MHT-CET Chemistry Sample Paper-11

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 face-centered cubic (fcc) unit cell has an edge length of 400 pm. If the density of the metal is 10 g cm^{-3}, the molar mass of the metal is approximately: (Use $N_A = 6 \times 10^{23}$)

(A) 96 g mol^{-1}

(B) 48 g mol^{-1}

(C) 64 g mol^{-1}

(D) 32 g mol^{-1}

Q2. The rate of a certain reaction becomes double when the temperature is raised from 300 K to 310 K. The activation energy (E_a) for this reaction is: (Given $R = 8.314$ J K^{-1} mol^{-1}, $\ln 2 = 0.693$)

(A) 53.6 kJ mol^{-1}

(B) 48.5 kJ mol^{-1}

(C) 58.3 kJ mol^{-1}

(D) 60.1 kJ mol^{-1}

Q3. Which of the following compounds will not show a positive Iodoform test?

(A) Ethanol

(B) Isopropyl alcohol

(C) Pentan-3-one

(D) Acetophenone

Q4. An organic compound 'A' with formula $C_3H_8O_3$ reacts with Fenton's reagent to give a compound that reduces Tollen's reagent. 'A' is most likely:

(A) Propan-1-ol

(B) Glycerol

(C) Propylene glycol

(D) Propan-2-ol

Q5. The number of bridging CO ligands and $Co - Co$ bonds in $Co_2(CO)_8$ in its solid state are respectively:

(A) 2 and 1

(B) 0 and 1

(C) 2 and 0

(D) 3 and 1

Q6. The standard reduction potentials of Li^+/Li, Zn^{2+}/Zn, and Ag^+/Ag are -3.05 V, -0.76 V, and $+0.80$ V respectively. The strongest reducing agent is:

(A) Ag

(B) Li

(C) Zn

(D) Li^+

Q7. The major product formed when 2-methylbut-2-ene reacts with HBr in the presence of peroxides is:

(A) 2-bromo-2-methylbutane

(B) 2-bromo-3-methylbutane

(C) 1-bromo-2-methylbutane

(D) 2,3-dibromo-2-methylbutane

Q8. The bond order of O_2^+ and O_2^- are respectively:

(A) 2.5 and 1.5

(B) 1.5 and 2.5

(C) 2.0 and 1.0

(D) 2.5 and 2.0

Q9. A 0.1 m aqueous solution of a weak acid is 30% ionized. If K_f for water is 1.86 K kg mol^{-1}, the freezing point of the solution is:

(A) $-0.24\ ^\circ C$

(B) $-0.18\ ^\circ C$

(C) $-0.54\ ^\circ C$

(D) $-0.32\ ^\circ C$

Q10. Which of the following elements has the highest second ionization enthalpy?

(A) Na

(B) Mg

(C) Al

(D) Si

Q11. The geometry and magnetic nature of $[Ni(CN)_4]^{2-}$ are:

(A) Tetrahedral, Paramagnetic

(B) Square planar, Diamagnetic

(C) Square planar, Paramagnetic

(D) Tetrahedral, Diamagnetic

Q12. In the Gabriel Phthalimide synthesis, the reactant used to introduce the alkyl group is a:

(A) Primary alkyl halide

(B) Tertiary alkyl halide

(C) Aryl halide

(D) Secondary alkyl halide

Q13. The process of converting a precipitate into a colloidal sol by adding an electrolyte is called:

(A) Peptization

(B) Coagulation

(C) Dialysis

(D) Tyndall effect

Q14. Calculate the work done (in Joules) when 2 moles of an ideal gas expand isothermally and reversibly from 10 L to 20 L at 300 K. (Given $R = 8.314$ J K^{-1} mol^{-1}, $\ln 2 = 0.693$)

(A) -3457 J

(B) -1728 J

(C) $+3457$ J

(D) -6914 J

Q15. The pH of a 10^{-8} M HCl solution is:

(A) 8

(B) 7

(C) 6.98

(D) 7.02

Q16. Which of the following is the most stable conformer of n-butane?

(A) Gauche

(B) Anti-staggered

(C) Partially eclipsed

(D) Fully eclipsed

Q17. The reaction of PCl_3 with water gives:

(A) $H_3PO_4 + HCl$

(B) $H_3PO_3 + HCl$

(C) $PH_3 + HCl$

(D) $POCl_3 + HCl$

(E) $H_3PO_2 + HCl$

Q18. The hybrid state of S in SF_6 is:

(A) sp^3d

(B) sp^3d^2

(C) sp^3d^3

(D) dsp^2

Q19. Phenol reacts with neutral $FeCl_3$ to give a characteristic color of:

(A) Red

(B) Violet

(C) Green

(D) Blue

Q20. The catalyst used in the hydrogenation of oils to fats is:

(A) Pt

(B) Ni

(C) Pd

(D) V_2O_5

Q21. The number of optical isomers for lactic acid is:

(A) 2

(B) 3

(C) 4

(D) 1

Q22. In a first-order reaction, the concentration of the reactant decreases from 0.8 M to 0.4 M in 15 minutes. The time taken for the concentration to change from 0.1 M to 0.025 M is:

(A) 30 minutes

(B) 15 minutes

(C) 45 minutes

(D) 60 minutes

Q23. Which of the following ions has the largest ionic radius?

(A) Na^+

(B) Mg^{2+}

(C) F^-

(D) O^{2-}

Q24. The monomer of Buna-N is:

(A) Styrene and 1,3-Butadiene

(B) Vinyl chloride

(C) Acrylonitrile and 1,3-Butadiene

(D) Isoprene

Q25. The oxidation state of Cr in CrO_5 is:

(A) +10

(B) +6

(C) +4

(D) +5

Q26. Identify the product 'Z' in the following sequence: $Benzene \xrightarrow{CH_3Cl/AlCl_3} X \xrightarrow{KMnO_4/OH^-} Y \xrightarrow{SOCl_2} Z$

(A) Benzyl chloride

(B) Benzoyl chloride

(C) Chlorobenzene

(D) Acetophenone

Q27. The solubility product of Ag_2CrO_4 is 3.2×10^{-11}. Its solubility in mol/L is:

(A) 2×10^{-4}

(B) 8×10^{-4}

(C) 1.26×10^{-4}

(D) 4×10^{-4}

Q28. Which of the following ligands is a bidentate ligand?

(A) $EDTA$

(B) Ethylenediamine

(C) NH_3

(D) CN^-

Q29. What is the change in internal energy (ΔU) for a process where 500 J of heat is absorbed by the system and 200 J of work is done by the system?

(A) 700 J

(B) 300 J

(C) -300 J

(D) 500 J

Q30. Which of the following contains the highest number of atoms?

(A) 1 g of $Au(s)$

(B) 1 g of $Ag(s)$

(C) 1 g of $Cu(s)$

(D) 1 g of $Li(s)$

Q31. The reagent used for the conversion of Propan-2-ol to Acetone is:

(A) $LiAlH_4$

(B) $KMnO_4/H^+$

(C) $Cu/573$ K

(D) H_2/Pd

Q32. Which of the following shows the Schottky defect?

(A) $NaCl$

(B) $AgCl$

(C) ZnS

(D) AgI

Q33. The osmotic pressure of a solution containing 6 g of urea (Molar mass = 60) in 1 L of solution at 300 K is: (Given $R = 0.0821$ L atm K^{-1} mol^{-1})

(A) 2.46 atm

(B) 4.92 atm

(C) 1.23 atm

(D) 0.246 atm

Q34. Which of the following is an example of an addition polymer?

(A) Nylon 6,6

(B) Terylene

(C) Polyethylene

(D) Bakelite

Q35. The most acidic hydrogen is present in:

(A) Ethane

(B) Ethyne

(C) Ethene

(D) Benzene

Q36. A compound C_2H_6O has two isomers. The isomer which reacts with Sodium metal is:

(A) Ethanol

(B) Dimethyl ether

(C) Methanol

(D) Acetone

Q37. The primary structure of a protein refers to:

(A) Helix structure

(B) Sequence of amino acids

(C) Folding of the chain

(D) Three-dimensional shape

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

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

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

(C) s^{-1}

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

Q39. The most stable oxidation state of Lanthanides is:

(A) +2

(B) +3

(C) +4

(D) +5

Q40. Which of the following is a transition element?

(A) Zn

(B) Cd

(C) Hg

(D) Fe

Q41. The geometry of XeF_2 is:

(A) Linear

(B) Bent

(C) V-shape

(D) Trigonal planar

Q42. The catalyst used in the Haber's process is:

(A) Iron with Molybdenum promoter

(B) Vanadium pentoxide

(C) Platinum

(D) Nickel

Q43. The value of ΔG° for a spontaneous reaction is:

(A) Positive

(B) Negative

(C) Zero

(D) One

Q44. In the reaction $R - X + AgCN \rightarrow P$, the product P is:

(A) $R - CN$

(B) $R - NC$

(C) $R - NH_2$

(D) $R - OH$

Q45. The coordination number of an atom in a hexagonal close-packed (hcp) structure is:

(A) 6

(B) 8

(C) 12

(D) 4

Q46. Which of the following is a Lewis acid?

(A) NH_3

(B) H_2O

(C) BF_3

(D) OH^-

Q47. The relation between solubility and K_{sp} for $Al(OH)_3$ is:

(A) $K_{sp} = S^2$

(B) $K_{sp} = 4S^3$

(C) $K_{sp} = 27S^4$

(D) $K_{sp} = 108S^5$

Q48. The molarity of pure water is:

(A) 55.5 M

(B) 18 M

(C) 1 M

(D) 100 M

Q49. Which reagent is used in Clemmensen reduction?

(A) $Zn - Hg/HCl$

(B) NH_2NH_2/KOH

(C) $LiAlH_4$

(D) $NaBH_4$

Q50. The cost of 1 kg of sugar is ₹ 40. If a solution contains 200 g of sugar, the cost of sugar in the solution is:

(A) ₹ 8

(B) ₹ 10

(C) ₹ 4

(D) ₹ 5

Detailed Solutions

Q1.

Solution

Concept:

The density (ρ) of a cubic unit cell is related to its molar mass (M), edge length (a), and number of atoms per unit cell (Z) by the formula:

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

For a face-centered cubic (fcc) lattice, the number of atoms per unit cell is $Z = 4$.

Solution:

1. Given values: - Density (ρ) = 10 g cm^{-3} - Edge length (a) = 400 pm = 400×10^{-10} cm = 4×10^{-8} cm - Avogadro's Number (N_A) = 6×10^{23} - Z (for fcc) = 4 2. Rearrange the density formula to solve for Molar Mass (M):

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

3. Substitute the values:

$$M = \frac{10 \times (4 \times 10^{-8})^3 \times 6 \times 10^{23}}{4}$$

4. Calculate a^3:

$$a^3 = (4 \times 10^{-8})^3 = 64 \times 10^{-24} \text{ cm}^3$$

5. Substitute and solve:

$$M = \frac{10 \times 64 \times 10^{-24} \times 6 \times 10^{23}}{4}$$

$$M = \frac{640 \times 6 \times 10^{-1}}{4}$$

$$M = \frac{3840 \times 0.1}{4} = \frac{384}{4} = 96 \text{ g mol}^{-1}$$

Final Answer: The molar mass of the metal is 96 g mol^{-1}.

Answer: (A)

Q2.

Solution

Concept:

The Arrhenius equation in its logarithmic form for two different temperatures T_1 and T_2 is:

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

where k_2/k_1 is the factor by which the rate increases (given as 2), E_a is the activation energy, and R is the gas constant.

Solution:

1. Given values: - $T_1 = 300$ K, $T_2 = 310$ K - $k_2/k_1 = 2$ - $R = 8.314$ J K^{-1} mol^{-1} - $\ln 2 = 0.693$ 2. Plug the values into the equation:

$$0.693 = \frac{E_a}{8.314}\left(\frac{310 - 300}{300 \times 310}\right)$$

3. Simplify the temperature term:

$$\frac{10}{93000}$$

4. Solve for E_a:

$$E_a = \frac{0.693 \times 8.314 \times 93000}{10}$$

$$E_a = 0.693 \times 8.314 \times 9300$$

$$E_a \approx 53598 \text{ J mol}^{-1}$$

5. Convert to kJ:

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

Final Answer: The activation energy is 53.6 kJ mol^{-1}.

Answer: (A)

Q3.

Solution

Concept:

The Iodoform test is positive for compounds containing a methyl keto group ($CH_3 - C = O$) or alcohols that can be oxidized to a methyl keto group, such as $CH_3 - CH(OH) - R$.

Solution:

1. Ethanol (CH_3CH_2OH) can be oxidized to Acetaldehyde (CH_3CHO), which has a methyl keto group. Positive. 2. Isopropyl alcohol ($CH_3CH(OH)CH_3$) can be oxidized to Acetone (CH_3COCH_3), which has a methyl keto group. Positive. 3. Pentan-3-one ($CH_3CH_2COCH_2CH_3$) is a symmetrical ketone. It does not have a terminal methyl group directly attached to the carbonyl carbon (no $CH_3 - CO-$ structure). Negative. 4. Acetophenone ($C_6H_5COCH_3$) has a methyl keto group. Positive. 5. Therefore, Pentan-3-one will not show a positive iodoform test.

Final Answer: Pentan-3-one does not show a positive iodoform test.

Answer: (C)

Q4.

Solution

Concept:

Fenton's reagent ($Fe^{2+} + H_2O_2$) is used for the oxidation of alcohols. Glycerol is a trihydric alcohol with the formula $C_3H_8O_3$. Its oxidation can produce Glyceraldehyde, which is a reducing sugar.

Solution:

1. Compound 'A' has the formula $C_3H_8O_3$. 2. Among the options, Glycerol ($CH_2OH - CHOH - CH_2OH$) matches this molecular formula. 3. When Glycerol is treated with Fenton's reagent, one of the primary alcohol groups is oxidized to an aldehyde group, forming Glyceraldehyde ($CHO - CHOH - CH_2OH$). 4. Glyceraldehyde contains an aldehyde group and thus reduces Tollen's reagent to form a silver mirror. 5. Other options like Propan-1-ol (C_3H_8O) do not match the molecular formula.

Final Answer: The compound is Glycerol.

Answer: (B)

Here is the solution for the chemistry question involving the structure of $Co_2(CO)_8$ in its solid state, formatted strictly according to your LaTeX template including the 'tikzpicture' diagram.

Q5.

Solution

Concept:

Structure of Metal Carbonyls (Organometallic Chemistry). The structure of Dicobalt octacarbonyl, $Co_2(CO)_8$, is temperature and state-dependent. In the solid state, it adopts a bridged structure to satisfy the 18-electron rule for each Cobalt center.

Solution:

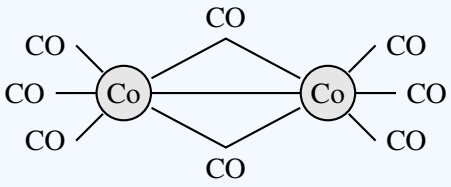
Step 1: Identify the oxidation state and valence electrons. Cobalt is in the 0 oxidation state. Co has 9 valence electrons ($3d^7 4s^2$).

Step 2: In the solid state, $Co_2(CO)_8$ contains two Cobalt atoms connected by a single $Co - Co$ bond.

Step 3: To complete the coordination and satisfy the stability of the cluster, two Carbonyl (CO) ligands act as bridges between the two Cobalt atoms (bridging ligands).

Step 4: The remaining six Carbonyl ligands are terminal, with three attached to each Cobalt atom.

Step 5: Thus, there are 2 bridging CO ligands and 1 $Co - Co$ bond.



Structure of $Co_2(CO)_8$ (Solid State)

Final Answer: The number of bridging CO ligands is 2 and the number of $Co - Co$ bonds is 1.

2 and 1

Answer: (A)

Q6.

Solution

Concept:

The strength of a reducing agent is determined by its standard reduction potential (E°_{red}). A lower (more negative) reduction potential indicates a greater tendency to lose electrons (undergo oxidation), making the substance a stronger reducing agent.

Solution:

1. Given standard reduction potentials: - $E^\circ(Li^+/Li) = -3.05$ V - $E^\circ(Zn^{2+}/Zn) = -0.76$ V - $E^\circ(Ag^+/Ag) = +0.80$ V 2. Compare the values: -3.05 V < -0.76 V $< +0.80$ V. 3. Lithium (Li) has the most negative reduction potential among the given options. 4. This means Li has the highest oxidation potential (+3.05 V), making it lose electrons most readily. 5. Therefore, Lithium metal (Li) is the strongest reducing agent. Li^+ is an oxidizing agent, not a reducing agent.

Final Answer: The strongest reducing agent is Li.

Answer: (B)

Q7.

Solution

Concept:

When HBr reacts with an unsymmetrical alkene in the presence of peroxides, the reaction follows the **Anti-Markovnikov rule** (Kharasch effect). The Bromine atom attaches to the less substituted carbon of the double bond. This occurs via a free-radical mechanism.

Solution:

1. The reactant is 2-methylbut-2-ene: $CH_3-C(CH_3)=CH-CH_3$. 2. Identify the double-bonded carbons: - Carbon-2 is bonded to two methyl groups (more substituted). - Carbon-3 is bonded to one methyl group and one hydrogen (less substituted). 3. In the presence of peroxides, the $Br^\bullet$ radical attacks the double bond. 4. According to Anti-Markovnikov's rule, the Br atom will attach to the carbon with more hydrogen atoms (Carbon-3). 5. The hydrogen atom will then attach to Carbon-2. 6. The resulting product is 2-bromo-3-methylbutane: $CH_3-CH(CH_3)-CH(Br)-CH_3$.

Final Answer: The major product is 2-bromo-3-methylbutane.

Answer: (B)

Q8.

Solution

Concept:

Molecular Orbital (MO) Theory is used to calculate the bond order. The formula is:

$$\text{Bond Order} = \frac{1}{2}(N_b - N_a)$$

where N_b is the number of electrons in bonding orbitals and N_a is the number of electrons in antibonding orbitals.

Solution:

1. Ground state O_2 has 16 electrons. Configuration: $\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \sigma 2p_z^2 \pi 2p_x^2 \pi 2p_y^2 \pi^* 2p_x^1 \pi^* 2p_y^1$. 2. For O_2^+ (15 electrons): - One electron is removed from the antibonding orbital ($\pi^* 2p_y$). - $N_b = 10, N_a = 5$. - Bond Order $= (10 - 5)/2 = 2.5$. 3. For O_2^- (17 electrons): - One electron is added to the antibonding orbital ($\pi^* 2p_y$). - $N_b = 10, N_a = 7$. - Bond Order $= (10 - 7)/2 = 1.5$. 4. Comparing the results: $O_2^+ = 2.5$ and $O_2^- = 1.5$.

Final Answer: The bond orders are 2.5 and 1.5 respectively.

Answer: (A)

Q9.

Solution

Concept:

The depression in freezing point (ΔT_f) for an electrolyte is given by:

$$\Delta T_f = i \cdot K_f \cdot m$$

where i is the Van't Hoff factor, K_f is the cryoscopic constant, and m is the molality. For a weak acid HA dissociating into H^+ and A^-, $i = 1 + \alpha$, where α is the degree of ionization.

Solution:

1. Given: - Molality (m) = 0.1 m - Ionization (α) = 30% = 0.3 - $K_f = 1.86$ K kg mol^{-1} 2. Calculate Van't Hoff factor (i): - $HA \rightleftharpoons H^+ + A^-$ - $i = 1 + \alpha = 1 + 0.3 = 1.3$ 3. Calculate ΔT_f: - $\Delta T_f = 1.3 \times 1.86 \times 0.1$ - $\Delta T_f = 1.3 \times 0.186 = 0.2418$ K (or $^\circ C$) 4. The freezing point of the solution (T_f) is: - $T_f = T_f^\circ - \Delta T_f$ - $T_f = 0^\circ C - 0.2418^\circ C = -0.2418^\circ C$ 5. Rounding to two decimal places gives $-0.24\ ^\circ C$.

Final Answer: The freezing point is $-0.24\ ^\circ C$.

Answer: (A)

Q10.

Solution

Concept:

The second ionization enthalpy (IE_2) is the energy required to remove an electron from a unipositive ion (M^+). It is exceptionally high when the removal of the second electron breaks a stable, noble gas electronic configuration.

Solution:

1. Electronic configurations of the atoms: - Na : $[Ne]3s^1$ - Mg : $[Ne]3s^2$ - Al : $[Ne]3s^23p^1$ - Si : $[Ne]3s^23p^2$ 2. Electronic configurations of the unipositive ions: - Na^+ : $[Ne]$ (Noble gas configuration) - Mg^+ : $[Ne]3s^1$ - Al^+ : $[Ne]3s^2$ - Si^+ : $[Ne]3s^23p^1$ 3. To remove the second electron from Na^+, we must break the very stable octet of Neon. This requires a massive amount of energy. 4. For Mg^+, Al^+, and Si^+, the second electron is removed from the $3s$ or $3p$ subshell, which is much easier than removing from a core noble gas shell. 5. Therefore, Na has the highest second ionization enthalpy.

Final Answer: Na has the highest second ionization enthalpy.

Answer: (A)

Q11.

Solution

Concept:

The geometry and magnetic properties of coordination complexes are explained by Valence Bond Theory (VBT) or Crystal Field Theory (CFT). For a d^8 metal ion like Ni^{2+}, the geometry depends on the strength of the ligand. Strong field ligands cause electron pairing.

Solution:

1. In $[Ni(CN)_4]^{2-}$, the oxidation state of Nickel is +2. 2. The electronic configuration of $Ni(Z = 28)$ is $[Ar]3d^84s^2$. Thus, Ni^{2+} is $[Ar]3d^8$. 3. Cyanide (CN^-) is a very strong field ligand. 4. According to CFT, strong field ligands cause a large splitting of d-orbitals, forcing the 8 electrons in the $3d$ subshell to pair up in the lower energy orbitals. 5. With all electrons paired, the complex is **Diamagnetic**. 6. For the bonding, one $3d$, one $4s$, and two $4p$ orbitals hybridize to form dsp^2 hybrid orbitals. 7. The dsp^2 hybridization corresponds to a **Square planar** geometry.

Final Answer: The geometry is square planar and it is diamagnetic.

Answer: (B)

Q12.

Solution

Concept:

The Gabriel Phthalimide synthesis is a method used to prepare pure primary amines. It involves the nucleophilic attack of the phthalimide anion on an organic halide.

Solution:

1. Potassium phthalimide reacts with an alkyl halide ($R - X$) via an S_N2 mechanism. 2. Because it is an S_N2 reaction, steric hindrance significantly affects the rate. 3. **Primary alkyl halides** (1°) are the most reactive and preferred for this synthesis as they allow for easy nucleophilic substitution. 4. Secondary alkyl halides react very slowly, and tertiary alkyl halides undergo elimination rather than substitution, forming alkenes. 5. Aryl halides do not undergo this reaction because the $C - X$ bond in aryl halides has partial double-bond character and is difficult to break.

Final Answer: A primary alkyl halide is used to introduce the alkyl group.

Answer: (A)

Q13.

Solution

Concept:

Surface Chemistry defines various methods for the preparation of colloids. When a freshly prepared precipitate is converted into a colloidal sol by shaking it with the dispersion medium in the presence of a small amount of electrolyte, the process is known as Peptization.

Solution:

1. **Peptization** involves the adsorption of ions from the added electrolyte (called the peptizing agent) onto the surface of the precipitate particles. 2. This creates an electrostatic charge on the particles, causing them to repel each other and break down into smaller particles of colloidal dimensions. 3. **Coagulation** is the opposite process (settling of particles). 4. **Dialysis** is a purification method for colloids. 5. **Tyndall effect** is an optical property of colloids (scattering of light).

Final Answer: The process is called Peptization.

Answer: (A)

Q14.

Solution

Concept:

For an isothermal and reversible expansion of an ideal gas, the work done (W) is calculated using the formula:

$$W = -2.303 \cdot n \cdot R \cdot T \cdot \log\left(\frac{V_2}{V_1}\right)$$

In thermodynamics, work done **by** the system (expansion) is given a negative sign.

Solution:

1. Given values: - $n = 2$ moles - $R = 8.314$ J K^{-1} mol^{-1} - $T = 300$ K - $V_1 = 10$ L, $V_2 = 20$ L 2. Use the natural log form first (or convert to $\log_{10}$):

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

$$W = -(2) \times (8.314) \times (300) \times \ln(2)$$

3. Substitute $\ln 2 = 0.693$:

$$W = -(2 \times 8.314 \times 300) \times 0.693$$

$$W = -(4988.4) \times 0.693$$

$$W = -3456.96 \text{ J}$$

4. Rounding gives approximately -3457 J.

Final Answer: The work done is -3457 J.

Answer: (A)

Q15.

Solution

Concept:

In very dilute solutions of strong acids (concentration $< 10^{-6}$ M), the H^+ ions contributed by the self-ionization of water cannot be ignored. The total $[H^+]$ is the sum of $[H^+]$ from the acid and $[H^+]$ from water.

Solution:

1. Given $[HCl] = 10^{-8}$ M. 2. If we only used $[H^+] = 10^{-8}$, the pH would be 8, which is impossible for an acid (even a very dilute one). 3. The actual total $[H^+] = [H^+]_{acid} + [H^+]_{water}$. 4. Let x be the concentration of H^+ from water. Then $[OH^-]$ is also x. But since H^+ is already present from HCl, $[H^+]_{total} = (10^{-8} + x)$. 5. $K_w = [H^+][OH^-] = (10^{-8} + x)(x) = 10^{-14}$. 6. Solving the quadratic equation $x^2 + 10^{-8}x - 10^{-14} = 0$, we find $x \approx 0.95 \times 10^{-7}$. 7. Total $[H^+] = 10^{-8} + 0.95 \times 10^{-7} = 1.05 \times 10^{-7}$ M. 8. $pH = -\log(1.05 \times 10^{-7}) = 7 - \log(1.05) \approx 6.98$. 9. This value is just below 7, which is logically correct for a very dilute acid.

Final Answer: The pH is 6.98.

Answer: (C)

Q16.

Solution

Concept:

Conformational isomerism in n-butane arises from rotation around the $C_2 - C_3$ bond. The stability of these conformers is determined by steric hindrance (van der Waals repulsion) and torsional strain. The four main conformers are Anti-staggered, Gauche, Partially Eclipsed, and Fully Eclipsed.

Solution:

1. In the **Anti-staggered** conformation, the two bulky methyl ($-CH_3$) groups are at a dihedral angle of 180°. This maximizes the distance between them, resulting in minimum steric repulsion. 2. In the **Gauche** conformation, the methyl groups are at 60°. There is some steric "Gauche interaction," making it less stable than the anti form. 3. In **Eclipsed** forms, both torsional strain and steric repulsion are high. The **Fully Eclipsed** form (where methyl groups overlap at 0°) is the least stable. 4. Stability Order: Anti-staggered > Gauche > Partially Eclipsed > Fully Eclipsed. 5. Therefore, the most stable conformer is the Anti-staggered form.

Final Answer: The most stable conformer is Anti-staggered.

Answer: (B)

Q17.

Solution

Concept:

The reaction of phosphorus halides with water is a classic example of a hydrolysis reaction. Phosphorus trichloride (PCl_3) is a covalent halide where phosphorus is in the +3 oxidation state. Upon hydrolysis, the oxidation state of the central atom typically remains unchanged.

Solution:

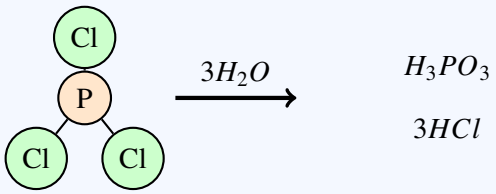
Step 1: Write down the reactants. Phosphorus trichloride (PCl_3) reacts with Water (H_2O).

Step 2: During the hydrolysis of PCl_3, the $P-Cl$ bonds are broken and replaced by $P-OH$ bonds. This leads to the formation of an oxoacid of phosphorus where phosphorus retains its +3 oxidation state.

Step 3: The oxoacid with phosphorus in the +3 state is Phosphorous acid (H_3PO_3). The chlorine atoms combine with the hydrogen from water to form Hydrogen Chloride (HCl) gas.

Step 4: The balanced chemical equation for the reaction is:

$$PCl_3 + 3H_2O \rightarrow H_3PO_3 + 3HCl$$



Hydrolysis of PCl_3

Final Answer:

The reaction of PCl_3 with water gives H_3PO_3 and HCl.

$$\boxed{H_3PO_3 + HCl}$$

Answer: (B)

Q18.

Solution

Concept:

The hybridization of a central atom can be determined using the formula:

$$H = \frac{1}{2}[V + M - C + A]$$

where V is valence electrons, M is monovalent atoms, C is cationic charge, and A is anionic charge.

Solution:

1. In SF_6 (Sulfur hexafluoride), the central atom is Sulfur (S). 2. Sulfur belongs to Group 16, so it has 6 valence electrons ($V = 6$). 3. There are 6 monovalent Fluorine atoms attached ($M = 6$). 4. The molecule is neutral ($C = 0, A = 0$). 5. Calculating H:

$$H = \frac{1}{2}[6 + 6 - 0 + 0] = \frac{12}{2} = 6$$

6. A value of $H = 6$ corresponds to sp^3d^2 hybridization. 7. This results in an octahedral geometry with bond angles of 90°.

Final Answer: The hybrid state of S in SF_6 is sp^3d^2.

Answer: (B)

Q19.

Solution

Concept:

The reaction with neutral Ferric chloride ($FeCl_3$) is a standard qualitative test for the detection of phenolic groups. Phenols form colored coordination complexes with $Fe(III)$ ions.

Solution:

1. When a few drops of neutral $FeCl_3$ solution are added to phenol, a complex is formed. 2. The reaction can be represented as:

$$6C_6H_5OH + FeCl_3 \rightarrow [Fe(OC_6H_5)_6]^{3-} + 3H^+ + 3Cl^-$$

3. The complex formed, ferric phenoxide, has a characteristic **violet** or purple coloration. 4. Simple alcohols do not give this color test, which makes it a useful distinguishing test between alcohols and phenols.

Final Answer: Phenol gives a violet color with neutral $FeCl_3$.

Answer: (B)

Q20.

Solution

Concept:

Hydrogenation is the process of adding hydrogen to unsaturated fats (oils) to make them saturated (fats). This is an example of heterogeneous catalysis.

Solution:

1. Vegetable oils contain long chains of unsaturated fatty acids (with double bonds). 2. Passing hydrogen gas through these oils in the presence of a metal catalyst converts the double bonds into single bonds, turning the liquid oil into solid fat (Vanaspati Ghee). 3. Finely divided **Nickel (Ni)** is the most commonly used catalyst for this industrial process due to its efficiency and lower cost compared to precious metals. 4. Pt and Pd can also catalyze the reaction but are generally too expensive for large-scale food production. V_2O_5 is used in the Contact process, not hydrogenation.

Final Answer: The catalyst used is Ni.

Answer: (B)

Q21.

Solution

Concept:

Optical isomerism occurs in molecules that have at least one chiral center (a carbon atom bonded to four different groups). Lactic acid (2-hydroxypropanoic acid) is a classic example of a molecule with a single chiral center.

Solution:

1. The chemical structure of lactic acid is $CH_3-CH(OH)-COOH$. 2. Examine the central carbon (Carbon-2): - It is bonded to a hydrogen atom ($-H$). - It is bonded to a hydroxyl group ($-OH$). - It is bonded to a methyl group ($-CH_3$). - It is bonded to a carboxyl group ($-COOH$). 3. Since all four groups are different, Carbon-2 is a chiral center. 4. According to the formula 2^n (where n is the number of chiral centers), the number of optical isomers is $2^1 = 2$. 5. These two isomers are the d-form (dextrorotatory) and the l-form (laevorotatory), which are non-superimposable mirror images (enantiomers) of each other.

Final Answer: The number of optical isomers for lactic acid is 2.

Answer: (A)

Q22.

Solution

Concept:

For a first-order reaction, the half-life ($t_{1/2}$) is constant and independent of the initial concentration. The time taken for the concentration to reduce by half is always the same.

Solution:

1. From the first part of the question, the concentration changes from 0.8 M to 0.4 M in 15 minutes. Since 0.4 is half of 0.8, the half-life ($t_{1/2}$) of the reaction is **15 minutes**. 2. We need to find the time taken for the concentration to change from 0.1 M to 0.025 M. 3. Analyze the reduction in steps of half-lives: - 0.1 M $\xrightarrow{t_{1/2}}$ 0.05 M (1st half-life) - 0.05 M $\xrightarrow{t_{1/2}}$ 0.025 M (2nd half-life) 4. The total process takes 2 half-lives. 5. Total time = $2 \times t_{1/2} = 2 \times 15$ minutes = 30 minutes.

Final Answer: The time taken is 30 minutes.

Answer: (A)

Q23.

Solution

Concept:

For isoelectronic species (ions/atoms with the same number of electrons), the ionic radius depends on the nuclear charge (number of protons). As the positive nuclear charge increases, the nucleus pulls the electrons more strongly, decreasing the radius.

Solution:

1. All the given ions ($Na^+, Mg^{2+}, F^-, O^{2-}$) have 10 electrons (they are isoelectronic with Neon). 2. Look at the number of protons (nuclear charge): - O^{2-} : 8 protons - F^- : 9 protons - Na^+ : 11 protons - Mg^{2+} : 12 protons 3. O^{2-} has the lowest nuclear charge (8 protons) to pull the 10 electrons. Therefore, its electron cloud is the most expanded. 4. Mg^{2+} has the highest nuclear charge (12 protons), making it the smallest. 5. Order of radius: $O^{2-} > F^- > Na^+ > Mg^{2+}$.

Final Answer: The largest ionic radius is O^{2-}.

Answer: (D)

Q24.

Solution

Concept:

Buna-N (also known as Nitrile rubber) is a synthetic co-polymer. Co-polymers are formed by the addition polymerization of two different types of unsaturated monomers.

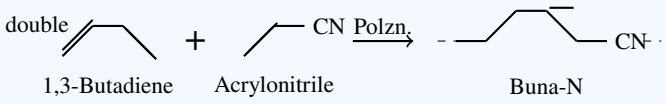
Solution:

Step 1: Identify the components of the name "Buna-N". "Bu" stands for 1,3-Butadiene, "na" refers to Sodium (Natrium) which was historically used as a catalyst, and "N" stands for Acrylonitrile (Vinyl cyanide).

Step 2: The monomers involved are 1,3-Butadiene ($CH_2 = CH - CH = CH_2$) and Acrylonitrile ($CH_2 = CH - CN$).

Step 3: During polymerization, the double bonds break and reform to link the monomers into a long chain elastomer.

Step 4: This polymer is highly resistant to oils and chemicals, unlike natural rubber.



Final Answer: The monomers of Buna-N are Acrylonitrile and 1,3-Butadiene.

Acrylonitrile and 1,3-Butadiene

Answer: (C)

Q25.

Solution

Concept:

The oxidation state of an element is usually determined by standard rules, but for some molecules like CrO_5, the structure must be considered to avoid "impossible" oxidation states. CrO_5 has a butterfly structure with peroxide linkages.

Solution:

1. In CrO_5, applying the standard rule ($x + 5(-2) = 0$) gives $x = +10$, which is impossible as Chromium only has 6 valence electrons. 2. Looking at the structure (Butterfly structure): - There is one oxygen atom attached via a double bond ($Cr = O$). - There are four oxygen atoms involved in two peroxide bonds ($-O - O-$). 3. Oxidation states in the structure: - The oxo-oxygen (O) has an oxidation state of -2. - Each of the four peroxide-oxygens has an oxidation state of -1. 4. Total charge balance: $x + (1 \times -2) + (4 \times -1) = 0$. - $x - 2 - 4 = 0$ - $x = +6$. 5. Thus, the oxidation state of Cr in CrO_5 is +6.

Final Answer: The oxidation state of Cr is +6.

Answer: (B)

Q26.

Solution

Concept:

This is a multi-step organic synthesis sequence involving Friedel-Crafts Alkylation, Oxidation of a side chain, and Nucleophilic Acyl Substitution.

Solution:

1. **Step 1:** Benzene reacts with CH_3Cl in the presence of anhydrous $AlCl_3$ (Friedel-Crafts Alkylation) to form Toluene (Methylbenzene). Thus, X is Toluene ($C_6H_5CH_3$). 2. **Step 2:** Toluene is oxidized by alkaline $KMnO_4$. Regardless of the length of the alkyl side chain, as long as there is at least one benzylic hydrogen, the entire side chain is oxidized to a carboxylic acid group. Thus, Y is Benzoic acid (C_6H_5COOH). 3. **Step 3:** Benzoic acid reacts with Thionyl chloride ($SOCl_2$). The hydroxyl ($-OH$) group of the carboxylic acid is replaced by a chlorine atom. This is the standard method for preparing acid chlorides. 4. The final product Z is **Benzoyl chloride** (C_6H_5COCl).

Final Answer: The product 'Z' is Benzoyl chloride.

Answer: (B)

Q27.

Solution

Concept:

For a salt of the type A_2B (like Ag_2CrO_4), the relationship between the solubility (S) and the solubility product (K_{sp}) is:

$$K_{sp} = [A^+]^2[B^{2-}] = (2S)^2(S) = 4S^3$$

Solution:

1. Given $K_{sp} = 3.2 \times 10^{-11}$. 2. Using the formula $K_{sp} = 4S^3$:

$$3.2 \times 10^{-11} = 4S^3$$

3. Divide by 4:

$$S^3 = \frac{3.2 \times 10^{-11}}{4} = 0.8 \times 10^{-11}$$

4. Rewrite the number to make it easier to find the cube root:

$$S^3 = 8 \times 10^{-12}$$

5. Taking the cube root of both sides:

$$S = \sqrt[3]{8 \times 10^{-12}}$$

$$S = 2 \times 10^{-4} \text{ mol/L}$$

Final Answer: The solubility is 2×10^{-4} mol/L.

Answer: (A)

Q28.

Solution

Concept:

Ligands are classified based on denticity, which refers to the number of donor atoms they use to bind to a single central metal ion. A bidentate ligand has two donor atoms and forms two coordinate bonds.

Solution:

1. **Ethylenediamine** ($NH_2CH_2CH_2NH_2$), often abbreviated as 'en', has two nitrogen atoms each with a lone pair. Both can coordinate to the same metal ion simultaneously, making it a **bidentate** ligand. 2. **EDTA** (Ethylenediaminetetraacetic acid) is a hexadentate ligand (six donor atoms). 3. **NH_3** (Ammonia) has only one donor atom (Nitrogen), making it monodentate. 4. **CN^-** (Cyanide) has two potential donor atoms (C or N), but it coordinates through only one at a time to a single metal, so it is considered a monodentate (specifically ambidentate) ligand.

Final Answer: Ethylenediamine is a bidentate ligand.

Answer: (B)

Q29.

Solution

Concept:

The First Law of Thermodynamics is expressed as:

$$\Delta U = q + w$$

where ΔU is the change in internal energy, q is the heat exchanged, and w is the work done. The sign convention is critical: heat absorbed by the system is $+q$, and work done **by** the system is $-w$.

Solution:

1. Given: - Heat absorbed (q) = +500 J - Work done by the system (w) = −200 J 2. Substitute these values into the first law equation:

$$\Delta U = (+500\ \text{J}) + (-200\ \text{J})$$

$$\Delta U = 500 - 200$$

$$\Delta U = 300\ \text{J}$$

3. The internal energy of the system increases by 300 J.

Final Answer: The change in internal energy is 300 J.

Answer: (B)

Q30.

Solution

Concept:

The number of atoms in a given mass of a substance is calculated using the formula:

$$\text{Number of atoms} = \frac{\text{Given mass}}{\text{Molar mass}} \times N_A \times \text{atomicity}$$

For pure metals (monoatomic), the number of atoms is inversely proportional to the molar mass when the given mass is constant.

Solution:

1. All samples have a mass of 1 g. 2. Compare the molar masses: - Au (Gold) $\approx$ 197 g/mol - Ag (Silver) $\approx$ 108 g/mol - Cu (Copper) $\approx$ 63.5 g/mol - Li (Lithium) $\approx$ 7 g/mol 3. Since number of atoms $\propto \frac{1}{\text{Molar Mass}}$, the element with the **lowest** molar mass will have the **highest** number of atoms per gram. 4. Lithium has the smallest molar mass (7 g/mol). 5. Number of atoms in 1 g of $Li = (1/7) \times N_A$, which is significantly higher than $(1/197) \times N_A$ for Gold.

Final Answer: 1 g of Lithium contains the highest number of atoms.

Answer: (D)

Q31.

Solution

Concept:

Oxidation of alcohols. Secondary alcohols can be dehydrogenated to form ketones by passing their vapors over a heated metal catalyst like Copper.

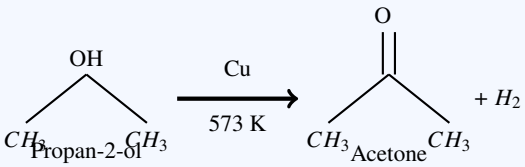
Solution:

Step 1: Identify the reactant and product. Propan-2-ol ($CH_3 - CH(OH) - CH_3$) is a secondary alcohol, and Acetone ($CH_3 - CO - CH_3$) is a ketone.

Step 2: Alcohols undergo dehydrogenation (loss of H_2) when treated with heated Copper (Cu) at 573 K.

Step 3: Primary alcohols yield aldehydes, secondary alcohols yield ketones, and tertiary alcohols undergo dehydration to yield alkenes under these conditions.

Step 4: Therefore, for the conversion of Propan-2-ol to Acetone, $Cu/573$ K is the most appropriate reagent.



Final Answer: The reagent used for the conversion of Propan-2-ol to Acetone is $Cu/573$ K.

$$\boxed{Cu/573 \text{ K}}$$

Answer: (C)

Q32.

Solution

Concept:

Point defects in ionic solids are classified into Stoichiometric and Non-stoichiometric defects. Schottky and Frenkel defects are the two main types of stoichiometric defects.

Solution:

1. **Schottky defect** occurs when an equal number of cations and anions are missing from their lattice sites. It is typically found in highly ionic compounds with high coordination numbers where the sizes of cations and anions are similar. 2. $**NaCl**$ is a classic example of a Schottky defect because Na^+ and Cl^- are relatively similar in size compared to other ionic pairs. 3. **Frenkel defect** occurs when an ion (usually the smaller cation) is dislocated from its lattice site to an interstitial site. This is common in compounds with a large difference in ion sizes, such as $AgCl$, ZnS, and AgI. 4. $AgBr$ is unique because it shows both Schottky and Frenkel defects.

Final Answer: $NaCl$ shows the Schottky defect.

Answer: (A)

Q33.

Solution

Concept:

Osmotic pressure (π) is a colligative property calculated using the formula:

$$\pi = iCRT$$

where C is molarity, R is the gas constant, T is temperature, and i is the Van't Hoff factor (for urea, $i = 1$ as it is a non-electrolyte).

Solution:

1. Calculate the number of moles of urea:

$$n = \frac{\text{Mass}}{\text{Molar mass}} = \frac{6\text{ g}}{60\text{ g/mol}} = 0.1\text{ mol}$$

2. Calculate Molarity (C):

$$C = \frac{n}{V} = \frac{0.1\text{ mol}}{1\text{ L}} = 0.1\text{ M}$$

3. Given values: - $R = 0.0821$ L atm K^{-1} mol^{-1} - $T = 300$ K 4. Substitute into the formula:

$$\pi = 1 \times 0.1 \times 0.0821 \times 300$$

$$\pi = 0.0821 \times 30 = 2.463\text{ atm}$$

5. Rounding to two decimal places gives 2.46 atm.

Final Answer: The osmotic pressure is 2.46 atm.

Answer: (A)

Q34.

Solution

Concept:

Polymers are classified by their mode of polymerization. **Addition polymers** are formed by the repeated addition of monomer molecules possessing double or triple bonds without the loss of any small molecules.

Solution:

1. **Polyethylene** is formed by the addition polymerization of ethene ($CH_2 = CH_2$) molecules. No side products are formed. 2. **Nylon 6,6** is a condensation polymer formed from adipic acid and hexamethylenediamine with the elimination of water molecules. 3. **Terylene** (Dacron) is a condensation polymer of ethylene glycol and terephthalic acid. 4. **Bakelite** is a condensation polymer of phenol and formaldehyde. 5. Therefore, Polyethylene is the correct example of an addition polymer.

Final Answer: Polyethylene is an addition polymer.

Answer: (C)

Q35.

Solution

Concept:

The acidity of hydrocarbons depends on the hybridization of the carbon atom bonded to the hydrogen. As the s-character of the hybrid orbital increases, the electronegativity of the carbon increases, making the $C - H$ bond more polar and the hydrogen more acidic.

Solution:

1. **Ethane** ($CH_3 - CH_3$): Carbons are sp^3 hybridized (25% s-character). 2. **Ethene** ($CH_2 = CH_2$): Carbons are sp^2 hybridized (33.3% s-character). 3. **Ethyne** ($CH \equiv CH$): Carbons are sp hybridized (50% s-character). 4. **Benzene** (C_6H_6): Carbons are sp^2 hybridized (33.3% s-character). 5. Ethyne has the highest s-character (50%). The sp hybridized carbon is the most electronegative, which allows it to stabilize the negative charge on the conjugate base (acetylide ion) most effectively. 6. Consequently, the hydrogens in ethyne are the most acidic.

Final Answer: The most acidic hydrogen is present in Ethyne.

Answer: (B)

Q36.

Solution

Concept:

Functional isomerism occurs when compounds have the same molecular formula but different functional groups. For the molecular formula C_2H_6O, two functional isomers exist: an alcohol and an ether.

Solution:

1. The molecular formula C_2H_6O corresponds to: - **Ethanol** (CH_3CH_2OH) - an alcohol. - **Dimethyl ether** (CH_3OCH_3) - an ether. 2. Alcohols possess an active hydrogen atom bonded to oxygen (the hydroxyl group). 3. Ethers do not have an active hydrogen atom. 4. Active hydrogen reacts with highly electropositive metals like Sodium (Na) to release Hydrogen gas:

$$2CH_3CH_2OH + 2Na \rightarrow 2CH_3CH_2ONa + H_2 \uparrow$$

5. Dimethyl ether does not react with Sodium metal under normal conditions. 6. Therefore, the isomer that reacts with Sodium is Ethanol.

Final Answer: The isomer is Ethanol.

Answer: (A)

Q37.

Solution

Concept:

The structure of proteins is described at four levels: primary, secondary, tertiary, and quaternary. Each level describes a specific aspect of the protein's complexity.

Solution:

1. **Primary structure:** This refers to the specific linear **sequence of amino acids** in the polypeptide chain. This sequence is held together by covalent peptide bonds. 2. **Secondary structure:** Refers to local folding patterns like the α-helix or β-pleated sheet, stabilized by hydrogen bonding. 3. **Tertiary structure:** Refers to the overall three-dimensional folding of the entire polypeptide chain, stabilized by various interactions (disulfide bridges, ionic bonds, hydrophobic interactions). 4. **Quaternary structure:** Refers to the spatial arrangement of multiple polypeptide subunits in a multi-subunit protein. 5. Any change in the primary sequence can completely change the function and nature of the protein.

Final Answer: Primary structure refers to the sequence of amino acids.

Answer: (B)

Q38.

Solution

Concept:

The rate law for a first-order reaction is expressed as:

$$\text{Rate} = k[A]^1$$

The units of the rate constant (k) depend on the overall order of the reaction.

Solution:

1. The unit of the Rate of reaction is always $mol\ \text{L}^{-1}\ \text{s}^{-1}$ (concentration divided by time). 2. For a first-order reaction:

$$\text{Rate} = k \times (\text{Concentration})$$

3. Rearrange to find the units of k:

$$k = \frac{\text{Rate}}{\text{Concentration}}$$

4. Substitute the units:

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

5. The $mol\ \text{L}^{-1}$ terms cancel out, leaving:

$$k = s^{-1}$$

6. Thus, the unit for a first-order rate constant is "per second" (time^{-1}).

Final Answer: The unit of the rate constant is s^{-1}.

Answer: (C)

Q39.

Solution

Concept:

Lanthanides (the 4f-block elements) exhibit a variety of oxidation states, but one state is significantly more stable and common across the entire series.

Solution:

1. Lanthanides have the general electronic configuration $[Xe]4f^n5d^16s^2$ or $[Xe]4f^n6s^2$. 2. The removal of the two $6s$ electrons and the one $5d$ electron (or one $4f$ electron) is energetically favorable. 3. Consequently, the **+3 oxidation state** is the most stable and predominant oxidation state for all Lanthanide elements. 4. While some elements show +2 (like Eu^{2+}) or +4 (like Ce^{4+}) oxidation states to achieve empty (f^0), half-filled (f^7), or completely filled (f^{14}) configurations, these ions usually revert to the +3 state in aqueous solutions.

Final Answer: The most stable oxidation state is +3.

Answer: (B)

Q40.

Solution

Concept:

According to the IUPAC definition, a transition element is an element whose atom has a partially filled d-subshell, or which can form at least one stable ion with a partially filled d-subshell.

Solution:

1. Zn, Cd, and Hg (Group 12) have a d^{10} configuration in their ground state as well as in their common oxidation states (e.g., Zn^{2+} is d^{10}). Therefore, they are often considered "non-typical" transition elements or simply d-block elements. 2. **Iron (Fe)** has the electronic configuration $[Ar]3d^6 4s^2$. 3. Since Iron has a partially filled d-subshell ($3d^6$), it strictly fits the definition of a transition element. 4. It also forms stable ions like Fe^{2+} ($3d^6$) and Fe^{3+} ($3d^5$), both of which have incomplete d-shells.

Final Answer: Iron is a transition element.

Answer: (D)

Q41.

Solution

Concept:

Molecular Geometry and VSEPR Theory. The shape of a molecule is determined by the total number of electron pairs (bonding and lone pairs) around the central atom to minimize repulsion.

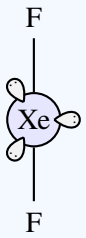
Solution:

Step 1: Determine the valence electrons of the central atom. Xenon (Xe) is a noble gas with 8 valence electrons.

Step 2: Calculate the number of bonding pairs and lone pairs. XeF_2 has 2 Fluorine atoms, so there are 2 bonding pairs. The remaining $8 - 2 = 6$ electrons form 3 lone pairs.

Step 3: Find the Steric Number. Steric Number = (Bonding Pairs) + (Lone Pairs) = 2 + 3 = 5. This corresponds to a trigonal bipyramidal electron geometry.

Step 4: Determine molecular shape. To minimize repulsion, the 3 lone pairs occupy the equatorial positions, and the 2 Fluorine atoms occupy the axial positions. This results in a straight-line arrangement.



Linear geometry of XeF_2

Final Answer: The geometry of XeF_2 is Linear.

Linear

Answer: (A)

Q42.

Solution

Concept:

The Haber's process is the industrial method for the synthesis of Ammonia (NH_3) from Nitrogen and Hydrogen. It requires specific conditions of temperature, pressure, and a catalyst to achieve an optimum yield.

Solution:

1. The reaction is: $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$. 2. The catalyst used is **finely divided Iron (Fe)**. 3. To increase the efficiency of the iron catalyst, a **promoter** like **Molybdenum (Mo)** or oxides of potassium and aluminum is added. 4. Vanadium pentoxide (V_2O_5) is used in the Contact process for H_2SO_4. 5. Platinum is used in the Ostwald process for HNO_3. 6. Nickel is used for the hydrogenation of oils.

Final Answer: The catalyst is Iron with Molybdenum promoter.

Answer: (A)

Q43.

Solution

Concept:

Gibbs Free Energy (ΔG) is the thermodynamic potential used to predict the spontaneity of a process at constant temperature and pressure.

Solution:

1. For a reaction to be **spontaneous**, the total entropy of the universe must increase (Second Law of Thermodynamics). 2. This translates to the Gibbs Free Energy change being **negative** ($\Delta G < 0$). 3. If ΔG is **positive**, the reaction is non-spontaneous (it requires external energy to proceed). 4. If ΔG is **zero**, the system is at equilibrium. 5. The relationship is given by $\Delta G = \Delta H - T\Delta S$, where a negative ΔG indicates that the process can occur without continuous external intervention.

Final Answer: The value of ΔG° for a spontaneous reaction is Negative.

Answer: (B)

Q44.

Solution

Concept:

The reaction of an alkyl halide with silver cyanide ($AgCN$) is a nucleophilic substitution reaction. Unlike Potassium Cyanide (KCN), $AgCN$ is predominantly covalent in nature.

Solution:

1. KCN is ionic and provides free CN^- ions. Since Carbon is a better nucleophile than Nitrogen, it forms Alkyl Cyanides ($R-CN$). 2. **$AgCN$** is covalent. The bond between Ag and C is strong, so the lone pair on the **Nitrogen** atom is more available to attack the alkyl group. 3. The attack through Nitrogen leads to the formation of an **Alkyl Isocyanide** ($R-NC$). 4. The reaction is: $R-X+AgCN \rightarrow R-NC+AgX$. 5. This is a classic example used to demonstrate ambidentate nucleophiles.

Final Answer: The product P is $R-NC$.

Answer: (B)

Q45.

Solution

Concept:

The coordination number is the number of nearest neighbors (atoms) touching a particular atom in a crystal lattice.

Solution:

1. In a **hexagonal close-packed (hcp)** structure, atoms are arranged in an ABAB... pattern. 2. Consider an atom in one layer: - It is touched by 6 atoms in its own layer. - It is touched by 3 atoms in the layer above it. - It is touched by 3 atoms in the layer below it. 3. Total number of nearest neighbors = 6 + 3 + 3 = 12. 4. Both hcp and ccp (cubic close-packed/fcc) structures have a coordination number of 12 and a packing efficiency of 74%. 5. For comparison, bcc has a coordination number of 8, and simple cubic has 6.

Final Answer: The coordination number in hcp is 12.

Answer: (C)

Q46.

Solution

Concept:

Lewis Theory of Acids and Bases. A Lewis acid is a chemical species that can accept a pair of electrons (electron-pair acceptor), while a Lewis base is a species that can donate a pair of electrons (electron-pair donor).

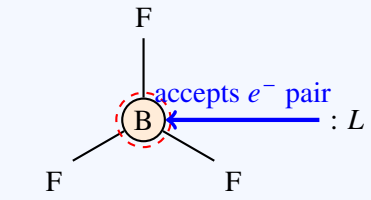
Solution:

Step 1: Analyze the electronic structure of the given options. A species acts as a Lewis acid if it is electron-deficient or has an empty orbital.

Step 2: NH_3 (Ammonia), H_2O (Water), and OH^- (Hydroxide) all possess at least one lone pair of electrons on their central atoms, making them Lewis bases.

Step 3: In BF_3 (Boron trifluoride), the central Boron atom is bonded to three Fluorine atoms. Boron has 3 valence electrons, and after sharing, it has only 6 electrons in its valence shell.

Step 4: Since Boron has an incomplete octet (it needs 2 more electrons to reach 8), it is electron-deficient and readily accepts an electron pair from a donor.



Incomplete Octet ($6e^-$)

BF_3 as a Lewis Acid

Final Answer: The species BF_3 is a Lewis acid.

$\boxed{BF_3}$

Answer: (C)

Q47.

Solution

Concept:

For a salt of the general formula A_xB_y, the dissociation in a saturated solution is:

$$A_xB_y(s) \rightleftharpoons xA^{y+}(aq) + yB^{x-}(aq)$$

If the solubility is S, the solubility product constant (K_{sp}) is given by:

$$K_{sp} = (xS)^x \cdot (yS)^y = x^x \cdot y^y \cdot S^{(x+y)}$$

Solution:

1. Aluminum hydroxide ($Al(OH)_3$) dissociates as follows:

$$Al(OH)_3 \rightleftharpoons Al^{3+} + 3OH^-$$

2. Here, $x = 1$ (for Al^{3+}) and $y = 3$ (for OH^-). 3. If the solubility of $Al(OH)_3$ is S mol/L, then: - $[Al^{3+}] = S$ - $[OH^-] = 3S$ 4. The K_{sp} expression is:

$$K_{sp} = [Al^{3+}] \cdot [OH^-]^3$$

5. Substitute the values:

$$K_{sp} = (S) \cdot (3S)^3$$

$$K_{sp} = S \cdot 27S^3 = 27S^4$$

Final Answer: The relation is $K_{sp} = 27S^4$.

Answer: (C)

Q48.

Solution

Concept:

Molarity (M) is defined as the number of moles of solute per liter of solution. For a pure substance like water, its "molarity" refers to the concentration of water molecules in pure liquid water.

Solution:

1. Consider 1 L (or 1000 mL) of pure water. 2. The density of water is approximately 1 g/mL, so the mass of 1 L of water is 1000 g. 3. The molar mass of water (H_2O) is:

$$(2 \times 1) + 16 = 18 \text{ g/mol}$$

4. Calculate the number of moles in 1000 g:

$$n = \frac{1000 \text{ g}}{18 \text{ g/mol}} = 55.55 \text{ moles}$$

5. Since these moles are contained in 1 L, the molarity is 55.55 mol/L. 6. This value is a constant for pure water at standard temperature (25 $^\circ C$).

Final Answer: The molarity of pure water is 55.5 M.

Answer: (A)

Q49.

Solution

Concept:

Clemmensen reduction is a chemical reaction used to reduce carbonyl groups (aldehydes or ketones) to methylene groups (alkanes). It is particularly effective for aryl-alkyl ketones.

Solution:

1. The reaction involves heating the carbonyl compound with **Zinc amalgam ($Zn - Hg$)** and **concentrated Hydrochloric acid (HCl)**. 2. The general reaction is: $R - CO - R' \xrightarrow{Zn(Hg)/HCl} R - CH_2 - R'$. 3. $**NH_2NH_2/KOH**$ is used in the Wolff-Kishner reduction, which also reduces carbonyls to alkanes but under basic conditions. 4. $**LiAlH_4**$ and $**NaBH_4**$ are hydride reducing agents that typically reduce carbonyls to alcohols, not all the way to alkanes. 5. Clemmensen reduction is preferred when the molecule is stable toward strong acids.

Final Answer: The reagent is $Zn - Hg/HCl$.

Answer: (A)

Q50.

Solution

Concept:

This is a stoichiometric and unit conversion problem. The total cost of a substance is directly proportional to its mass when the price per unit mass is constant.

Solution:

1. Given the cost of 1 kg (1000 g) of sugar is ₹ 40. 2. We need to find the cost for 200 g. 3. First, find the cost of 1 g of sugar:

$$\text{Cost per gram} = \frac{\text{Total Cost}}{\text{Total Mass}} = \frac{| 40}{1000 \text{ g}} = | 0.04 \text{ per gram}$$

4. Now, calculate the cost for 200 g:

$$\text{Cost} = \text{Mass} \times \text{Cost per gram}$$

$$\text{Cost} = 200 \text{ g} \times | 0.04/\text{g} = | 8$$

5. Alternatively, using the fraction: 200 g is $\frac{200}{1000} = \frac{1}{5}$ of a kilogram. 6. Cost = $\frac{1}{5} \times | 40 = | 8$.

Final Answer: The cost is ₹ 8.

Answer: (A)

Answer Key

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