MHT-CET Chemistry Sample Paper-15

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. An element with molar mass 27 $g\ mol^{-1}$ forms a cubic unit cell with edge length 405 pm. If its density is 2.7 $g\ cm^{-3}$, what is the nature of the cubic unit cell?

(A) Simple Cubic

(B) Face-Centered Cubic

(C) Body-Centered Cubic

(D) End-Centered Cubic

Q2. The vapor pressure of pure benzene at a certain temperature is 640 $mm\ Hg$. A non-volatile solid weighing 2.175 g is added to 39 g of benzene. The vapor pressure of the solution is 600 $mm\ Hg$. The molar mass of the solid is:

(A) 65 $g\ mol^{-1}$

(B) 78 $g\ mol^{-1}$

(C) 130 $g\ mol^{-1}$

(D) 260 $g\ mol^{-1}$

Q3. For the reaction $A + B \rightarrow C$, the rate law is $Rate = k[A]^2[B]^{1/2}$. What is the unit of the rate constant k?

(A) $mol^{-1.5}\ L^{1.5}\ s^{-1}$

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

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

(D) $mol^{1.5}\ L^{-1.5}\ s^{-1}$

Q4. A reaction is 50% complete in 2 hours and 75% complete in 4 hours. The order of the reaction is:

(A) Zero

(B) First

(C) Second

(D) Third

Q5. The enthalpy of combustion of methane, graphite, and dihydrogen at 298 K are $-890.3\ kJ\ mol^{-1}$, $-393.5\ kJ\ mol^{-1}$, and $-285.8\ kJ\ mol^{-1}$ respectively. Enthalpy of formation of $CH_4(g)$ will be:

(A) $-74.8\ kJ\ mol^{-1}$

(B) $-52.2\ kJ\ mol^{-1}$

(C) $+74.8\ kJ\ mol^{-1}$

(D) $+52.2\ kJ\ mol^{-1}$

Q6. What is the solubility of $AgCl$ in 0.1 M $CaCl_2$ solution? (Given K_{sp} of $AgCl = 1.6 \times 10^{-10}$)

(A) $1.6 \times 10^{-9}\ M$

(B) $8 \times 10^{-10}\ M$

(C) $1.26 \times 10^{-5}\ M$

(D) $4 \times 10^{-10}\ M$

Q7. The resistance of a 0.1 M KCl solution is 100 Ω. If the resistance of the same cell when filled with 0.02 M KCl solution is 520 Ω, calculate the conductivity of 0.02 M KCl solution. (Conductivity of 0.1 M KCl is $1.29\ S\ m^{-1}$)

(A) $0.248\ S\ m^{-1}$

(B) $1.29\ S\ m^{-1}$

(C) $0.0248\ S\ m^{-1}$

(D) $0.129\ S\ m^{-1}$

Q8. In a process, 701 J of heat is absorbed by a system and 394 J of work is done by the system. What is the change in internal energy?

(A) 1095 J

(B) 307 J

(C) $-307\ J$

(D) 701 J

Q9. For a reaction, $\Delta H = 30\ kJ\ mol^{-1}$ and $\Delta S = 45\ J\ K^{-1}mol^{-1}$. At what temperature will the reaction become spontaneous?

(A) Above 666.6 K

(B) Below 666.6 K

(C) Above 1.5 K

(D) Below 1.5 K

Q10. The Van't Hoff factor for a 0.1 M $Ba(NO_3)_2$ solution is 2.74. The degree of dissociation is:

(A) 91.3%

(B) 87%

(C) 100%

(D) 74%

Q11. The correct order of bond angles in NH_3, PH_3, AsH_3, and SbH_3 is:

(A) $NH_3 > PH_3 > AsH_3 > SbH_3$

(B) $SbH_3 > AsH_3 > PH_3 > NH_3$

(C) $NH_3 = PH_3 = AsH_3 = SbH_3$

(D) $PH_3 > NH_3 > AsH_3 > SbH_3$

Q12. Which of the following is an outer orbital complex and exhibits paramagnetic behavior?

(A) $[Ni(NH_3)_6]^{2+}$

(B) $[Zn(NH_3)_6]^{2+}$

(C) $[Cr(NH_3)_6]^{3+}$

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

Q13. The spin-only magnetic moment of $[MnBr_4]^{2-}$ is 5.9 BM. The geometry of the complex ion is:

(A) Square planar

(B) Tetrahedral

(C) Octahedral

(D) Pyramidal

Q14. Which of the following noble gases is used in magnetic resonance imaging (MRI) systems?

(A) Helium

(B) Neon

(C) Argon

(D) Xenon

Q15. The stability of +1 oxidation state among Al, Ga, In, and Tl increases in the sequence:

(A) $Al < Ga < In < Tl$

(B) $Tl < In < Ga < Al$

(C) $In < Tl < Ga < Al$

(D) $Ga < In < Al < Tl$

Q16. In which of the following compounds does the central atom possess sp^3d^2 hybridization?

(A) PCl_5

(B) BrF_5

(C) SF_4

(D) ClF_3

Q17. The transition metal used in the Monsanto acetic acid process is:

(A) Rhodium

(B) Cobalt

(C) Iron

(D) Nickel

Q18. Which lanthanide ion is used as a powerful oxidizing agent in analytical chemistry?

(A) Ce^{4+}

(B) Lu^{3+}

(C) Gd^{3+}

(D) Sm^{2+}

Q19. The pair of ions that are isoelectronic and isostructural is:

(A) CO_3^{2-}, NO_3^-

(B) ClO_3^-, CO_3^{2-}

(C) SO_3^{2-}, NO_3^-

(D) ClO_3^-, SO_4^{2-}

Q20. In the volumetric estimation of Fe^{2+}, $K_2Cr_2O_7$ is preferred over $KMnO_4$ because:

(A) $K_2Cr_2O_7$ is a stronger oxidizing agent.

(B) $K_2Cr_2O_7$ can be used in the presence of HCl.

(C) $KMnO_4$ is a primary standard.

(D) $K_2Cr_2O_7$ is more soluble in water.

Q21. Arrange the following in increasing order of their reactivity towards S_N1 reaction:
(i) CH_3CH_2Cl (ii) $(CH_3)_2CHCl$ (iii) $(CH_3)_3CCl$ (iv) $C_6H_5CH_2Cl$

(A) (i) < (ii) < (iii) < (iv)

(B) (i) < (ii) < (iv) < (iii)

(C) (iv) < (iii) < (ii) < (i)

(D) (ii) < (i) < (iii) < (iv)

Q22. Phenol on treatment with CO_2 in the presence of $NaOH$ followed by acidification gives:

(A) Salicylaldehyde

(B) Salicylic acid

(C) Aspirin

(D) Benzoic acid

Q23. Which of the following will not undergo Aldol condensation?

(A) Acetaldehyde

(B) Propanone

(C) Benzaldehyde

(D) Trichloroacetaldehyde

Q24. An organic compound with molecular formula $C_4H_{11}N$ on reaction with nitrous acid gives an alcohol and nitrogen gas. The compound is:

(A) Tertiary amine

(B) Secondary amine

(C) Primary amine

(D) Quaternary ammonium salt

Q25. Which of the following carbohydrates is a non-reducing sugar?

(A) Glucose

(B) Fructose

(C) Lactose

(D) Sucrose

Q26. The major product formed when ethyl benzene is oxidized with alkaline $KMnO_4$ is:

(A) Benzyl alcohol

(B) Benzaldehyde

(C) Benzoic acid

(D) Acetophenone

Q27. The monomer of Neoprene is:

(A) Chloroprene

(B) Isoprene

(C) Acrylonitrile

(D) Caprolactam

Q28. Which test is used to distinguish between primary, secondary, and tertiary amines?

(A) Carbylamine test

(B) Hinsberg's test

(C) Lucas test

(D) Tollen's test

Q29. The reaction $R - COOH + N_3H \xrightarrow{H_2SO_4} R - NH_2 + CO_2 + N_2$ is known as:

(A) Hofmann bromamide reaction

(B) Schmidt reaction

(C) Curtius rearrangement

(D) Gabriel phthalimide synthesis

Q30. In the following reaction: $Ethanol \xrightarrow{PBr_3} X \xrightarrow{alc.KOH} Y \xrightarrow{H_2SO_4, H_2O, \Delta} Z$. The product Z is:

(A) Ethane

(B) Ethanol

(C) Ethene

(D) Ethyne

Q31. The molar conductivity of 0.007 M acetic acid is 20 $S\ cm^2\ mol^{-1}$. If Λ_m° for H^+ is 350 $S\ cm^2\ mol^{-1}$ and for CH_3COO^- is 50 $S\ cm^2\ mol^{-1}$, the dissociation constant K_a of acetic acid is:

(A) 1.75×10^{-5}

(B) 1.75×10^{-4}

(C) 2.5×10^{-5}

(D) 7.0×10^{-5}

Q32. For the reaction $2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$, $\Delta H = -117\ kJ$. If the volume of the reaction vessel is halved:

(A) The equilibrium shifts to the left.

(B) The amount of NO_2 increases.

(C) K_c increases.

(D) K_c decreases.

Q33. Which of the following will have the highest boiling point?

(A) 0.1 M $NaCl$

(B) 0.1 M $Urea$

(C) 0.1 M $MgCl_2$

(D) 0.1 M $Al_2(SO_4)_3$

Q34. The number of ions produced by the complex $[Co(NH_3)_4Cl_2]Cl$ in an aqueous solution is:

(A) 2

(B) 3

(C) 4

(D) 5

Q35. If the rate constant for a first-order reaction is k, the time required for the completion of 99% of the reaction is given by:

(A) $t = \frac{2.303}{k}$

(B) $t = \frac{4.606}{k}$

(C) $t = \frac{6.909}{k}$

(D) $t = \frac{0.693}{k}$

Q36. The correct order of basicity of methyl-substituted amines in the gaseous phase is:

(A) $Me_3N > Me_2NH > MeNH_2 > NH_3$

(B) $Me_2NH > MeNH_2 > Me_3N > NH_3$

(C) $Me_2NH > Me_3N > MeNH_2 > NH_3$

(D) $NH_3 > MeNH_2 > Me_2NH > Me_3N$

Q37. Which of the following is used as an antiseptic and disinfectant?

(A) 0.2% Phenol

(B) 1% Phenol

(C) Bithional

(D) Both (A) and (C)

Q38. Na_2SO_4 is water-soluble but $BaSO_4$ is insoluble because:

(A) Lattice energy of $BaSO_4$ exceeds its hydration energy.

(B) $BaSO_4$ is more ionic than Na_2SO_4.

(C) Hydration energy of Ba^{2+} is higher than Na^+.

(D) $BaSO_4$ has a higher molar mass.

Q39. What is the product C in the following reaction? $Benzene \xrightarrow{CH_3Cl, AlCl_3} A \xrightarrow{KMnO_4, OH^-} B \xrightarrow{NH_3, \Delta} C$

(A) Benzamide

(B) Benzonitrile

(C) Aniline

(D) Benzylamine

Q40. The IUPAC name of the complex $K_3[Cr(C_2O_4)_3]$ is:

(A) Potassium tris(oxalato)chromium(III)

(B) Potassium trioxalatochromate(III)

(C) Potassium tris(oxalato)chromate(III)

(D) Tripotassium trioxalatochromate(III)

Q41. A 5% solution (w/v) of cane sugar (MW = 342) is isotonic with 1% solution (w/v) of substance X. The molecular weight of X is:

(A) 34.2

(B) 171.2

(C) 68.4

(D) 136.8

Q42. In a solid lattice, the cation has left a lattice site and is located at an interstitial position. The lattice defect is:

(A) Schottky defect

(B) Frenkel defect

(C) Vacancy defect

(D) Non-stoichiometric defect

Q43. The values of ΔH and ΔS for the reaction $C(graphite) + CO_2(g) \rightarrow 2CO(g)$ are +170 kJ and 170 $J\ K^{-1}$ respectively. The reaction will be spontaneous at:

(A) 710 K

(B) 910 K

(C) 1110 K

(D) 510 K

Q44. Which of the following amino acids is optically inactive?

(A) Alanine

(B) Glycine

(C) Valine

(D) Leucine

Q45. The standard electrode potential for F_2/F^- is +2.87 V, Cl_2/Cl^- is +1.36 V, Br_2/Br^- is +1.09 V, and I_2/I^- is +0.54 V. The strongest oxidizing agent is:

(A) F_2

(B) Cl_2

(C) Br_2

(D) I_2

Q46. The reagent that can distinguish between 1-butyne and 2-butyne is:

(A) Br_2 in CCl_4

(B) Ammoniacal $AgNO_3$

(C) Dilute $KMnO_4$

(D) O_3

Q47. If E°_{cell} for a given reaction has a negative value, which of the following gives the correct relationships for the values of ΔG° and K_{eq}?

(A) $\Delta G^{\circ} > 0, K_{eq} < 1$

(B) $\Delta G^{\circ} < 0, K_{eq} > 1$

(C) $\Delta G^{\circ} < 0, K_{eq} < 1$

(D) $\Delta G^{\circ} > 0, K_{eq} > 1$

Q48. Nylon-6 is prepared from:

(A) Hexamethylenediamine

(B) Adipic acid

(C) Caprolactam

(D) Ethylene glycol

Q49. Which of the following is a "narrow spectrum" antibiotic?

(A) Penicillin G

(B) Ampicillin

(C) Amoxycillin

(D) Chloramphenicol

Q50. The secondary structure of protein is stabilized by:

(A) Peptide bond

(B) Hydrogen bond

(C) Glycosidic bond

(D) Vander Waals forces

Detailed Solutions

Q1.

Solution

Concept:

The density (d) of a cubic crystal system is related to the number of atoms per unit cell (Z), the molar mass (M), the edge length (a), and Avogadro's number (N_A) by the formula:

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

The value of Z determines the nature of the unit cell: $Z = 1$ for Simple Cubic, $Z = 2$ for BCC, and $Z = 4$ for FCC.

Solution:

1. Given values: $M = 27\ g\ mol^{-1}$, $d = 2.7\ g\ cm^{-3}$, and $a = 405\ pm = 405 \times 10^{-10}\ cm$. 2. Rearrange the density formula to solve for Z:

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

3. Substitute the values into the equation:

$$Z = \frac{2.7 \times (405 \times 10^{-10})^3 \times 6.022 \times 10^{23}}{27}$$

4. Simplify the calculation:

$$Z = \frac{2.7 \times 66.43 \times 10^{-24} \times 6.022 \times 10^{23}}{27}$$

$$Z \approx \frac{1.08}{0.27} \approx 3.99$$

5. Since $Z \approx 4$, the unit cell is Face-Centered Cubic (FCC).

Final Answer: The nature of the cubic unit cell is Face-Centered Cubic.

Answer: (B)

Q2.

Solution

Concept:

According to Raoult's Law for a solution containing a non-volatile solute, the relative lowering of vapor pressure is equal to the mole fraction of the solute in the solution. The formula is:

$$\frac{P^o - P_s}{P^o} = \frac{n_2}{n_1 + n_2}$$

For dilute solutions, this can be approximated or used in the form:

$$\frac{P^o - P_s}{P_s} = \frac{n_2}{n_1}$$

where P^o is the vapor pressure of pure solvent, P_s is the vapor pressure of the solution, n_2 is the moles of solute, and n_1 is the moles of solvent.

Solution:

1. Identify the given values: Vapor pressure of pure benzene (P^o) = 640 $mm\ Hg$ Vapor pressure of solution (P_s) = 600 $mm\ Hg$ Mass of solute (w_2) = 2.175 g Mass of benzene (w_1) = 39 g Molar mass of benzene (M_1, C_6H_6) = 78 $g\ mol^{-1}$
2. Calculate the moles of solvent (benzene):

$$n_1 = \frac{w_1}{M_1} = \frac{39}{78} = 0.5\ mol$$

3. Use the relation for lowering of vapor pressure:

$$\frac{P^o - P_s}{P_s} = \frac{n_2}{n_1}$$

$$\frac{640 - 600}{600} = \frac{w_2/M_2}{0.5}$$

4. Simplify and solve for M_2:

$$\frac{40}{600} = \frac{2.175}{M_2 \times 0.5}$$

$$\frac{1}{15} = \frac{4.35}{M_2}$$

$$M_2 = 4.35 \times 15$$

$$M_2 = 65.25\ g\ mol^{-1}$$

5. Comparing with the given options, the molar mass is approximately 65 $g\ mol^{-1}$.

Final Answer: The molar mass of the solid is 65 $g\ mol^{-1}$.

Answer: (A)

Q3.

Solution

Concept:

The general unit for a rate constant k for a reaction of n^{th} order is given by the formula:

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

where n is the overall order of the reaction. The overall order is the sum of the powers of the concentration terms in the rate law expression.

Solution:

1. Identify the rate law given in the question:

$$Rate = k[A]^2[B]^{1/2}$$

2. Calculate the overall order (n):

$$n = 2 + \frac{1}{2} = 2.5$$

3. Substitute the value of n into the general unit formula:

$$\text{Unit of } k = (mol\ L^{-1})^{1-2.5}\ s^{-1}$$

$$\text{Unit of } k = (mol\ L^{-1})^{-1.5}\ s^{-1}$$

4. Simplify the expression by distributing the exponent:

$$\text{Unit of } k = mol^{-1.5}\ (L^{-1})^{-1.5}\ s^{-1}$$

$$\text{Unit of } k = mol^{-1.5}\ L^{1.5}\ s^{-1}$$

5. Comparing this result with the given options, it matches option (A).

Final Answer: The unit of the rate constant k is $mol^{-1.5}\ L^{1.5}\ s^{-1}$.

Answer: (A)

Q4.

Solution

Concept:

The order of a reaction can be determined by the relationship between the half-life ($t_{1/2}$) and the concentration of reactants. For a first-order reaction, the half-life is independent of the initial concentration, meaning the time required for a specific percentage of completion remains constant relative to the remaining concentration. Specifically, for first-order kinetics:

$$t_{75\%} = 2 \times t_{50\%}$$

Solution:

1. From the given data: Time for 50% completion ($t_{50\%}$) = 2 hours. Time for 75% completion ($t_{75\%}$) = 4 hours.
2. Analyze the relationship between the two time intervals: 75% completion means that 25% of the reactant remains. This is equivalent to the reaction going through two successive half-lives (100% $\rightarrow$ 50% $\rightarrow$ 25%).
3. Check the ratio:

$$\frac{t_{75\%}}{t_{50\%}} = \frac{4 \text{ hours}}{2 \text{ hours}} = 2$$

4. Since $t_{75\%}$ is exactly twice the $t_{50\%}$, the half-life is constant ($t_{1/2}$ = 2 hours) regardless of the concentration decrease.
5. This property is a characteristic of first-order reactions. In zero-order reactions, $t_{75\%} = 1.5 \times t_{50\%}$, and in second-order reactions, $t_{75\%} = 3 \times t_{50\%}$.

Final Answer: The order of the reaction is First.

Answer: (B)

Q5.

Solution

Concept:

The enthalpy of formation ($\Delta_f H^\circ$) of a compound is the enthalpy change for the formation of one mole of the compound from its constituent elements in their standard states. According to Hess's Law, the enthalpy change of a reaction can be calculated using enthalpies of combustion ($\Delta_c H^\circ$) as:

$$\Delta_r H^\circ = \sum \Delta_c H^\circ(\text{reactants}) - \sum \Delta_c H^\circ(\text{products})$$

Solution:

1. Write the required thermochemical equation for the formation of methane:

$$C(s, \text{graphite}) + 2H_2(g) \rightarrow CH_4(g)$$

2. List the given enthalpy of combustion values: (i) $C(s) + O_2(g) \rightarrow CO_2(g); \Delta_c H^\circ = -393.5\ kJ\ mol^{-1}$ (ii) $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l); \Delta_c H^\circ = -285.8\ kJ\ mol^{-1}$ (iii) $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l); \Delta_c H^\circ = -890.3\ kJ\ mol^{-1}$

3. Apply the formula for enthalpy of formation:

$$\Delta_f H^\circ(CH_4) = [\Delta_c H^\circ(C) + 2 \times \Delta_c H^\circ(H_2)] - [\Delta_c H^\circ(CH_4)]$$

4. Substitute the numerical values:

$$\Delta_f H^\circ(CH_4) = [(-393.5) + 2 \times (-285.8)] - [-890.3]$$

$$\Delta_f H^\circ(CH_4) = [-393.5 - 571.6] + 890.3$$

$$\Delta_f H^\circ(CH_4) = -965.1 + 890.3$$

5. Calculate the final value:

$$\Delta_f H^\circ(CH_4) = -74.8\ kJ\ mol^{-1}$$

Final Answer: The enthalpy of formation of $CH_4(g)$ is $-74.8\ kJ\ mol^{-1}$.

Answer: (A)

Q6.

Solution

Concept:

The Common Ion Effect on solubility. The solubility of a sparingly soluble salt decreases in the presence of a solution containing one of its constituent ions.

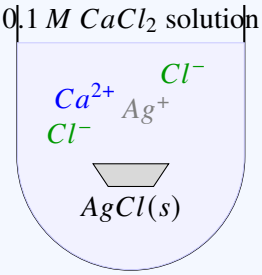
Solution:

Step 1: Write the dissociation equation for the sparingly soluble salt: $AgCl(s) \rightleftharpoons Ag^{+}(aq) + Cl^{-}(aq)$ The solubility product is $K_{sp} = [Ag^{+}][Cl^{-}]$.

Step 2: Determine the concentration of the common ion (Cl^{-}) from the strong electrolyte $CaCl_2$: $CaCl_2 \rightarrow Ca^{2+} + 2Cl^{-}$ Since $[CaCl_2] = 0.1\,M$, then $[Cl^{-}] = 2 \times 0.1 = 0.2\,M$.

Step 3: Let s be the solubility of $AgCl$ in this solution. Total $[Cl^{-}] = (0.2 + s)\,M$. Since K_{sp} is very small, $s \ll 0.2$, so $[Cl^{-}] \approx 0.2\,M$. Total $[Ag^{+}] = s\,M$.

Step 4: Substitute into the K_{sp} expression: $1.6 \times 10^{-10} = (s)(0.2)$ $s = \frac{1.6 \times 10^{-10}}{0.2} = 8 \times 10^{-10}\,M$.



Final Answer:

$$\boxed{8 \times 10^{-10}\,M}$$

Answer: (B)

Q7.

Solution

Concept:

Conductivity (κ) is related to resistance (R) and the cell constant (G^*) by the formula:

$$\kappa = \frac{1}{R} \times G^* \quad \text{or} \quad G^* = \kappa \times R$$

The cell constant ($G^* = l/A$) remains the same for a particular cell, regardless of the solution used.

Solution:

1. Calculate the cell constant (G^*) using the data for 0.1 M KCl: $\kappa_1 = 1.29\ S\ m^{-1}$ $R_1 = 100\ \Omega$ $G^* = \kappa_1 \times R_1 = 1.29 \times 100 = 129\ m^{-1}$
2. Use the cell constant to find the conductivity of 0.02 M KCl: $R_2 = 520\ \Omega$ $G^* = 129\ m^{-1}$ $\kappa_2 = \frac{G^*}{R_2}$
3. Perform the calculation:

$$\kappa_2 = \frac{129}{520}$$

$$\kappa_2 \approx 0.248\ S\ m^{-1}$$

Final Answer: The conductivity of 0.02 M KCl solution is 0.248 $S\ m^{-1}$.

Answer: (A)

Q8.

Solution

Concept:

According to the First Law of Thermodynamics, the change in internal energy (ΔU) of a system is given by:

$$\Delta U = q + w$$

where q is the heat exchanged and w is the work done. Following the IUPAC sign convention: * Heat absorbed by the system: q is positive (+). * Work done by the system: w is negative (−).

Solution:

1. Identify the given values with correct signs: Heat absorbed (q) = +701 J Work done by the system (w) = −394 J
2. Substitute the values into the First Law equation:

$$\Delta U = 701 + (-394)$$

3. Calculate the result:

$$\Delta U = 701 - 394 = 307\ J$$

Final Answer: The change in internal energy is 307 J.

Answer: (B)

Q9.

Solution

Concept:

A reaction is spontaneous when the change in Gibbs free energy (ΔG) is negative ($\Delta G < 0$). The relationship is given by:

$$\Delta G = \Delta H - T\Delta S$$

At equilibrium (where the reaction is about to become spontaneous), $\Delta G = 0$, thus $T = \Delta H/\Delta S$.

Solution:

1. Convert units to be consistent (typically Joules): $\Delta H = 30\ kJ\ mol^{-1} = 30,000\ J\ mol^{-1}$ $\Delta S = 45\ J\ K^{-1}mol^{-1}$
2. Find the temperature at which $\Delta G = 0$:

$$T = \frac{\Delta H}{\Delta S} = \frac{30,000}{45}$$

3. Calculate the value:

$$T = 666.66... \approx 666.7\ K$$

4. Determine the condition for spontaneity: Since ΔH and ΔS are both positive, the $T\Delta S$ term must be larger than ΔH to make ΔG negative. This happens at temperatures above 666.6 K.

Final Answer: The reaction will become spontaneous above 666.6 K.

Answer: (A)

Q10.

Solution

Concept:

The Van't Hoff factor (i) is related to the degree of dissociation (α) by the formula:

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

where n is the number of ions produced per molecule of the solute.

Solution:

1. Determine n for Barium nitrate, $Ba(NO_3)_2$: $Ba(NO_3)_2 \rightarrow Ba^{2+} + 2NO_3^-$ Total ions (n) = $1 + 2 = 3$.
2. Substitute the given values ($i = 2.74, n = 3$) into the formula:

$$2.74 = 1 + \alpha(3 - 1)$$

$$2.74 = 1 + 2\alpha$$

3. Solve for α:

$$1.74 = 2\alpha$$

$$\alpha = \frac{1.74}{2} = 0.87$$

4. Convert to percentage:

$$\text{Degree of dissociation} = 0.87 \times 100 = 87\%$$

Final Answer: The degree of dissociation is 87%.

Answer: (B)

Q11.

Solution

Concept:

According to VSEPR theory and the concept of electronegativity, as we move down the group from Nitrogen to Antimony, the electronegativity of the central atom decreases. This causes the bond pairs of electrons to move further away from the central atom, reducing the electron-pair repulsion and allowing the bond angle to decrease. Additionally, for PH_3, AsH_3, and SbH_3, the bonding involves almost pure p-orbitals (Drago's rule), leading to angles close to 90°, whereas NH_3 is sp^3 hybridized with a higher angle.

Solution:

1. Compare the central atoms: N, P, As, Sb belong to Group 15. 2. Electronegativity order: $N(3.0) > P(2.1) > As(2.0) > Sb(1.9)$. 3. In NH_3, high electronegativity of N pulls bond pairs closer, increasing repulsion and resulting in an angle of $\approx 107°$. 4. In PH_3, AsH_3, and SbH_3, the large size and low electronegativity of the central atom result in bond angles of $\approx 93.6°$, $91.8°$, and $91.3°$ respectively. 5. The bond angle decreases as the size of the central atom increases.

Final Answer: The correct order is $NH_3 > PH_3 > AsH_3 > SbH_3$.

Answer: (A)

Q12.

Solution

Concept:

Outer orbital complexes use nd orbitals for hybridization (usually sp^3d^2), which typically occurs with weak field ligands or when the d-subshell configuration prevents the use of inner $(n-1)d$ orbitals. Paramagnetic behavior occurs when there are one or more unpaired electrons in the metal ion.

Solution:

1. Analyze $[Ni(NH_3)_6]^{2+}$: Ni^{2+} is $[Ar]3d^8$. Ammonia acts as a neutral ligand. In an octahedral field, d^8 always has 2 unpaired electrons in the e_g level. It must use $4d$ orbitals for hybridization (sp^3d^2), making it an outer orbital complex and paramagnetic. 2. Analyze $[Zn(NH_3)_6]^{2+}$: Zn^{2+} is $[Ar]3d^{10}$. All electrons are paired (diamagnetic). 3. Analyze $[Cr(NH_3)_6]^{3+}$: Cr^{3+} is $[Ar]3d^3$. It uses inner d orbitals (d^2sp^3), making it an inner orbital complex. 4. Analyze $[Co(NH_3)_6]^{3+}$: Co^{3+} is $[Ar]3d^6$. NH_3 is a strong field ligand for Co^{3+}, causing pairing. It is an inner orbital complex (d^2sp^3) and diamagnetic.

Final Answer: $[Ni(NH_3)_6]^{2+}$ is an outer orbital complex and exhibits paramagnetic behavior.

Answer: (A)

Q13.

Solution

Concept:

The spin-only magnetic moment (μ_s) is calculated using the formula:

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

where n is the number of unpaired electrons. The geometry of a complex with a coordination number of 4 can be either tetrahedral (sp^3 hybridization) or square planar (dsp^2 hybridization). High-spin complexes with weak-field ligands like Br^- usually favor tetrahedral geometry.

Solution:

1. Determine the number of unpaired electrons (n):

$$5.9 = \sqrt{n(n+2)}$$

Squaring both sides: $34.81 = n^2 + 2n$. For $n = 5$, $\sqrt{5(5+2)} = \sqrt{35} \approx 5.91\ BM$. Thus, $n = 5$.

2. Find the oxidation state of Mn in $[MnBr_4]^{2-}$: $x + 4(-1) = -2 \Rightarrow x = +2$. Mn^{2+} configuration is $[Ar]3d^5$.

3. Analyze the electronic distribution: Since there are 5 unpaired electrons, all five $3d$ orbitals are singly occupied. This means no d-orbital is available for dsp^2 hybridization.

4. Conclusion: The complex must use $4s$ and $4p$ orbitals for hybridization, resulting in sp^3 hybridization, which corresponds to a tetrahedral geometry.

Final Answer: The geometry of the complex ion is Tetrahedral.

Answer: (B)

Q14.

Solution

Concept:

Noble gases have various specialized applications due to their chemical inertness and unique physical properties. Magnetic Resonance Imaging (MRI) machines use superconducting magnets that generate intense heat. To maintain superconductivity, these magnets must be cooled to extremely low temperatures.

Solution:

1. MRI scanners require liquid coolants to keep the superconducting wire at temperatures near absolute zero. 2. Helium has the lowest boiling point of any element (4.2 K). 3. Liquid helium is the standard cryogenic refrigerant used to cool the superconducting magnets in MRI systems to allow them to operate without electrical resistance. 4. While Xenon is sometimes used in specialized medical imaging (like hyperpolarized Xenon MRI for lungs), Helium is the primary noble gas fundamental to the operation of standard MRI hardware.

Final Answer: Helium is used in magnetic resonance imaging (MRI) systems.

Answer: (A)

Q15.

Solution

Concept:

The stability of oxidation states in Group 13 is influenced by the inert pair effect. As we move down the group, the ns^2 electrons become increasingly reluctant to participate in bonding due to poor shielding of the nucleus by d and f electrons. Consequently, the lower oxidation state (+1) becomes more stable than the higher oxidation state (+3) for heavier elements.

Solution:

1. Group 13 elements are: Al, Ga, In, Tl. 2. For Al, the +3 state is highly stable, and +1 is almost non-existent. 3. Moving down to Tl, the inert pair effect is most pronounced. 4. $Tl(I)$ is significantly more stable than $Tl(III)$. 5. Therefore, the stability of the +1 oxidation state increases down the group.

Final Answer: The stability increases in the sequence $Al < Ga < In < Tl$.

Answer: (A)

Q16.

Solution

Concept:

Determination of hybridization using the Steric Number rule: $S.N. = \frac{1}{2}[V + M - C + A]$, where V is valence electrons, M is monovalent atoms, C is cationic charge, and A is anionic charge. $S.N. = 6$ corresponds to sp^3d^2 hybridization.

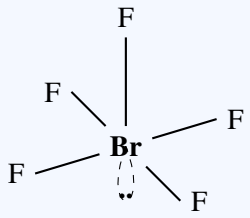
Solution:

Step 1: For PCl_5, $S.N. = \frac{1}{2}[5 + 5] = 5$. Hybridization is sp^3d (Trigonal bipyramidal).

Step 2: For BrF_5, $S.N. = \frac{1}{2}[7 + 5] = 6$. Hybridization is sp^3d^2. The geometry is octahedral, but with one lone pair, the shape is square pyramidal.

Step 3: For SF_4, $S.N. = \frac{1}{2}[6 + 4] = 5$. Hybridization is sp^3d (See-saw).

Step 4: For ClF_3, $S.N. = \frac{1}{2}[7 + 3] = 5$. Hybridization is sp^3d (T-shaped).



Square Pyramidal (sp^3d^2)

Final Answer:

BrF_5

Answer: (B)

Q17.

Solution

Concept:

The Monsanto process is an industrial method for the manufacture of acetic acid by catalytic carbonylation of methanol. It operates at a pressure of $30 - 60\ atm$ and a temperature of $150 - 200^{\circ}C$.

Solution:

1. The Monsanto process specifically uses a Rhodium-based catalyst system. 2. The active catalyst species is the complex $[Rh(CO)_2I_2]^-$. 3. While the Cativa process (a similar later development) uses Iridium, the original Monsanto process is synonymous with Rhodium. 4. Other metals like Cobalt were used in earlier processes (like the BASF process), but they required much higher pressures.

Final Answer: The transition metal used in the Monsanto process is Rhodium.

Answer: (A)

Q18.

Solution

Concept:

The lanthanide series consists of elements from Cerium ($Z = 58$) to Lutetium ($Z = 71$). While +3 is the most stable oxidation state for lanthanides, some elements exhibit +2 or +4 states. Cerium in the +4 state (Ce^{4+}) is highly unstable relative to Ce^{3+} because it tends to revert to the more stable +3 state by gaining an electron.

Solution:

1. Ce^{4+} has the electronic configuration $[Xe]4f^0$. 2. It has a strong tendency to gain one electron to reach the stable +3 state ($[Xe]4f^1$). 3. Because it gains electrons (undergoes reduction), it acts as a powerful oxidizing agent. 4. In analytical chemistry, Ceric ammonium sulfate or Ceric sulfate is widely used in "Cerimetry" for volumetric analysis. 5. Other ions like Lu^{3+} and Gd^{3+} are in their most stable states and do not act as strong oxidants, while Sm^{2+} is a reducing agent.

Final Answer: Ce^{4+} is used as a powerful oxidizing agent.

Answer: (A)

Q19.

Solution

Concept:

Isoelectronic species have the same total number of electrons. Isostructural species have the same shape and geometry (hybridization). For polyatomic ions, we compare the total valence electrons and the central atom's hybridization.

Solution:

1. Analyze CO_3^{2-} and NO_3^-: Total electrons in CO_3^{2-}: $6(\text{C}) + 3 \times 8(\text{O}) + 2 = 32$. Total electrons in NO_3^-: $7(\text{N}) + 3 \times 8(\text{O}) + 1 = 32$. They are isoelectronic. 2. Check Structure: In CO_3^{2-}, C is sp^2 hybridized with 3 bond pairs and 0 lone pairs. Shape: Trigonal planar. In NO_3^-, N is sp^2 hybridized with 3 bond pairs and 0 lone pairs. Shape: Trigonal planar. 3. Conclusion: Since they have the same number of electrons and the same trigonal planar geometry, they are both isoelectronic and isostructural. 4. Other pairs like ClO_3^- (sp^3, Pyramidal) and CO_3^{2-} (sp^2, Planar) do not match.

Final Answer: The pair CO_3^{2-}, NO_3^- is isoelectronic and isostructural.

Answer: (A)

Q20.

Solution

Concept:

Potassium permanganate ($KMnO_4$) and Potassium dichromate ($K_2Cr_2O_7$) are both strong oxidizing agents used in redox titrations. However, their compatibility with different acids and their stability as standards differ significantly.

Solution:

1. In titrations involving iron ores, HCl is often used to dissolve the sample. 2. $KMnO_4$ is such a strong oxidizing agent that it can oxidize the Cl^- ions from HCl into Cl_2 gas. This leads to an incorrect (higher) reading for the Fe^{2+} estimation. 3. $K_2Cr_2O_7$, being slightly less vigorous than $KMnO_4$, does not oxidize Cl^- under standard titration conditions. Therefore, it can be safely used in the presence of HCl. 4. Additionally, $K_2Cr_2O_7$ is a primary standard (stable, high purity), whereas $KMnO_4$ is a secondary standard. 5. While both are used, the specific advantage regarding HCl makes $K_2Cr_2O_7$ preferable for iron estimation.

Final Answer: $K_2Cr_2O_7$ is preferred because it can be used in the presence of HCl.

Answer: (B)

Q21.

Solution

Concept:

The reactivity of alkyl halides towards S_N1 reactions depends on the stability of the carbocation intermediate formed during the rate-determining step. The stability order of carbocations is generally: Benzyl ≈ Tertiary (3°) > Secondary (2°) > Primary (1°). Resonance stabilization (as seen in the benzyl carbocation) usually provides significant stability.

Solution:

1. Identify the carbocations formed: (i) $CH_3CH_2Cl \rightarrow CH_3CH_2^+$ (Primary, 1°) (ii) $(CH_3)_2CHCl \rightarrow (CH_3)_2CH^+$ (Secondary, 2°) (iii) $(CH_3)_3CCl \rightarrow (CH_3)_3C^+$ (Tertiary, 3°) (iv) $C_6H_5CH_2Cl \rightarrow C_6H_5CH_2^+$ (Benzyl)

2. Compare stabilities: The primary carbocation (i) is the least stable. The secondary (ii) is more stable due to inductive effect/hyperconjugation. The tertiary (iii) is very stable. The benzyl carbocation (iv) is highly stabilized by resonance with the benzene ring.

3. In many standard competitive exam contexts, the resonance-stabilized benzyl cation is considered more reactive or comparable to the tertiary cation, placing (iv) at the highest reactivity.

Final Answer: The increasing order of reactivity is (i) < (ii) < (iii) < (iv).

Answer: (A)

Q22.

Solution

Concept:

The reaction of phenol with carbon dioxide and sodium hydroxide is known as the **Kolbe-Schmitt reaction**. It is an electrophilic substitution reaction where the phenoxide ion reacts with CO_2 to form an ortho-hydroxy aromatic acid.

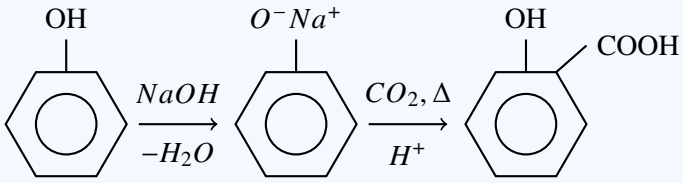
Solution:

Step 1: Phenol reacts with $NaOH$ to form the sodium phenoxide ion, which is more reactive toward electrophiles than phenol itself.

Step 2: Sodium phenoxide is treated with CO_2 at approximately 400 K and 4 – 7 atm pressure. The CO_2 acts as a weak electrophile and attacks the ortho position.

Step 3: The resulting sodium salicylate is then acidified to yield 2-hydroxybenzoic acid.

Step 4: 2-hydroxybenzoic acid is commonly known as **Salicylic acid**.



Kolbe-Schmitt Reaction

Final Answer:

Salicylic acid

Answer: (B)

Q23.

Solution

Concept:

Aldol condensation occurs in aldehydes or ketones that possess at least one **α-hydrogen** atom. The α-hydrogen is necessary for the formation of the enolate ion in the presence of a dilute base.

Solution:

1. Acetaldehyde (CH_3CHO): Has 3 α-hydrogens. Will undergo Aldol. 2. Propanone (CH_3COCH_3): Has 6 α-hydrogens. Will undergo Aldol. 3. Benzaldehyde (C_6H_5CHO): The CHO group is attached to a benzene ring carbon that has no hydrogens. It lacks α-hydrogens. 4. Trichloroacetaldehyde (CCl_3CHO): The α-carbon is fully substituted with chlorine atoms; it has no α-hydrogens.

Note: Both (C) and (D) lack α-hydrogens. However, in standard textbook contexts, Benzaldehyde and Chloral (Trichloroacetaldehyde) are the classic examples of compounds that undergo Cannizzaro reaction instead of Aldol condensation.

Final Answer: Benzaldehyde and Trichloroacetaldehyde will not undergo Aldol condensation. (Based on typical single-choice format, Benzaldehyde is the most common answer).

Answer: (C)

Q24.

Solution

Concept:

The reaction of amines with nitrous acid (HNO_2, prepared in situ from $NaNO_2 + HCl$) is a diagnostic test to distinguish between primary, secondary, and tertiary amines.

Solution:

1. **Primary aliphatic amines** ($R - NH_2$) react with nitrous acid to form highly unstable diazonium salts, which immediately decompose to release nitrogen gas (N_2) and form a mixture of compounds, primarily alcohols.

$$R - NH_2 + HNO_2 \rightarrow [R - N_2^+Cl^-] \xrightarrow{H_2O} R - OH + N_2 \uparrow + HCl$$

2. **Secondary amines** react to form yellow oily N-nitrosamines. 3. **Tertiary amines** react to form soluble nitrite salts. 4. Since the compound $C_4H_{11}N$ releases N_2 and forms an alcohol, it must be a primary amine.

Final Answer: The compound is a Primary amine.

Answer: (C)

Q25.

Solution

Concept:

A reducing sugar is a carbohydrate that contains a free aldehyde or ketone group (or a hemiacetal/hemiketal group in cyclic form) capable of reducing Tollen's or Fehling's reagents. In non-reducing sugars, these functional groups are involved in the glycosidic linkage between monosaccharide units, preventing them from opening into their reactive chain forms.

Solution:

1. **Glucose** and **Fructose** are monosaccharides; they always have a free (or potentially free) reducing group. 2. **Lactose** is a disaccharide (Galactose + Glucose) where one glucose unit retains its hemiacetal group, making it a reducing sugar. 3. **Sucrose** is a disaccharide composed of Glucose and Fructose. The linkage occurs between the C_1 of α-glucose and the C_2 of β-fructose. 4. Since both reducing functional groups (the aldehyde of glucose and the ketone of fructose) are tied up in the glycosidic bond, sucrose cannot act as a reducing agent.

Final Answer: Sucrose is a non-reducing sugar.

Answer: (D)

Q26.

Solution

Concept:

Strong oxidizing agents like alkaline $KMnO_4$ or acidic $K_2Cr_2O_7$ oxidize alkyl side chains of benzene rings completely to a carboxyl group ($-COOH$), provided that the carbon atom directly attached to the ring (the benzylic carbon) has at least one hydrogen atom.

Solution:

1. Ethyl benzene has the structure $C_6H_5 - CH_2CH_3$. 2. The benzylic carbon (CH_2) has two hydrogens, making it susceptible to oxidation. 3. Regardless of the length of the alkyl chain (methyl, ethyl, propyl, etc.), the entire side chain is cleaved and oxidized down to a single carbon carboxylic acid attached to the ring. 4. The resulting product is 1-phenylmethanoic acid, commonly known as Benzoic acid.

Final Answer: The major product is Benzoic acid.

Answer: (C)

Q27.

Solution

Concept:

Polymers are large molecules built from repeating structural units called monomers. Neoprene (also known as polychloroprene) is a synthetic rubber produced by the free radical polymerization of a specific halogenated diene.

Solution:

1. **Chloroprene** (2-chloro-1,3-butadiene) is the monomer for Neoprene. 2. **Isoprene** (2-methyl-1,3-butadiene) is the monomer for natural rubber. 3. **Acrylonitrile** is the monomer for PAN (Orlon). 4. **Caprolactam** is the monomer for Nylon 6.

Final Answer: The monomer of Neoprene is Chloroprene.

Answer: (A)

Q28.

Solution

Concept:

Different chemical tests are used to identify the functional environment of nitrogen in amines. To distinguish between all three classes ($1^\circ, 2^\circ, 3^\circ$), a reagent must produce a unique, observable result for each.

Solution:

1. **Carbylamine test:** Only primary amines react to give foul-smelling isocyanides; it cannot distinguish between 2° and 3°. 2. **Hinsberg's test:** Uses benzene sulfonyl chloride ($C_6H_5SO_2Cl$). - 1° amines form a precipitate soluble in alkali. - 2° amines form a precipitate insoluble in alkali. - 3° amines do not react at all. 3. **Lucas test:** Used to distinguish alcohols, not amines. 4. **Tollen's test:** Used for aldehydes.

Final Answer: Hinsberg's test is used to distinguish between primary, secondary, and tertiary amines.

Answer: (B)

Q29.

Solution

Concept:

The reaction described involves the treatment of a carboxylic acid with hydrazoic acid (N_3H) in the presence of a concentrated mineral acid (usually H_2SO_4). This rearrangement leads to the formation of a primary amine with one less carbon atom than the starting acid, along with the evolution of carbon dioxide and nitrogen gas.

Solution:

1. **Schmidt reaction:** Specifically refers to the acid-catalyzed reaction of hydrazoic acid with carbonyl compounds (acids, aldehydes, or ketones). With carboxylic acids, it yields amines. 2. **Hofmann bromamide reaction:** Involves an amide reacting with Br_2 and $NaOH$. 3. **Curtius rearrangement:** Involves the thermal decomposition of an acyl azide ($RCON_3$) to an isocyanate, which is then hydrolyzed to an amine. 4. **Gabriel phthalimide synthesis:** A method used to prepare pure primary amines using potassium phthalimide and alkyl halides. 5. Given the reagents $R - COOH$ and N_3H, it is the Schmidt reaction.

Final Answer: The reaction is known as the Schmidt reaction.

Answer: (B)

Q30.

Solution

Concept:

This sequence involves a series of functional group transformations: substitution, elimination, and hydration. 1. PBr_3 converts alcohols to alkyl bromides. 2. Alcoholic KOH brings about dehydrohalogenation (elimination) to form alkenes. 3. Acid-catalyzed hydration (H_2SO_4/H_2O) converts alkenes back to alcohols.

Solution:

1. **Step 1:** CH_3CH_2OH (Ethanol) reacts with PBr_3.

$$CH_3CH_2OH + PBr_3 \rightarrow CH_3CH_2Br \text{ (X: Ethyl bromide)}$$

2. **Step 2:** Ethyl bromide reacts with alcoholic KOH (heating).

$$CH_3CH_2Br \xrightarrow{alc.KOH} CH_2 = CH_2 \text{ (Y: Ethene)}$$

3. **Step 3:** Ethene undergoes hydration in the presence of dilute H_2SO_4.

$$CH_2 = CH_2 + H_2O \xrightarrow{H^+} CH_3CH_2OH \text{ (Z: Ethanol)}$$

4. Therefore, the starting material is regenerated as the final product.

Final Answer: The product Z is Ethanol.

Answer: (B)

Q31.

Solution

Concept:

Determination of the dissociation constant (K_a) of a weak electrolyte using Kohlrausch's Law and molar conductivity. The degree of dissociation is given by $\alpha = \frac{\Lambda_m}{\Lambda_m^\circ}$.

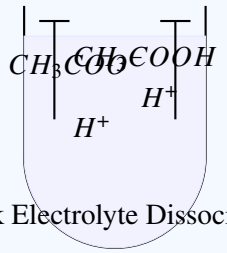
Solution:

Step 1: Calculate the molar conductivity at infinite dilution (Λ_m°) for acetic acid using Kohlrausch's Law: $\Lambda_m^\circ(CH_3COOH) = \lambda_{H^+}^\circ + \lambda_{CH_3COO^-}^\circ$ $\Lambda_m^\circ = 350 + 50 = 400\, S\, cm^2\, mol^{-1}$.

Step 2: Calculate the degree of dissociation (α): $\alpha = \frac{\Lambda_m}{\Lambda_m^\circ} = \frac{20}{400} = 0.05$.

Step 3: Calculate the dissociation constant (K_a) using the formula $K_a = \frac{C\alpha^2}{1-\alpha}$. Since α is small (0.05), we can use the approximation $K_a \approx C\alpha^2$. $K_a = 0.007 \times (0.05)^2 = 0.007 \times 0.0025$.

Step 4: Solve for K_a: $K_a = 1.75 \times 10^{-5}$.



Weak Electrolyte Dissociation

Final Answer:

$$\boxed{1.75 \times 10^{-5}}$$

Answer: (A)

Q32.

Solution

Concept:

Le Chatelier's Principle states that if a change is applied to a system at equilibrium, the system will shift in a direction that tends to counteract the change. When the volume of a gaseous reaction vessel is halved, the pressure doubles. The equilibrium will shift toward the side with fewer moles of gas to decrease the pressure.

Solution:

1. Count the moles of gaseous reactants and products: Reactants: $2\, mol\, NO + 1\, mol\, O_2 = 3\, moles$. Products: $2\, mol\, NO_2 = 2\, moles$.

2. Effect of volume reduction: Halving the volume increases the pressure. The system shifts to the side with fewer gas moles (the right side).

3. Results of the shift: The concentration and amount of NO_2 will increase. The values of K_c and K_p are temperature-dependent only; they do not change when volume or pressure changes at constant temperature.

Final Answer: The amount of NO_2 increases.

Answer: (B)

Q33.

Solution

Concept:

Boiling point elevation (ΔT_b) is a colligative property, which means it depends on the number of solute particles in the solution. It is given by:

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

where i is the Van't Hoff factor (number of ions/particles produced per formula unit). For the same molarity, the solution with the highest value of i will have the highest boiling point.

Solution:

1. Determine the Van't Hoff factor (i) for each 0.1 M solution: (A) $NaCl \rightarrow Na^+ + Cl^-$ ($i = 2$) (B) $Urea$ (non-electrolyte) ($i = 1$) (C) $MgCl_2 \rightarrow Mg^{2+} + 2Cl^-$ ($i = 3$) (D) $Al_2(SO_4)_3 \rightarrow 2Al^{3+} + 3SO_4^{2-}$ ($i = 5$)
2. Compare the i values: $Al_2(SO_4)_3$ produces the maximum number of particles (5) per formula unit.
3. Conclusion: 0.1 M $Al_2(SO_4)_3$ will show the maximum elevation in boiling point and thus have the highest boiling point.

Final Answer: 0.1 M $Al_2(SO_4)_3$ will have the highest boiling point.

Answer: (D)

Q34.

Solution

Concept:

When a coordination compound dissolves in water, the species inside the coordination sphere (square brackets) remain together as a single entity, while the counter ions outside the bracket dissociate completely into individual ions.

Solution:

1. Identify the coordination sphere and the counter ions in $[Co(NH_3)_4Cl_2]Cl$. 2. The complex dissociates in aqueous solution as follows:

$$[Co(NH_3)_4Cl_2]Cl(aq) \rightarrow [Co(NH_3)_4Cl_2]^+(aq) + Cl^-(aq)$$

3. The species $[Co(NH_3)_4Cl_2]^+$ is one complex ion (cation). 4. The species Cl^- is one chloride ion (anion). 5. Total number of ions = 1 (cation) + 1 (anion) = 2.

Final Answer: The number of ions produced is 2.

Answer: (A)

Q35.

Solution

Concept:

The integrated rate equation for a first-order reaction is:

$$t = \frac{2.303}{k} \log \frac{[R]_0}{[R]}$$

where $[R]_0$ is the initial concentration and $[R]$ is the concentration at time t. For 99% completion, the remaining concentration is 1% of the initial amount.

Solution:

1. Let initial concentration $[R]_0 = 100$. 2. For 99% completion, the amount reacted is 99, so remaining $[R] = 100 - 99 = 1$. 3. Substitute these values into the rate equation:

$$t = \frac{2.303}{k} \log \left(\frac{100}{1} \right)$$

4. Since $\log(100) = \log(10^2) = 2$:

$$t = \frac{2.303}{k} \times 2$$

5. Calculate the final value:

$$t = \frac{4.606}{k}$$

Final Answer: The time required is $t = \frac{4.606}{k}$.

Answer: (B)

Q36.

Solution

Concept:

Basicity of amines depends on the availability of the lone pair of electrons on the nitrogen atom. In the gaseous phase, there are no solvent effects (like hydration) or steric hindrances caused by the solvent. Therefore, the basicity is determined solely by the inductive effect ($+I$ effect) of the alkyl groups.

Solution:

1. Methyl groups (CH_3-) are electron-releasing groups ($+I$ effect). 2. As the number of methyl groups increases, the electron density on the nitrogen atom increases, making the lone pair more available for donation to a proton. 3. Order of $+I$ effect: Tertiary (3°) > Secondary (2°) > Primary (1°) > Ammonia. 4. In the gaseous phase, the order of basicity follows this inductive effect strictly:

$$(CH_3)_3N > (CH_3)_2NH > CH_3NH_2 > NH_3$$

(Note: In aqueous solution, the order changes due to hydration and steric effects).

Final Answer: The correct order is $Me_3N > Me_2NH > MeNH_2 > NH_3$.

Answer: (A)

Q37.

Solution

Concept:

The concentration of a chemical substance can determine whether it acts as an antiseptic (applied to living tissue) or a disinfectant (applied to inanimate objects). Phenol is a classic example of such a substance. Additionally, certain compounds are specifically designed for antiseptic use in soaps.

Solution:

1. **Phenol:** A 0.2% solution of phenol acts as an **antiseptic**, while a 1% solution of phenol acts as a **disinfectant**. 2. **Bithional:** This compound is added to soaps to impart **antiseptic** properties (it reduces the odors produced by bacterial decomposition of organic matter on the skin). 3. Since 0.2% phenol is an antiseptic/disinfectant (concentration dependent) and Bithional is a well-known antiseptic, the question asks which is used as such. 4. Option (A) is an antiseptic. Option (C) is an antiseptic. Option (B) is strictly a disinfectant.

Final Answer: Both (A) and (C) are used as antiseptics/disinfectants.

Answer: (D)

Q38.

Solution

Concept:

The solubility of an ionic compound in water is determined by the competition between **Lattice Energy** (the energy required to break the ionic crystal lattice) and **Hydration Energy** (the energy released when ions are solvated by water molecules). For a substance to be soluble, the hydration energy must be greater than or equal to the lattice energy.

Solution:

1. In Na_2SO_4, the hydration energy of the ions is sufficient to overcome the lattice energy, making it soluble. 2. In $BaSO_4$, both the cation (Ba^{2+}) and the anion (SO_4^{2-}) are large and have high charges (compared to Na^+). This results in a very high lattice energy. 3. For $BaSO_4$, the hydration energy released upon dissolving is not enough to compensate for the high lattice energy required to break the solid structure. 4. Therefore, $BaSO_4$ remains insoluble in water.

Final Answer: Lattice energy of $BaSO_4$ exceeds its hydration energy.

Answer: (A)

Q39.

Solution

Concept:

This sequence involves Friedel-Crafts alkylation, side-chain oxidation, and amination of a carboxylic acid. 1. Alkylation introduces an alkyl group. 2. Oxidation of the alkyl group yields a carboxylic acid. 3. Heating a carboxylic acid with ammonia produces an amide.

Solution:

1. **Step 1:** Benzene reacts with CH_3Cl and anhydrous $AlCl_3$ (Friedel-Crafts Alkylation).

$$C_6H_6 + CH_3Cl \xrightarrow{AlCl_3} C_6H_5CH_3 \text{ (A: Toluene)}$$

2. **Step 2:** Toluene is oxidized by alkaline $KMnO_4$.

$$C_6H_5CH_3 \xrightarrow{KMnO_4, OH^-} C_6H_5COOH \text{ (B: Benzoic acid)}$$

3. **Step 3:** Benzoic acid reacts with NH_3 followed by heating.

$$C_6H_5COOH + NH_3 \rightarrow C_6H_5COONH_4 \xrightarrow{\Delta} C_6H_5CONH_2 \text{ (C: Benzamide)}$$

4. The final product is Benzamide.

Final Answer: The product C is Benzamide.

Answer: (A)

Q40.

Solution

Concept:

IUPAC nomenclature for coordination compounds. The cation is named first, and for an anionic complex, the metal name ends in the suffix **-ate**. The oxidation state is indicated by a Roman numeral in parentheses.

Solution:

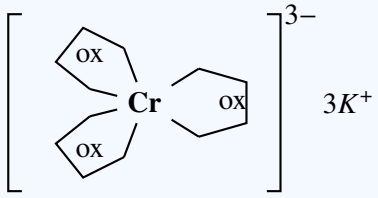
Step 1: Identify the cation and anion. The cation is K^+ (Potassium) and the complex anion is $[Cr(C_2O_4)_3]^{3-}$.

Step 2: Calculate the oxidation state of Chromium (x). Potassium is +1 and oxalate (C_2O_4) is −2. $3(+1) + x + 3(-2) = 0 \Rightarrow 3 + x - 6 = 0 \Rightarrow x = +3$.

Step 3: Name the ligands. There are three oxalate ions, so we use the prefix "tri" with the ligand name "oxalato".

Step 4: Name the metal. Since the complex is an anion, Chromium becomes "chromate".

Step 5: Combine the names. The name is Potassium trioxalatochromate(III). Note that "Tripotassium" is incorrect as prefixes are not used for counter ions.



Structure of $[Cr(C_2O_4)_3]^{3-}$

Final Answer:

Potassium trioxalatochromate(III)

Answer: (B)

Q41.

Solution

Concept:

Isotonic solutions have the same osmotic pressure ($\pi_1 = \pi_2$) at the same temperature. According to the van't Hoff equation $\pi = CRT$, for two non-electrolytes to be isotonic:

$$C_1 = C_2$$

where C is the molar concentration (molarity). Molarity can be expressed as:

$$C = \frac{\text{Mass in grams}}{\text{Molar mass} \times \text{Volume in Liters}}$$

Solution:

1. For cane sugar (1): 5% (w/v) means 5 g in 100 mL. $C_1 = \frac{5}{342 \times 0.1}$ 2. For substance X (2): 1% (w/v) means 1 g in 100 mL. $C_2 = \frac{1}{M_X \times 0.1}$ 3. Equate C_1 and C_2:

$$\frac{5}{342} = \frac{1}{M_X}$$

4. Solve for M_X:

$$M_X = \frac{342}{5} = 68.4\ g\ mol^{-1}$$

Final Answer: The molecular weight of X is 68.4.

Answer: (C)

Q42.

Solution

Concept:

Point defects in stoichiometric solids are categorized primarily into Schottky and Frenkel defects. - **Schottky defect:** Equal numbers of cations and anions are missing from their lattice sites. - **Frenkel defect:** An ion (usually the smaller cation) is dislodged from its normal lattice site and occupies an interstitial site.

Solution:

1. The question describes a scenario where a cation leaves its original site (creating a vacancy) and moves to an interstitial position. 2. This specific combination of a vacancy defect and an interstitial defect is the definition of a **Frenkel defect**. 3. This defect is common in ionic solids where there is a large difference in size between the cation and anion (e.g., ZnS, $AgCl$, $AgBr$). 4. Unlike the Schottky defect, the Frenkel defect does not change the density of the solid.

Final Answer: The lattice defect is the Frenkel defect.

Answer: (B)

Q43.

Solution

Concept:

Spontaneity of a reaction is determined by the Gibbs free energy change (ΔG). A reaction is spontaneous when $\Delta G < 0$. The relationship is:

$$\Delta G = \Delta H - T\Delta S$$

The temperature at which the reaction is at equilibrium ($\Delta G = 0$) is $T = \Delta H/\Delta S$. For a reaction with positive ΔH and positive ΔS to be spontaneous, $T\Delta S$ must be greater than ΔH, meaning the temperature must be above the equilibrium temperature.

Solution:

1. Convert ΔH to Joules: $\Delta H = 170\ kJ = 170,000\ J$ $\Delta S = 170\ J\ K^{-1}$
2. Calculate the equilibrium temperature (T):

$$T = \frac{\Delta H}{\Delta S} = \frac{170,000}{170} = 1000\ K$$

3. Determine the condition for spontaneity: Since both ΔH and ΔS are positive, the reaction becomes spontaneous at temperatures $T > 1000\ K$.
4. Comparing with the options: Only $1110\ K$ is greater than $1000\ K$.

Final Answer: The reaction will be spontaneous at $1110\ K$.

Answer: (C)

Q44.

Solution

Concept:

An amino acid is optically active if its α-carbon is a chiral center, meaning it is bonded to four different groups. If the α-carbon is bonded to two identical groups, the molecule is achiral and thus optically inactive.

Solution:

1. The general structure of an α-amino acid is $H_2N - CH(R) - COOH$. 2. In **Glycine**, the side chain (R) is a hydrogen atom (H). 3. This results in the α-carbon being bonded to: a carboxyl group, an amino group, and two hydrogen atoms. 4. Because it has two identical hydrogen atoms attached to the central carbon, Glycine lacks a chiral center and is the only common amino acid that is optically inactive. 5. Alanine, Valine, and Leucine all have distinct R groups, making their α-carbons chiral.

Final Answer: Glycine is optically inactive.

Answer: (B)

Q45.

Solution

Concept:

The standard reduction potential (E°) measures the tendency of a chemical species to be reduced (gain electrons). The more positive the reduction potential value, the greater the tendency of the species to accept electrons and, consequently, the stronger it acts as an oxidizing agent.

Solution:

1. Compare the given reduction potentials: - F_2/F^-: +2.87 V - Cl_2/Cl^-: +1.36 V - Br_2/Br^-: +1.09 V - I_2/I^-: +0.54 V

2. F_2 has the highest (most positive) reduction potential. 3. This indicates that F_2 has the strongest tendency to undergo reduction ($F_2 + 2e^- \rightarrow 2F^-$) among the halogens listed. 4. Therefore, Fluorine is the most powerful oxidizing agent.

Final Answer: The strongest oxidizing agent is F_2.

Answer: (A)

Q46.

Solution

Concept:

Terminal alkynes (alkynes with a triple bond at the end of the chain, like 1-butyne) have an acidic hydrogen atom attached to the triply bonded carbon. Non-terminal alkynes (like 2-butyne) do not. Terminal alkynes react with ammoniacal silver nitrate (Tollens' reagent) or ammoniacal cuprous chloride to form metallic acetylides, appearing as precipitates.

Solution:

1. **1-butyne ($CH_3CH_2C \equiv CH$):** Contains a terminal acidic hydrogen. It reacts with ammoniacal $AgNO_3$ to form a white precipitate of silver butynide ($CH_3CH_2C \equiv CAg$). 2. **2-butyne ($CH_3C \equiv CCH_3$):** A non-terminal alkyne. It lacks the acidic hydrogen and does not react with ammoniacal $AgNO_3$. 3. **Other Reagents:** Br_2/CCl_4, dilute $KMnO_4$ (Baeyer's reagent), and O_3 react with both 1-butyne and 2-butyne because both contain a triple bond, making these reagents unsuitable for distinguishing between them.

Final Answer: Ammoniacal $AgNO_3$ can distinguish between 1-butyne and 2-butyne.

Answer: (B)

Q47.

Solution

Concept:

The relationship between the standard cell potential (E°_{cell}), standard Gibbs free energy change (ΔG°), and the equilibrium constant (K_{eq}) is given by:

$$\Delta G^\circ = -nFE^\circ_{cell}$$

$$\Delta G^\circ = -RT \ln K_{eq}$$

Solution:

1. **Relating E°_{cell} and ΔG°:** If E°_{cell} is negative, the product $-nFE^\circ_{cell}$ becomes positive (since n and F are always positive constants). Therefore, $\Delta G^\circ > 0$. 2. **Relating ΔG° and K_{eq}:** From the equation $\Delta G^\circ = -RT \ln K_{eq}$, if ΔG° is positive, then $-RT \ln K_{eq}$ must be positive. This means $\ln K_{eq}$ must be negative. 3. For $\ln K_{eq}$ to be negative, the value of K_{eq} must be less than 1 ($K_{eq} < 1$). 4. A negative E°_{cell} indicates a non-spontaneous reaction under standard conditions.

Final Answer: The correct relationships are $\Delta G^\circ > 0, K_{eq} < 1$.

Answer: (A)

Q48.

Solution

Concept:

Nylon-6 is a homopolymer synthesized through the ring-opening polymerization of a cyclic amide (lactam). Unlike Nylon-6,6, which is formed from two different monomers, Nylon-6 is derived from a single six-carbon monomer.

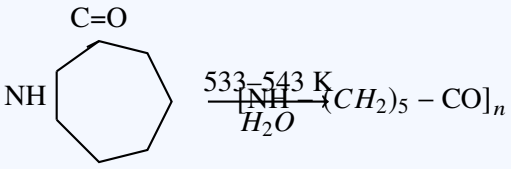
Solution:

Step 1: The monomer for Nylon-6 is Caprolactam, which is a cyclic amide containing six carbon atoms.

Step 2: The process involves heating caprolactam with a small amount of water at high temperatures (533–543 K).

Step 3: The water causes the ring to open, forming ϵ-aminocaproic acid, which then undergoes polymerization to form the long-chain polyamide known as Nylon-6.

Step 4: Other options like Hexamethylenediamine and Adipic acid are used to make Nylon-6,6, while Ethylene glycol is used for Terylene (Dacron).



Final Answer:

Caprolactam

Answer: (C)

Q49.

Solution

Concept:

Antibiotics are classified based on the range of bacteria they target. **Broad-spectrum** antibiotics are effective against a wide variety of both Gram-positive and Gram-negative bacteria. **Narrow-spectrum** antibiotics are effective primarily against a specific group of bacteria (either Gram-positive or Gram-negative, but not both).

Solution:

1. **Penicillin G:** This is the natural form of penicillin. It has a narrow spectrum of activity, being primarily effective against Gram-positive bacteria. 2. **Ampicillin** and **Amoxycillin:** These are synthetic modifications of penicillin. These changes allow them to target a wider range of bacteria, making them broad-spectrum antibiotics. 3. **Chloramphenicol:** This is a classic example of a broad-spectrum antibiotic used to treat various infections like typhoid and meningitis. 4. Therefore, Penicillin G is the narrow-spectrum antibiotic among the choices.

Final Answer: Penicillin G is a narrow spectrum antibiotic.

Answer: (A)

Q50.

Solution

Concept:

The structure of proteins is organized into four levels. The **primary structure** is the sequence of amino acids held by peptide bonds. The **secondary structure** refers to the local folding of the polypeptide chain into specific shapes like α-helices or β-pleated sheets.

Solution:

1. Secondary structures arise from regular folding patterns within the polypeptide backbone. 2. These patterns are held in place by **hydrogen bonds** between the carbonyl oxygen ($C = O$) of one amino acid and the amide hydrogen ($N - H$) of another amino acid. 3. While peptide bonds hold the amino acids together (primary), and interactions like disulfide bridges or van der Waals forces often stabilize tertiary structures, the defining stabilization for secondary structures is the hydrogen bond. 4. Glycosidic bonds are found in carbohydrates, not protein backbones.

Final Answer: The secondary structure of protein is stabilized by Hydrogen bond.

Answer: (B)

Answer Key

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