymer used extensively for non-stick coatings on cookware due to its high resistance to heat and chemical inertness.

Solution:
1. **Identification:** Teflon is the brand name for Polytetrafluoroethylene (PTFE). 2. **Structure:** As the name suggests, it is a polymer of tetrafluoroethene. 3. **Reaction:** Under high pressure and in the presence of a free radical or persulphate catalyst, tetrafluoroethene molecules undergo addition polymerization:

$$n(CF_2 = CF_2) \rightarrow -[CF_2 - CF_2]-_n$$

4. **Other options:** * Vinyl chloride is the monomer for PVC. * Isoprene is the monomer for natural rubber. * Styrene is the monomer for polystyrene.

Final Answer: The monomer of Teflon is Tetrafluoroethene.

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

Q48.

Solution

Concept:
For extremely dilute solutions of strong acids ($< 10^{-6}$ M), the concentration of H^+ ions provided by the acid is comparable to or smaller than the concentration of H^+ ions naturally present in water due to auto-ionization (10^{-7} M at $25°C$). Therefore, the contribution from water must be included.

Solution:
1. **Total $[H^+]$:** Let $[H^+]_{total} = [H^+]_{acid} + [H^+]_{water}$. 2. In water, $[H^+][OH^-] = 10^{-14}$. If x is the H^+ concentration from water, then total $[H^+] = 10^{-8} + x$. 3. Since OH^- also comes only from water, $[OH^-] = x$. 4. Setting up the equation:

$$(10^{-8} + x)(x) = 10^{-14}$$

$$x^2 + 10^{-8}x - 10^{-14} = 0$$

5. Solving this quadratic equation for x gives $x \approx 0.95 \times 10^{-7}$ M. 6. Total $[H^+] = 10^{-8} + 0.95 \times 10^{-7} = 1.05 \times 10^{-7}$ M. 7. Calculating pH:

$$pH = -\log(1.05 \times 10^{-7}) \approx 6.98$$

8. **Logic check:** Adding any amount of acid to water, no matter how small, will make the solution slightly acidic (pH $<$ 7). A pH of 8 would imply a basic solution, which is impossible for an HCl solution.

Final Answer: The pH of 10^{-8} M HCl is between 6.9 and 7.

Answer: (C)

Q49.

Solution

Concept:
Linkage isomerism occurs in coordination compounds containing **ambidentate ligands**. These are ligands that possess two different donor atoms and can coordinate to the central metal atom through either one of them.

Solution:
1. **Analyze the ligands:** * **H_2O and NH_3:** These are monodentate ligands with only one type of donor atom (Oxygen and Nitrogen, respectively). * **Cl^-:** A simple halide ion with only one donor site. * **SCN^- (Thiocyanate):** This is an ambidentate ligand. It can bind to a metal through the Sulfur atom ($M - SCN$, thiocyanato-S) or through the Nitrogen atom ($M - NCS$, isothiocyanato-N). 2. Other common examples of ligands showing linkage isomerism include NO_2^- (Nitro/Nitrito) and CN^- (Cyano/Isocyano).

Final Answer: Linkage isomerism is shown by SCN^-.

Answer: (C)

Q50.

Solution

Concept:
The oxidation number of an element in a compound is determined based on the relative electronegativities of the atoms involved. Oxygen is the second most electronegative element, but **Fluorine** is the most electronegative element in the periodic table.

Solution:
1. In almost all compounds, Oxygen has an oxidation state of -2 (or -1 in peroxides). However, when bonded to Fluorine, Oxygen must take a positive oxidation state because Fluorine always takes a -1 oxidation state in its compounds. 2. Let the oxidation number of Oxygen in OF_2 be x. 3. The sum of oxidation numbers in a neutral molecule is zero:

$$x + 2(\text{oxidation state of F}) = 0$$

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

$$x - 2 = 0$$

$$x = +2$$

4. In this molecule, Oxygen is less electronegative than Fluorine, so the shared electrons are pulled closer to the Fluorine atoms.

Final Answer: The oxidation number of Oxygen in OF_2 is +2.

Answer: (D)

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	A	3	B	4	B	5	B
6	A	7	A	8	B	9	C	10	A
11	C	12	C	13	B	14	B	15	C
16	A	17	A	18	A	19	A	20	B
21	A	22	C	23	A	24	C	25	D
26	A	27	C	28	A	29	B	30	C
31	A	32	C	33	A	34	C	35	B
36	B	37	A	38	C	39	C	40	C
41	B	42	B	43	A	44	A	45	A
46	A	47	B	48	C	49	C	50	D