NEET- UG Chemistry Sample Paper-5

Duration: 1 Hour **Maximum Marks: 180**

Instructions

- This paper contains a total of **45** Multiple Choice Questions.
- Each correct answer carries **+4 marks**.
- Each incorrect answer carries **-1 mark**.
- No negative marking for unattempted questions.

Q1. A mixture of 2.3 g formic acid and 4.5 g oxalic acid is treated with concentrated H_2SO_4. The evolved gaseous mixture is passed through KOH pellets. Weight (in g) of the remaining product at STP will be:

(A) 1.4

(B) 3.0

(C) 2.8

(D) 4.4

Q2. The angular momentum of an electron in a particular orbit of Li^{2+} ion is J. If the de-Broglie wavelength of this electron is λ, then the radius of this orbit is given by:

(A) $\frac{J\lambda}{2\pi}$

(B) $\frac{J\lambda}{2\pi h}$

(C) $\frac{J\lambda}{h}$

(D) $\frac{h\lambda}{2\pi J}$

Q3. Which of the following molecules has the maximum dipole moment based on molecular geometry and electronegativity differences?

(A) NF_3

(B) NH_3

(C) BF_3

(D) $CHCl_3$

Q4. Consider the following species: CN^+, CN^-, NO and CN. Which one of these will have the highest bond order?

(A) NO

(B) CN^-

(C) CN^+

(D) CN

Q5. The enthalpy of combustion of carbon to CO_2 is -393.5 kJ mol^{-1}. The heat released upon formation of 35.2 g of CO_2 from carbon and dioxygen gas is:

(A) -314.8 kJ

(B) -630 kJ

(C) -3.15 kJ

(D) -31.5 kJ

Q6. For a reaction, $A(s) + 2B^+(aq) \rightleftharpoons A^{2+}(aq) + 2B(s)$, K_c is found to be 10^{12}. The E°_{cell} is:

(A) 0.354 V

(B) 0.708 V

(C) 0.0295 V

(D) 0.59 V

Q7. The solubility of $BaSO_4$ in water is 2.42×10^{-3} g L^{-1} at 298 K. The value of its solubility product (K_{sp}) will be (Molar mass of $BaSO_4 = 233$ g mol^{-1}):

(A) 1.08×10^{-10} mol^2 L^{-2}

(B) 1.08×10^{-12} mol^2 L^{-2}

(C) 1.08×10^{-14} mol^2 L^{-2}

(D) 1.08×10^{-8} mol^2 L^{-2}

(E) 1.42×10^{-3} mol^2 L^{-2}

Q8. In the reaction $3Br_2 + 6CO_3^{2-} + 3H_2O \rightarrow 5Br^- + BrO_3^- + 6HCO_3^-$, which of the following statements is correctly describing the redox nature?

(A) Bromine is oxidized and carbonate is reduced

(B) Bromine is reduced and water is oxidized

(C) Bromine is both oxidized and reduced

(D) Bromine is neither oxidized nor reduced

Q9. The rate constant of a first order reaction is 4.606×10^{-3} s^{-1}. The time required to reduce 2.0 g of the reactant to 0.2 g is:

(A) 200 s

(B) 500 s

(C) 1000 s

(D) 100 s

Q10. Which of the following series of transitions in the spectrum of hydrogen atom falls in visible region?

(A) Lyman series

(B) Balmer series

(C) Paschen series

(D) Brackett series

Q11. The correct order of atomic radii in group 13 elements is:

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

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

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

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

Q12. When copper is heated with conc. HNO_3 it produces:

(A) $Cu(NO_3)_2$ and NO

(B) $Cu(NO_3)_2$, NO and NO_2

(C) $Cu(NO_3)_2$ and N_2O

(D) $Cu(NO_3)_2$ and NO_2

Q13. The geometry and magnetic behaviour of the complex $[Ni(CO)_4]$ are:

(A) Square planar, diamagnetic

(B) Tetrahedral, diamagnetic

(C) Square planar, paramagnetic

(D) Tetrahedral, paramagnetic

Q14. Identify the major product in the following reaction: $CH_3CH(OH)CH_2CH_2COOH \xrightarrow{\Delta, H^+}$

(A) A five-membered lactone

(B) A six-membered lactone

(C) An unsaturated acid

(D) A dicarboxylic acid

Q15. The most suitable reagent for the following conversion is: $CH_3-C \equiv C-CH_3 \rightarrow$ cis-But-2-ene

(A) $Na/$liquid NH_3

(B) $H_2, Pd/C, quinoline$

(C) Zn/HCl

(D) $Hg^{2+}/H^+, H_2O$

Q16. The correct order of increasing field strength of ligands in the spectrochemical series is:

(A) $SCN^- < F^- < CN^- < C_2O_4^{2-}$

(B) $F^- < SCN^- < C_2O_4^{2-} < CN^-$

(C) $SCN^- < F^- < C_2O_4^{2-} < CN^-$

(D) $CN^- < C_2O_4^{2-} < SCN^- < F^-$

Q17. An organic compound 'X' having molecular formula $C_5H_{10}O$ yields phenylhydrazone and gives negative response to the Iodoform test and Tollen's test. It produces n-pentane on reduction. 'X' could be:

(A) pentanal

(B) pentan-2-one

(C) pentan-3-one

(D) 2-methylbutanal

Q18. Which of the following is an amphoteric oxide?

(A) V_2O_5

(B) Cr_2O_3

(C) ZnO

(D) All of these

Q19. The rate of a reaction doubles when its temperature changes from 300 K to 310 K. Activation energy of such a reaction will be: ($R = 8.314\ \text{J K}^{-1}\ \text{mol}^{-1}$ and $\log 2 = 0.301$)

(A) 53.6 kJ mol^{-1}

(B) 48.6 kJ mol^{-1}

(C) 58.5 kJ mol^{-1}

(D) 60.5 kJ mol^{-1}

Q20. The basic structural unit of silicates is:

(A) SiO_4^{4-}

(B) SiO_3^{2-}

(C) SiO_4^{2-}

(D) $Si_2O_7^{6-}$

Q21. Which of the following amines will give the carbylamine test?

(A) N, N-Diethylaniline

(B) m-Methylaniline

(C) N-Methylaniline

(D) N, N-Dimethylaniline

Q22. The molar conductivity of 0.007 M acetic acid is 20 S cm^2 mol^{-1}. What is its degree of dissociation if Λ_m° for H^+ is 350 and for CH_3COO^- is 50 S cm^2 mol^{-1}?

(A) 0.05

(B) 0.5

(C) 0.1

(D) 0.01

Q23. Sucrose on hydrolysis gives:

(A) α-D-Glucose + β-D-Glucose

(B) α-D-Glucose + β-D-Fructose

(C) α-D-Fructose + β-D-Fructose

(D) β-D-Glucose + α-D-Fructose

Q24. The correct statement regarding electrophoresis is:

(A) Movement of colloidal particles under an applied electric potential.

(B) Movement of dispersion medium under an applied electric potential.

(C) Neutralization of charge on colloidal particles.

(D) Scattering of light by colloidal particles.

Q25. The IUPAC name of the compound $CH_3CH(OH)CH_2CH_2CHO$ is:

(A) 4-hydroxypentanal

(B) 1-oxo-4-pentanol

(C) 4-oxopentan-1-ol

(D) 2-hydroxypentanal

Q26. Identify the incorrect statement for PCl_5 from the following:

(A) Three axial $P - Cl$ bonds make an angle of 120° with each other.

(B) Two axial $P - Cl$ bonds make an angle of 180° with each other.

(C) Axial $P - Cl$ bonds are longer than equatorial $P - Cl$ bonds.

(D) PCl_5 molecule is non-reactive.

Q27. Which property of colloids is independent of the charge on the colloidal particles?

(A) Coagulation

(B) Electrophoresis

(C) Electro-osmosis

(D) Tyndall effect

Q28. Which of the following is most reactive towards nucleophilic substitution reaction?

(A) 2-nitrochlorobenzene

(B) 4-nitrochlorobenzene

(C) 2,4,6-trinitrochlorobenzene

(D) chlorobenzene

Q29. The magnetic moment of 2.84 BM is given by: (At. nos. $Ni = 28, Ti = 22, Cr = 24, Co = 27$)

(A) Ti^{3+}

(B) Cr^{3+}

(C) Co^{2+}

(D) Ni^{2+}

Q30. The structure of the product formed by the reaction of acetone with ethylmagnesium bromide followed by hydrolysis is:

(A) 2-methylbutan-2-ol

(B) Pentan-2-ol

(C) Pentan-3-ol

(D) 2-methylpropan-2-ol

Q31. The solubility of $AgCl(s)$ with solubility product 1.6×10^{-10} in 0.1 M $NaCl$ solution would be:

(A) 1.26×10^{-5} M

(B) 1.6×10^{-9} M

(C) 1.6×10^{-11} M

(D) Zero

Q32. In a face-centered cubic lattice, atom A occupies the corners and atom B occupies the face-centered positions. If one atom of B is missing from one of the face-centered points, the formula of the compound is:

(A) A_2B_3

(B) A_2B_5

(C) A_2B

(D) AB_2

Q33. For the reaction $2A + B \rightarrow 3C + D$, which of the following does not express the reaction rate?

(A) $-\frac{d[B]}{dt}$

(B) $\frac{d[D]}{dt}$

(C) $-\frac{1}{2}\frac{d[A]}{dt}$

(D) $-\frac{1}{3}\frac{d[C]}{dt}$

Q34. The calculated spin-only magnetic moment of Fe^{2+} ion is:

(A) 3.87 BM

(B) 4.90 BM

(C) 5.92 BM

(D) 2.84 BM

Q35. Which of the following is the correct order of acidity?

(A) $CH \equiv CH > CH_3 - C \equiv CH > CH_2 = CH_2 > CH_3 - CH_3$

(B) $CH_3 - CH_3 > CH_2 = CH_2 > CH_3 - C \equiv CH > CH \equiv CH$

(C) $CH \equiv CH > CH_2 = CH_2 > CH_3 - C \equiv CH > CH_3 - CH_3$

(D) $CH \equiv CH > CH_3 - C \equiv CH > CH_3 - CH_3 > CH_2 = CH_2$

Q36. Match the column I with column II for the given reactions: (i) $CH_3COCl + H_2 \xrightarrow{Pd-BaSO_4} CH_3CHO$ (ii) $CH_3CN + SnCl_2 + HCl \rightarrow CH_3CHO$ (iii) $C_6H_6 + CO + HCl \xrightarrow{AlCl_3} C_6H_5CHO$

(A) (i)-Rosenmund, (ii)-Stephen, (iii)-Gatterman Koch

(B) (i)-Stephen, (ii)-Rosenmund, (iii)-Gatterman Koch

(C) (i)-Rosenmund, (ii)-Gatterman Koch, (iii)-Stephen

(D) (i)-Etard, (ii)-Stephen, (iii)-Rosenmund

Q37. What is the mass of non-volatile solute (molar mass 40 g mol^{-1}) which should be dissolved in 114 g octane to reduce its vapour pressure to 80%?

(A) 20 g

(B) 30 g

(C) 10 g

(D) 8 g

Q38. The compound that is most reactive towards electrophilic nitration is:

(A) Toluene

(B) Benzene

(C) Benzoic acid

(D) Nitrobenzene

Q39. Which of the following does not show optical isomerism?

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

(B) $[Co(en)_2Cl_2]^{+}$

(C) $[Co(NH_3)_3Cl_3]^0$

(D) $[Co(en)Cl_2(NH_3)_2]^+$

Q40. An example of a condensation polymer is:

(A) Nylon 6,6

(B) Teflon

(C) Buna-S

(D) Polyethene

Q41. For the second period elements, the correct order of first ionization enthalpy is:

(A) $Li < B < Be < C < O < N < F < Ne$

(B) $Li < Be < B < C < N < O < F < Ne$

(C) $Li < B < Be < C < N < O < F < Ne$

(D) $Li < Be < B < C < O < N < F < Ne$

Q42. Which of the following will not give the iodoform test?

(A) Acetophenone

(B) Ethanal

(C) Benzophenone

(D) Ethanol

Q43. The cell constant of a conductivity cell:

(A) changes with change of electrolyte

(B) changes with change of concentration of electrolyte

(C) changes with temperature of electrolyte

(D) remains constant for a helper cell

Q44. The hybridisation of Ni in $[NiCl_4]^{2-}$ is:

(A) sp^3

(B) dsp^2

(C) sp^3d

(D) d^2sp^3

Q45. Which functional group is present in Zwitterion of amino acids?

(A) $-NH_2$ and $-COOH$

(B) $-NH_3^+$ and $-COO^-$

(C) $-NH_2$ and $-COO^-$

(D) $-NH_3^+$ and $-COOH$

Detailed Solutions

Q1.

Solution

Concept:
The reaction of formic acid ($HCOOH$) and oxalic acid ($H_2C_2O_4$) with concentrated sulfuric acid (H_2SO_4) is a dehydration reaction. Concentrated H_2SO_4 acts as a strong dehydrating agent. Formic acid dehydrates to give carbon monoxide (CO) and water, while oxalic acid dehydrates to give CO, carbon dioxide (CO_2), and water. KOH pellets are used to absorb acidic gases like CO_2.

Solution:
1. Dehydration of Formic Acid:

$$HCOOH \xrightarrow{H_2SO_4} CO + H_2O$$

Moles of $HCOOH = \frac{2.3}{46} = 0.05$ mol. Moles of CO produced = 0.05 mol.
2. Dehydration of Oxalic Acid:

$$H_2C_2O_4 \xrightarrow{H_2SO_4} CO + CO_2 + H_2O$$

Moles of $H_2C_2O_4 = \frac{4.5}{90} = 0.05$ mol. Moles of CO produced = 0.05 mol. Moles of CO_2 produced = 0.05 mol.
3. Total gases evolved before KOH: Total $CO = 0.05 + 0.05 = 0.1$ mol. Total $CO_2 = 0.05$ mol.
4. Action of KOH: KOH absorbs CO_2 entirely. The remaining gas is only CO. Moles of remaining gas (CO) = 0.1 mol.
5. Mass of remaining product (CO): Mass = Moles × Molar mass of CO Mass = $0.1 \times 28 = 2.8$ g.
Final Answer: The mass of the remaining product is 2.8 g.

Answer: (C)

Q2.

Solution

Concept:

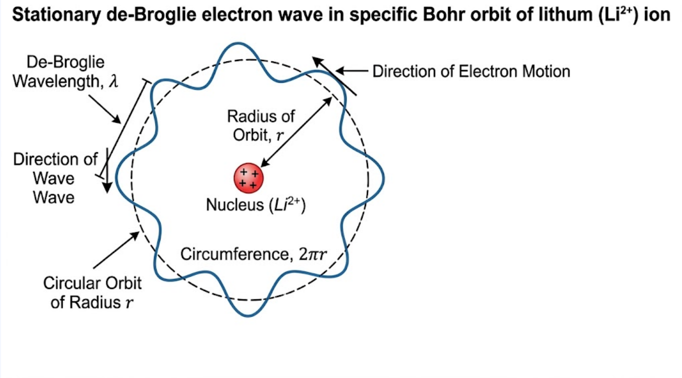
The relationship between the Bohr orbit and de-Broglie wavelength is rooted in the quantization of angular momentum. According to de-Broglie's hypothesis, for an electron to exist in a stable orbit, the circumference of the orbit must be an integral multiple of its wavelength:

$$2\pi r = n\lambda$$

Also, Bohr's quantization rule states:

$$mvr = \frac{nh}{2\pi}$$

where mvr is the angular momentum (J).



Stationary de-Broglie electron wave in specific Bohr orbit of lithum (Li²⁺) ion

Solution:

1. From Bohr's quantization of angular momentum (J):

$$J = \frac{nh}{2\pi}$$

Rearranging for n:

$$n = \frac{2\pi J}{h}$$

2. From the condition for a stationary wave in a circular orbit:

$$2\pi r = n\lambda$$

3. Substitute the value of n from step 1 into the equation in step 2:

$$2\pi r = \left(\frac{2\pi J}{h}\right)\lambda$$

4. Solving for the radius r:

$$r = \frac{J\lambda}{h}$$

Final Answer: The radius of the orbit is $\frac{J\lambda}{h}$.

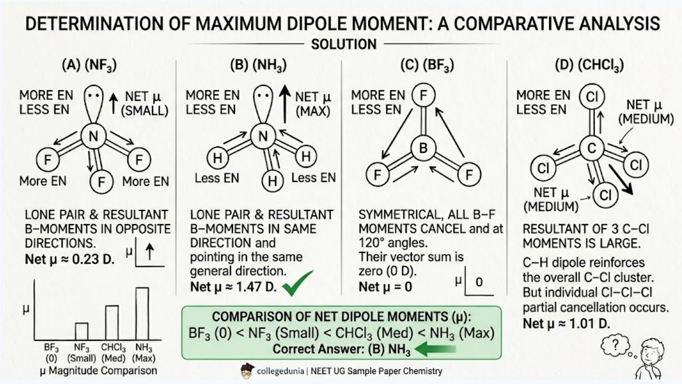
Answer: (C)

Q3.

Solution

Concept:

Dipole moment (μ) is a vector quantity that depends on the electronegativity difference between atoms and the spatial arrangement (geometry) of bonds. In symmetric molecules, bond dipoles can cancel out. In molecules like NH_3 and NF_3, the lone pair moment also contributes.



LONE PAIR & RESULTANT B–MOMENTS IN OPPOSITE DIRECTIONS. Net μ ≈ 0.23 D.

LONE PAIR & RESULTANT B–MOMENTS IN SAME DIRECTION and pointing in the same general direction. Net μ ≈ 1.47 D. ✓

SYMMETRICAL, ALL B–F MOMENTS CANCEL and at 120° angles. Their vector sum is zero (0 D). Net μ = 0

RESULTANT OF 3 C–Cl MOMENTS IS LARGE. C–H dipole reinforces the overall C–Cl cluster. But individual Cl–Cl–Cl partial cancellation occurs. Net μ ≈ 1.01 D.

COMPARISON OF NET DIPOLE MOMENTS (μ): BF_3 (0) < NF_3 (Small) < $CHCl_3$ (Med) < NH_3 (Max)
Correct Answer: (B) NH_3

Solution:

1. BF_3: It has a trigonal planar geometry. The three $B - F$ bond dipoles are oriented at 120° to each other, resulting in a net dipole moment of zero. 2. NH_3 vs NF_3: Both have pyramidal geometry with one lone pair. - In NH_3, Nitrogen is more electronegative than Hydrogen. The bond dipoles are directed towards N, which is the same direction as the lone pair dipole. They reinforce each other. - In NF_3, Fluorine is more electronegative than Nitrogen. The bond dipoles are directed towards F, which opposes the lone pair dipole. - Therefore, $\mu_{NH_3} > \mu_{NF_3}$. 3. $CHCl_3$: It has a tetrahedral geometry. While it has a significant dipole moment, the reinforcement in NH_3 due to the lone pair and H-atoms makes NH_3 highly polar. 4. Comparing NH_3 and $CHCl_3$, NH_3 generally exhibits a stronger molecular dipole due to the concentrated charge of the lone pair and the small size of the molecule.

Final Answer: NH_3 has the maximum dipole moment among the choices.

Answer: (B)

Q4.

Solution

Concept:
Bond order can be determined using Molecular Orbital (MO) Theory. For diatomic species, the bond order is calculated as:

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

where N_b is the number of electrons in bonding orbitals and N_a is the number of electrons in antibonding orbitals. For species with 14 electrons (isoelectronic with N_2), the bond order is 3.

Solution:
1. Total Electrons in CN^+: $6(C) + 7(N) - 1 = 12$ electrons. Bond Order = 2. 2. Total Electrons in CN^-: $6(C) + 7(N) + 1 = 14$ electrons. This is isoelectronic with N_2. Bond Order = 3. 3. Total Electrons in NO: $7(N) + 8(O) = 15$ electrons. Bond Order = 2.5. 4. Total Electrons in CN: $6(C) + 7(N) = 13$ electrons. Bond Order = 2.5. 5. Comparing the values: CN^- has the highest bond order of 3.

Final Answer: CN^- has the highest bond order.

Answer: (B)

Q5.

Solution

Concept:
The enthalpy of combustion is the heat change when one mole of a substance is completely burnt in oxygen. For carbon, the reaction is:

$$C(s) + O_2(g) \longrightarrow CO_2(g) \quad \Delta H = -393.5 \text{ kJ mol}^{-1}$$

This means 1 mole of CO_2 formed releases 393.5 kJ of heat.

Solution:
1. Calculate the molar mass of CO_2: Molar mass $= 12 + 2(16) = 44$ g mol^{-1}. 2. Calculate the number of moles of CO_2 provided: Moles $= \frac{\text{Given mass}}{\text{Molar mass}} = \frac{35.2 \text{ g}}{44 \text{ g mol}^{-1}} = 0.8$ mol. 3. Calculate the total heat released: Heat released = Moles $\times \Delta H_{combustion}$ Heat released $= 0.8 \times (-393.5$ kJ/mol$)$ 4. Performing the multiplication: $0.8 \times 393.5 = 314.8$ kJ. 5. Since the reaction is exothermic, the value is -314.8 kJ.

Final Answer: The heat released is -314.8 kJ.

Answer: (A)

Q6.

Solution

Concept:

The relationship between the equilibrium constant (K_c) and the standard cell potential (E°_{cell}) is given by the Nernst equation at equilibrium. At 298 K, the formula is:

$$E^\circ_{cell} = \frac{0.0591}{n} \log K_c$$

where n is the number of electrons transferred in the balanced redox reaction.

Solution:

1. Identify the number of electrons (n) transferred: The reaction is $A(s) + 2B^+(aq) \rightleftharpoons A^{2+}(aq) + 2B(s)$. - Oxidation: $A \longrightarrow A^{2+} + 2e^-$ - Reduction: $2B^+ + 2e^- \longrightarrow 2B$ Thus, $n = 2$. 2. Given $K_c = 10^{12}$. 3. Substitute the values into the formula:

$$E^\circ_{cell} = \frac{0.059}{2} \log(10^{12})$$

4. Simplify the logarithm: $\log(10^{12}) = 12$. 5. Calculate the final value:

$$E^\circ_{cell} = \frac{0.059}{2} \times 12 = 0.059 \times 6 = 0.354 \text{ V}$$

Final Answer: The standard cell potential is 0.354 V.

Answer: (A)

Q7.

Solution

Concept:
The solubility product (K_{sp}) represents the equilibrium between a solid ionic compound and its ions in a saturated solution. For $BaSO_4$, the dissociation is:

$$BaSO_4(s) \rightleftharpoons Ba^{2+}(aq) + SO_4^{2-}(aq)$$

If s is the molar solubility, then $K_{sp} = s^2$. Note that solubility must be in mol L^{-1}.
Solution:
1. Convert solubility from g L^{-1} to mol L^{-1}: Molar solubility (s) = $\frac{\text{Solubility in g/L}}{\text{Molar mass}}$

$$s = \frac{2.42 \times 10^{-3}\text{ g L}^{-1}}{233\text{ g mol}^{-1}} \approx 1.038 \times 10^{-5}\text{ mol L}^{-1}$$

2. Write the K_{sp} expression:

$$K_{sp} = [Ba^{2+}][SO_4^{2-}] = s \times s = s^2$$

3. Calculate K_{sp}:

$$K_{sp} = (1.038 \times 10^{-5})^2 \approx 1.077 \times 10^{-10}$$

4. Rounding to significant figures: $K_{sp} \approx 1.08 \times 10^{-10}$ mol^2 L^{-2}.
Final Answer: The solubility product is 1.08×10^{-10} mol^2 L^{-2}.

Answer: (A)

Q8.

Solution

Concept:
A disproportionation reaction is a specific type of redox reaction where the same element undergoes both oxidation and reduction simultaneously. To determine this, we check the oxidation states of the elements in the reactants and products.
Solution:
1. Assign oxidation states to Bromine (Br): - In Br_2 (reactant): Oxidation state is 0 (elemental state). - In Br^- (product): Oxidation state is -1. - In BrO_3^- (product): Let x be the state of Br. $x + 3(-2) = -1 \Rightarrow x - 6 = -1 \Rightarrow x = +5$. 2. Analyze the changes: - Br goes from 0 to -1 (Decrease in oxidation number = Reduction). - Br goes from 0 to +5 (Increase in oxidation number = Oxidation). 3. Since Bromine is both oxidized and reduced in the same reaction, it is a disproportionation reaction.
Final Answer: Bromine is both oxidized and reduced.

Answer: (C)

Q9.

Solution

Concept:
For a first-order reaction, the integrated rate equation is:

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

where k is the rate constant, t is the time, $[A]_0$ is the initial concentration (or mass), and $[A]$ is the final concentration (or mass).

Solution:
1. Given values: $k = 4.606 \times 10^{-3}\ \text{s}^{-1}$ Initial mass $[A]_0 = 2.0$ g Final mass $[A] = 0.2$ g 2. Rearrange the formula for time (t):

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

3. Substitute the values:

$$t = \frac{2.303}{4.606 \times 10^{-3}} \log\left(\frac{2.0}{0.2}\right)$$

4. Simplify the expression: $\frac{2.303}{4.606} = 0.5$. $\log(10) = 1$. 5. Calculate t:

$$t = \frac{0.5}{10^{-3}} \times 1 = 0.5 \times 10^3 = 500\ \text{s}$$

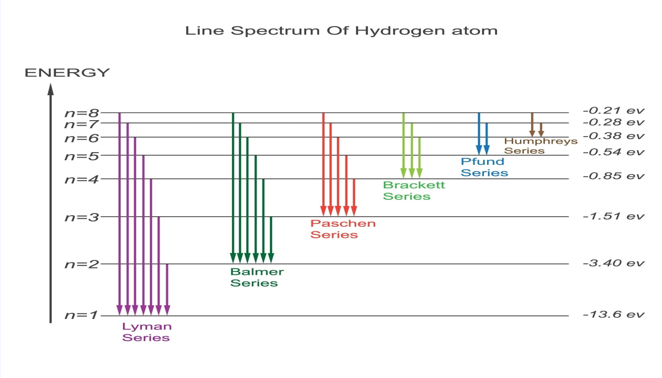
Final Answer: The time required is 500 s.

Answer: (B)

Q10.

Solution

Concept:
The hydrogen emission spectrum consists of several series of spectral lines. Each series corresponds to electronic transitions from higher energy levels (n_2) to a specific lower energy level (n_1). The visible portion of the electromagnetic spectrum corresponds to the Balmer series.



Solution:
1. Lyman Series: Transitions to $n_1 = 1$. These fall in the Ultraviolet (UV) region. 2. Balmer Series: Transitions to $n_1 = 2$ (from $n_2 = 3, 4, 5, \ldots$). These are the only lines that fall in the Visible region. 3. Paschen Series: Transitions to $n_1 = 3$. These fall in the Infrared (IR) region. 4. Brackett Series: Transitions to $n_1 = 4$. These fall in the Infrared (IR) region. 5. Pfund Series: Transitions to $n_1 = 5$. These also fall in the Far-Infrared region.
Final Answer: The Balmer series falls in the visible region.

Answer: (B)

Q11.

Solution

Concept:
In Group 13 (the Boron family), atomic radii usually increase down the group. However, there is a significant anomaly between Aluminium (Al) and Gallium (Ga). This is due to the "Scandide Contraction" or the poor shielding effect of the 10d electrons in Gallium.
Solution:
1. Typically, as we move down a group, the addition of a new principal energy level increases the atomic size. 2. For Group 13, the order is expected to be $B < Al < Ga < In < Tl$. 3. However, Gallium (Ga) follows the 3d-transition series. The 3d-electrons have a poor shielding effect, which allows the nucleus to exert a stronger pull on the outer electrons. 4. Consequently, the atomic radius of Gallium (135 pm) is slightly smaller than that of Aluminium (143 pm). 5. The actual order is: $B < Ga < Al < In < Tl$.
Final Answer: The correct order of atomic radii is $B < Ga < Al < In < Tl$.

Answer: (C)

Q12.

Solution

Concept:

The reaction of copper with nitric acid (HNO_3) depends heavily on the concentration of the acid. Nitric acid is a strong oxidizing agent. With dilute HNO_3, the primary gaseous product is nitric oxide (NO), but with concentrated HNO_3, the primary gaseous product is nitrogen dioxide (NO_2).

Solution:

1. When Copper (Cu) reacts with concentrated nitric acid, the acid is reduced to NO_2 (nitrogen dioxide), which is a brown gas. 2. The balanced chemical equation for the reaction is:

$$Cu + 4HNO_3(\text{conc.}) \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$$

3. The oxidation state of Nitrogen changes from +5 in HNO_3 to +4 in NO_2. 4. Copper is oxidized from 0 to +2 to form copper(II) nitrate. 5. In contrast, if the acid were dilute, the reaction would be:

$$3Cu + 8HNO_3(\text{dilute}) \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$$

Final Answer: The products are $Cu(NO_3)_2$ and NO_2.

Answer: (D)

Q13.

Solution

Concept:

To determine the geometry and magnetism of coordination compounds, we look at the oxidation state of the central metal and the nature of the ligands. Carbon monoxide (CO) is a very strong field ligand that causes maximum pairing of electrons.

Solution:

1. Oxidation state of Ni in $[Ni(CO)_4]$: Since CO is a neutral ligand, the oxidation state of Ni is 0. 2. Electronic configuration of $Ni(0)$: $[Ar]3d^8 4s^2$. 3. Effect of CO ligand: Being a strong field ligand, CO causes the $4s$ electrons to shift into the $3d$ orbitals. The configuration becomes: $[Ar]3d^{10}4s^0$. 4. Hybridization: With $3d$ fully filled, the metal uses one $4s$ and three $4p$ orbitals for bonding. Hybridization = sp^3, which corresponds to a **Tetrahedral** geometry. 5. Magnetic behavior: Since all electrons are paired ($3d^{10}$), the complex is **Diamagnetic**.

Final Answer: The complex is tetrahedral and diamagnetic.

Answer: (B)

Q14.

Solution

Concept:
γ-hydroxy acids and δ-hydroxy acids undergo intramolecular esterification (cyclization) upon heating in the presence of an acid catalyst to form cyclic esters known as lactones. The stability of the resulting ring (usually 5 or 6 membered) dictates the major product.

Solution:
1. Analyze the structure of $CH_3CH(OH)CH_2CH_2COOH$: - Carbon 1: $-COOH$ - Carbon 2: $-CH_2-$ - Carbon 3: $-CH_2-$ - Carbon 4: $-CH(OH)-$ (attached to a methyl group) 2. This is a γ-hydroxy acid because the hydroxyl group is on the fourth carbon relative to the carboxyl carbon. 3. Intramolecular reaction between the $-OH$ group and the $-COOH$ group involves the loss of a water molecule (H_2O). 4. Counting the atoms in the ring: - The Oxygen from the OH group. - Carbons 4, 3, 2, and 1. - This creates a 5-membered ring (4 carbons and 1 oxygen). 5. A five-membered cyclic ester is specifically called a γ-lactone.

Final Answer: The major product is a five-membered lactone.

Answer: (A)

Q15.

Solution

Concept:
The reduction of alkynes to alkenes can be stereoselective depending on the reagent used. - Partial hydrogenation with a "poisoned" catalyst gives a *cis*-alkene. - Reduction with alkali metals in liquid ammonia (Birch reduction) gives a *trans*-alkene.

Solution:
1. The starting material is But-2-yne ($CH_3 - C \equiv C - CH_3$). 2. To obtain **cis-But-2-ene**, we need syn-addition of hydrogen. 3. Reagent (A) Na/liquid NH_3: This is a Birch reduction, which results in anti-addition, yielding the *trans* isomer. 4. Reagent (B) $H_2, Pd/C, quinoline$: This is known as **Lindlar's Catalyst**. The quinoline (or $BaSO_4$) poisons the palladium catalyst, preventing further reduction to an alkane and ensuring syn-addition of hydrogen. 5. Syn-addition to an internal alkyne yields the *cis*-alkene.

Final Answer: The most suitable reagent is $H_2, Pd/C, quinoline$.

Answer: (B)

Q16.

Solution

Concept:

The spectrochemical series is a list of ligands ordered by their field strength, which determines the magnitude of crystal field splitting (Δ_o or Δ_t). Stronger field ligands cause greater splitting and are more likely to result in low-spin complexes.

Solution:

1. Field strength depends on the donor atom. Generally, the order is: Halides < Oxygen donors < Nitrogen donors < Carbon donors. 2. In the given options, SCN^- (sulfur donor) and F^- are weak field ligands. 3. $C_2O_4^{2-}$ (oxalate) is an oxygen donor, which is stronger than halides but weaker than nitrogen or carbon donors. 4. CN^- (cyanide) is a carbon donor and is one of the strongest field ligands in the series. 5. The established order in the spectrochemical series is: $I^- < Br^- < SCN^- < Cl^- < S^{2-} < F^- < OH^- < C_2O_4^{2-} < H_2O < NCS^- < EDTA^{4-} < NH_3 < en < CN^- < CO$. 6. Comparing the options: $SCN^- < F^- < C_2O_4^{2-} < CN^-$ matches the trend.

Final Answer: The correct order is $SCN^- < F^- < C_2O_4^{2-} < CN^-$.

Answer: (C)

Q17.

Solution

Concept:

To identify an organic compound, we use chemical tests: 1. Phenylhydrazone formation indicates a carbonyl group (aldehyde or ketone). 2. Negative Tollen's test means it is not an aldehyde. 3. Negative Iodoform test means it is not a methyl ketone (no CH_3CO- group). 4. Reduction to n-pentane confirms a 5-carbon straight chain.

Solution:

1. Molecular formula $C_5H_{10}O$ suggests a pentanal or pentanone. 2. Negative Tollen's test: Eliminates pentanal and 2-methylbutanal. The compound must be a ketone. 3. Negative Iodoform test: Eliminates pentan-2-one ($CH_3COCH_2CH_2CH_3$) because it contains a methyl ketone group. 4. Pentan-3-one ($CH_3CH_2COCH_2CH_3$) is a ketone that does not have a methyl group directly attached to the carbonyl carbon. Thus, it gives a negative iodoform test. 5. Reduction: $CH_3CH_2COCH_2CH_3 \xrightarrow{[H]} CH_3CH_2CH_2CH_2CH_3$ (n-pentane).

Final Answer: The compound 'X' is pentan-3-one.

Answer: (C)

Q18.

Solution

Concept:

Amphoteric oxides are oxides that can react with both acids and bases to form salt and water. Many transition metal oxides in intermediate oxidation states and certain main group metals like Zinc exhibit this behavior.

Solution:

1. V_2O_5 (Vanadium pentoxide): It reacts with acids to give VO_2^+ salts and with bases to give vanadates (VO_4^{3-}). Thus, it is amphoteric. 2. Cr_2O_3 (Chromium(III) oxide): It is a well-known amphoteric oxide, reacting with acids to give Cr^{3+} ions and with concentrated bases to form chromites. 3. ZnO (Zinc oxide): It is a classic example of an amphoteric oxide. - $ZnO + 2HCl \rightarrow ZnCl_2 + H_2O$ - $ZnO + 2NaOH \rightarrow Na_2ZnO_2 + H_2O$ 4. Since all three provided oxides exhibit both acidic and basic properties, they are all amphoteric.

Final Answer: All of the given oxides are amphoteric.

Answer: (D)

Q19.

Solution

Concept:

The Arrhenius equation relates the rate constant to the temperature and activation energy (E_a):

$$\log\left(\frac{k_2}{k_1}\right) = \frac{E_a}{2.303R}\left(\frac{T_2 - T_1}{T_1T_2}\right)$$

If the rate doubles, $k_2/k_1 = 2$.

Solution:

1. Given: $T_1 = 300$ K, $T_2 = 310$ K, $R = 8.314$ J K^{-1} mol^{-1}, $\log 2 = 0.301$. 2. Substitute into the formula:

$$0.301 = \frac{E_a}{2.303 \times 8.314}\left(\frac{310 - 300}{300 \times 310}\right)$$

3. Simplify:

$$0.301 = \frac{E_a}{19.147}\left(\frac{10}{93000}\right)$$

4. Rearrange for E_a:

$$E_a = \frac{0.301 \times 19.147 \times 93000}{10}$$

$$E_a = 0.301 \times 19.147 \times 9300$$

5. Calculate:

$$E_a \approx 53598 \text{ J mol}^{-1} = 53.6 \text{ kJ mol}^{-1}$$

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

Answer: (A)

Q20.

Solution

Concept:
Silicates are minerals containing Silicon and Oxygen. The fundamental building block of all silicate structures is the silicon-oxygen tetrahedron.

Solution:
1. In silicates, the Silicon atom is sp^3 hybridized. 2. It is bonded to four Oxygen atoms in a tetrahedral arrangement. 3. The formal charge calculation: Silicon (+4) and four Oxygens (−2 each) results in a net charge of $4 + 4(-2) = -4$. 4. Thus, the discrete unit is the orthosilicate ion, represented as SiO_4^{4-}. 5. Various silicate structures (chain, sheet, cyclic, 3D) are formed by sharing the Oxygen corners of these SiO_4^{4-} tetrahedra.

Final Answer: The basic structural unit is SiO_4^{4-}.

Answer: (A)

Q21.

Solution

Concept:
The carbylamine reaction (also known as the Hoffmann isocyanide test) is a chemical test for the detection of primary amines. When a primary amine is heated with chloroform ($CHCl_3$) and alcoholic potassium hydroxide (KOH), it forms an isocyanide (carbylamine), which has an extremely foul or characteristic unpleasant smell.

Solution:
1. The carbylamine test is strictly specific to primary (1°) amines. Secondary (2°) and tertiary (3°) amines do not undergo this reaction. 2. Let us analyze the given options: - N, N-Diethylaniline: This is a tertiary (3°) amine. It will not give the test. - m-Methylaniline: This is an aromatic primary (1°) amine (also known as m-toluidine). It contains the $-NH_2$ group. - N-Methylaniline: This is a secondary (2°) amine. It will not give the test. - N, N-Dimethylaniline: This is a tertiary (3°) amine. It will not give the test. 3. The reaction for m-Methylaniline is:

$$CH_3C_6H_4NH_2 + CHCl_3 + 3KOH \xrightarrow{\Delta} CH_3C_6H_4NC + 3KCl + 3H_2O$$

4. The formation of m-tolyl isocyanide confirms the presence of the primary amine.

Final Answer: m-Methylaniline will give the carbylamine test.

Answer: (B)

Q22.

Solution

Concept:

The degree of dissociation (α) of a weak electrolyte is the ratio of its molar conductivity (Λ_m) at a given concentration to its molar conductivity at infinite dilution (Λ_m°).

$$\alpha = \frac{\Lambda_m}{\Lambda_m^\circ}$$

According to Kohlrausch's Law, Λ_m° for a weak acid like acetic acid is the sum of the individual molar conductivities of its ions at infinite dilution.

Solution:

1. Calculate the molar conductivity at infinite dilution (Λ_m°) for acetic acid (CH_3COOH):

$$\Lambda_m^\circ(CH_3COOH) = \lambda^\circ(H^+) + \lambda^\circ(CH_3COO^-)$$

$$\Lambda_m^\circ = 350 + 50 = 400 \text{ S cm}^2 \text{ mol}^{-1}$$

2. The given molar conductivity at 0.007 M is $\Lambda_m = 20 \text{ S cm}^2 \text{ mol}^{-1}$. 3. Calculate the degree of dissociation (α):

$$\alpha = \frac{20}{400}$$

4. Simplify the fraction:

$$\alpha = \frac{2}{40} = \frac{1}{20} = 0.05$$

5. The degree of dissociation is 0.05 (or 5%).

Final Answer: The degree of dissociation is 0.05.

Answer: (A)

Q23.

Solution

Concept:

Sucrose ($C_{12}H_{22}O_{11}$) is a non-reducing disaccharide. It consists of two monosaccharide units linked by a glycosidic bond between the $C1$ of glucose and $C2$ of fructose. This linkage is specifically an $\alpha - 1, 2$-glycosidic bond.

Solution:

1. Hydrolysis of sucrose occurs in the presence of dilute acids or the enzyme invertase. 2. The chemical reaction is:

$$C_{12}H_{22}O_{11} + H_2O \rightarrow C_6H_{12}O_6(\text{Glucose}) + C_6H_{12}O_6(\text{Fructose})$$

3. Sucrose is dextrorotatory (+66.5°), but upon hydrolysis, it gives a mixture of: - D-(+)-Glucose (dextrorotatory, +52.7°) - D-(-)-Fructose (levorotatory, −92.4°) 4. The specific isomers involved in the structure of sucrose are α-D-Glucose and β-D-Fructose. 5. Because the resulting mixture is levorotatory (due to the high magnitude of fructose rotation), the process is called "inversion of sugar."

Final Answer: Sucrose on hydrolysis gives α-D-Glucose and β-D-Fructose.

Answer: (B)

Q24.

Solution

Concept:

Colloidal particles carry an electric charge. Electrophoresis is a phenomenon based on the migration of these charged particles under the influence of an external electric field. It is a vital technique used to determine the nature of the charge on colloidal particles.

Solution:

1. When an electric potential is applied across two platinum electrodes immersed in a colloidal solution, the colloidal particles move towards the oppositely charged electrode. 2. If the particles are positively charged, they move towards the cathode (negative electrode). 3. If the particles are negatively charged, they move towards the anode (positive electrode). 4. This movement is distinct from electro-osmosis, where the dispersion medium moves while the particles are held stationary. 5. Tyndall effect is related to light scattering, not electric fields. 6. Therefore, electrophoresis specifically refers to the movement of colloidal particles.

Final Answer: Electrophoresis is the movement of colloidal particles under an applied electric potential.

Answer: (A)

Q25.

Solution

Concept:
The IUPAC nomenclature of organic compounds follows a priority order for functional groups. Aldehydes ($-CHO$) have a higher priority than alcohols ($-OH$). Therefore, the carbon chain is numbered starting from the aldehyde carbon.

Solution:
1. Identify the longest carbon chain containing the principal functional group ($-CHO$). 2. The chain has 5 carbons: $C1(CHO) - C2(H_2) - C3(H_2) - C4(H, OH) - C5(H_3)$. 3. Numbering from the aldehyde end: - Carbon 1: Aldehyde group. - Carbon 2: $-CH_2-$ - Carbon 3: $-CH_2-$ - Carbon 4: Has a hydroxyl ($-OH$) group attached. - Carbon 5: Methyl group. 4. Since the aldehyde is the principal group, the suffix is "-anal" (Pentanal). 5. The hydroxyl group is treated as a substituent called "hydroxy" located at position 4. 6. Combining these: 4-hydroxypentanal.
Final Answer: The IUPAC name is 4-hydroxypentanal.

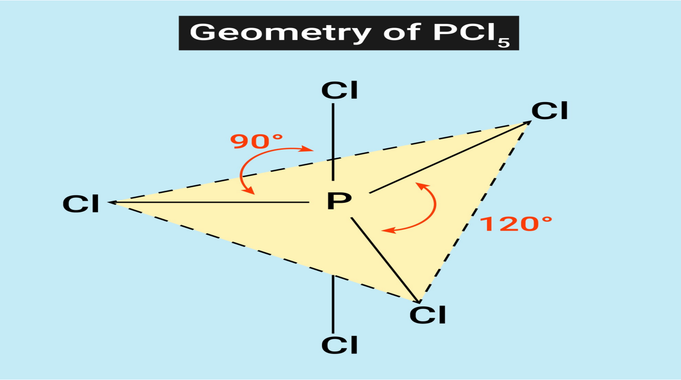
Answer: (A)

Q26.

Solution

Concept:

The structure of Phosphorus pentachloride (PCl_5) in the gas phase is a trigonal bipyramidal geometry. This geometry is a result of sp^3d hybridization of the Phosphorus atom. In this structure, there are two distinct types of bonds: axial and equatorial.



Solution:

1. In the trigonal bipyramidal structure of PCl_5, three $P - Cl$ bonds lie in one plane (equatorial plane) making an angle of 120° with each other. 2. The remaining two $P - Cl$ bonds (axial bonds) lie above and below the equatorial plane, making an angle of 90° with the plane and 180° with each other. 3. Repulsion analysis: The axial bond pairs suffer more repulsion from the equatorial bond pairs. To minimize this repulsion, the axial bonds are pushed further away, making them longer (240 pm) compared to the equatorial bonds (202 pm). 4. Therefore, statement (A) is incorrect because it claims three **axial** bonds make an angle of 120°, whereas it is the three **equatorial** bonds that do so. 5. Additionally, PCl_5 is chemically reactive, contrary to statement (D).

Final Answer: The incorrect statement is that three axial $P - Cl$ bonds make an angle of 120° with each other.

Answer: (A)

Q27.

Solution

Concept:

The properties of colloids are divided into physical, optical, and kinetic/electrical properties. Electrical properties (like coagulation, electrophoresis, and electro-osmosis) are directly dependent on the presence and magnitude of the charge on the colloidal particles. Optical properties, however, depend on the size of the particles relative to the wavelength of light.

Solution:

1. **Coagulation:** This is the process of settling of colloidal particles by neutralizing their charge using an electrolyte. It is highly dependent on charge. 2. **Electrophoresis:** This is the movement of particles toward an electrode, which happens only because the particles are charged. 3. **Electro-osmosis:** This is the movement of the dispersion medium in an electric field, which is a consequence of the charged layer at the particle-medium interface. 4. **Tyndall effect:** This is the scattering of light by colloidal particles. It depends on the refractive indices of the phases and the size of the particles (1 nm to 1000 nm), but it has nothing to do with whether the particles carry a charge or not.

Final Answer: Tyndall effect is independent of the charge on the colloidal particles.

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

Q28.

Solution

Concept:

Nucleophilic aromatic substitution (S_NAr) in haloarenes is generally difficult due to the partial double bond character of the $C - X$ bond. However, the presence of Electron Withdrawing Groups (EWG) like $-NO_2$ at **ortho** and **para** positions significantly increases the reactivity by stabilizing the anionic intermediate (Meisenheimer complex) through resonance.

Solution:

1. Chlorobenzene is the least reactive as it has no activating withdrawing groups. 2. 2-nitrochlorobenzene and 4-nitrochlorobenzene have one $-NO_2$ group, which increases reactivity compared to chlorobenzene. 3. 2,4,6-trinitrochlorobenzene (Picryl chloride) has three $-NO_2$ groups at both ortho positions and the para position. 4. The cumulative electron-withdrawing effect of three nitro groups makes the carbon attached to the chlorine extremely electron-deficient. 5. This compound is so reactive that it undergoes hydrolysis to form picric acid simply by warming with water, without the need for strong bases like $NaOH$.

Final Answer: 2,4,6-trinitrochlorobenzene is the most reactive towards nucleophilic substitution.

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

Q29.

Solution

Concept:

The spin-only magnetic moment (μ_s) is calculated using the number of unpaired electrons (n) in the metal ion:

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

A value of 2.84 BM corresponds to approximately 2 unpaired electrons ($2.84^2 \approx 8$, and $2(2+2) = 8$).

Solution:

1. Ti^{3+} ($Z = 22$): Electronic configuration is $[Ar]3d^1$. Unpaired electrons (n) = 1. $\mu = \sqrt{1(3)} = 1.73$ BM. 2. Cr^{3+} ($Z = 24$): Electronic configuration is $[Ar]3d^3$. Unpaired electrons (n) = 3. $\mu = \sqrt{3(5)} = 3.87$ BM. 3. Co^{2+} ($Z = 27$): Electronic configuration is $[Ar]3d^7$. Unpaired electrons (n) = 3. $\mu = \sqrt{3(5)} = 3.87$ BM. 4. Ni^{2+} ($Z = 28$): Electronic configuration is $[Ar]3d^8$. - In the $3d$ subshell: ↑↓ ↑↓ ↑↓ ↑ ↑. - Unpaired electrons (n) = 2. - $\mu = \sqrt{2(2+2)} = \sqrt{8} \approx 2.83 - 2.84$ BM.

Final Answer: The magnetic moment of 2.84 BM is given by Ni^{2+}.

Answer: (D)

Q30.

Solution

Concept:

The reaction of a Grignard reagent ($R - MgX$) with a ketone yields a tertiary alcohol after acid hydrolysis. Acetone is the simplest ketone (CH_3COCH_3), and ethylmagnesium bromide (CH_3CH_2MgBr) provides the ethyl nucleophile.

Solution:

1. Nucleophilic attack: The ethyl group ($C_2H_5^-$) from the Grignard reagent attacks the carbonyl carbon of acetone.

$$(CH_3)_2C = O + CH_3CH_2MgBr \longrightarrow (CH_3)_2C(OMgBr)CH_2CH_3$$

2. Hydrolysis: The addition of water/acid (H_3O^+) replaces the $-OMgBr$ group with a hydroxyl ($-OH$) group.

$$(CH_3)_2C(OMgBr)CH_2CH_3 + H_2O \longrightarrow (CH_3)_2C(OH)CH_2CH_3 + Mg(OH)Br$$

3. Structure Analysis: The product has a 4-carbon parent chain (butane) with a methyl group and a hydroxyl group both at the second carbon. 4. IUPAC Name: 2-methylbutan-2-ol.

Final Answer: The product is 2-methylbutan-2-ol.

Answer: (A)

Q31.

Solution

Concept:

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

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

The solubility product constant is $K_{sp} = [Ag^+][Cl^-]$. When $NaCl$ is added, it provides a high concentration of Cl^- ions, shifting the equilibrium to the left.

Solution:

1. Let the solubility of $AgCl$ in 0.1 M $NaCl$ be s. 2. The concentration of ions in the solution will be: - $[Ag^+] = s$ - $[Cl^-] = s + 0.1$ 3. Since $AgCl$ is sparingly soluble and the common ion effect further reduces s, we can assume $s \ll 0.1$. Therefore, $[Cl^-] \approx 0.1$ M. 4. Using the K_{sp} expression:

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

$$1.6 \times 10^{-10} = s \times (0.1)$$

5. Solving for s:

$$s = \frac{1.6 \times 10^{-10}}{0.1} = 1.6 \times 10^{-9} \text{ M}$$

Final Answer: The solubility of $AgCl$ is 1.6×10^{-9} M.

Answer: (B)

Q32.

Solution

Concept:

In a unit cell, the number of atoms contributed depends on their position: - Corners contribute $\frac{1}{8}$ of an atom to the unit cell. - Face-centers contribute $\frac{1}{2}$ of an atom to the unit cell. The total number of atoms of each type is calculated based on the number of positions occupied.

Solution:

1. Atoms of A at the corners: There are 8 corners in a cube. Number of A atoms = $8 \times \frac{1}{8} = 1$. 2. Atoms of B at the face-centers: Normally, there are 6 face-centers. However, the problem states 1 atom of B is missing. Number of B positions occupied = $6 - 1 = 5$. Number of B atoms = $5 \times \frac{1}{2} = 2.5$ or $\frac{5}{2}$. 3. Ratio of A to B: $A : B = 1 : \frac{5}{2}$. 4. Simplification: Multiply by 2 to get whole numbers: A_2B_5.

Final Answer: The formula of the compound is A_2B_5.

Answer: (B)

Q33.

Solution

Concept:

The rate of a chemical reaction is expressed as the change in concentration of a reactant or product divided by its stoichiometric coefficient. For a general reaction $aA + bB \rightarrow cC + dD$, the rate is:

$$\text{Rate} = -\frac{1}{a}\frac{d[A]}{dt} = -\frac{1}{b}\frac{d[B]}{dt} = \frac{1}{c}\frac{d[C]}{dt} = \frac{1}{d}\frac{d[D]}{dt}$$

Reactants have a negative sign (disappearance), and products have a positive sign (appearance).

Solution:

1. Given reaction: $2A + B \rightarrow 3C + D$. 2. Rate in terms of A: $-\frac{1}{2}\frac{d[A]}{dt}$. 3. Rate in terms of B: $-\frac{1}{1}\frac{d[B]}{dt} = -\frac{d[B]}{dt}$. 4. Rate in terms of C: $+\frac{1}{3}\frac{d[C]}{dt}$. 5. Rate in terms of D: $+\frac{1}{1}\frac{d[D]}{dt} = \frac{d[D]}{dt}$. 6. Looking at option (D): $-\frac{1}{3}\frac{d[C]}{dt}$ is incorrect because C is a product, so the rate of its formation must be positive.

Final Answer: Option (D) does not express the reaction rate correctly.

Answer: (D)

Q34.

Solution

Concept:

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

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

where n is the number of unpaired electrons in the metal ion.

Solution:

1. Determine the oxidation state and configuration: Iron (Fe) has atomic number 26. Ground state configuration: $[Ar]3d^6 4s^2$. For Fe^{2+}, the two $4s$ electrons are removed: $[Ar]3d^6$. 2. Count unpaired electrons in $3d^6$: According to Hund's rule, electrons fill orbitals singly before pairing. Orbital 1: ↑↓, Orbital 2: ↑, Orbital 3: ↑, Orbital 4: ↑, Orbital 5: ↑. Number of unpaired electrons $(n) = 4$. 3. Calculate μ:

$$\mu = \sqrt{4(4+2)} = \sqrt{4 \times 6} = \sqrt{24}$$

4. $\sqrt{24}$ is approximately 4.8989 BM. 5. Rounding to standard significant figures gives 4.90 BM.

Final Answer: The calculated spin-only magnetic moment is 4.90 BM.

Answer: (B)

Q35.

Solution

Concept:

The acidity of hydrocarbons depends on the hybridization of the carbon atom bonded to the hydrogen. The greater the **s-character** of the hybridized orbital, the more electronegative the carbon atom is, and the more easily the $C-H$ bond can release a proton (H^+). - sp hybridization (50% s-character) > sp^2 (33.3% s-character) > sp^3 (25% s-character).

Solution:

1. Ethyne ($CH \equiv CH$): Carbons are sp hybridized. Most acidic. 2. Propyne ($CH_3 - C \equiv CH$): The terminal carbon is sp hybridized, but the electron-releasing methyl group ($+I$ effect) slightly reduces the acidity compared to ethyne. 3. Ethene ($CH_2 = CH_2$): Carbons are sp^2 hybridized. Less acidic than alkynes. 4. Ethane ($CH_3 - CH_3$): Carbons are sp^3 hybridized. Least acidic. 5. The correct order is: Ethyne > Propyne > Ethene > Ethane.

Final Answer: The correct order of acidity is $CH \equiv CH > CH_3 - C \equiv CH > CH_2 = CH_2 > CH_3 - CH_3$.

Answer: (A)

Q36.

Solution

Concept:

The synthesis of aldehydes from various precursors involves specific named reactions. These reactions are essential tools in organic chemistry for selective oxidation or reduction. 1. **Rosenmund Reduction:** Hydrogenation of acyl chlorides using H_2 over $Pd - BaSO_4$ (Lindlar's type catalyst). 2. **Stephen Reaction:** Reduction of nitriles using $SnCl_2$ and HCl, followed by hydrolysis. 3. **Gatterman-Koch Reaction:** Synthesis of benzaldehyde from benzene using CO and HCl in the presence of anhydrous $AlCl_3$ or $CuCl$.

Solution:

1. Reaction (i): $CH_3COCl + H_2 \xrightarrow{Pd-BaSO_4} CH_3CHO$. This is the **Rosenmund reduction**, where the $BaSO_4$ acts as a catalyst poison to prevent further reduction of the aldehyde to an alcohol. 2. Reaction (ii): $CH_3CN + SnCl_2 + HCl \rightarrow [CH_3CH = NH \cdot HCl] \xrightarrow{H_2O} CH_3CHO$. This is the **Stephen reaction**, involving the formation of an imine intermediate. 3. Reaction (iii): $C_6H_6 + CO + HCl \xrightarrow{AlCl_3} C_6H_5CHO$. This is the **Gatterman-Koch reaction**, which introduces a formyl group into the benzene ring. 4. Matching the sequence: (i) Rosenmund, (ii) Stephen, (iii) Gatterman-Koch.

Final Answer: The correct sequence is (i)-Rosenmund, (ii)-Stephen, (iii)-Gatterman Koch.

Answer: (A)

Q37.

Solution

Concept:

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

$$\frac{P^\circ - P}{P^\circ} = X_{solute} = \frac{n}{n + N}$$

Where P° is the vapor pressure of the pure solvent, P is the vapor pressure of the solution, n is the moles of solute, and N is the moles of solvent.

Solution:

1. Given that the vapor pressure is reduced to 80%, this means $P = 0.8P^\circ$. 2. The relative lowering of vapor pressure is:

$$\frac{P^\circ - 0.8P^\circ}{P^\circ} = \frac{0.2P^\circ}{P^\circ} = 0.2$$

3. Moles of solvent (Octane, C_8H_{18}): Molar mass of octane = $(8 \times 12) + (18 \times 1) = 114$ g mol^{-1}. $N = \frac{114 \text{ g}}{114 \text{ g mol}^{-1}} = 1$ mol. 4. Using the formula $0.2 = \frac{n}{n+1}$:

$$0.2(n + 1) = n \Rightarrow 0.2n + 0.2 = n \Rightarrow 0.8n = 0.2$$

$$n = \frac{0.2}{0.8} = 0.25 \text{ mol}$$

5. Calculate mass of solute: Mass = moles × molar mass = $0.25 \times 40 = 10$ g.

Final Answer: The mass of the solute required is 10 g.

Answer: (C)

Q38.

Solution

Concept:

Nitration is an electrophilic aromatic substitution reaction. The rate of the reaction depends on the electron density of the benzene ring. Groups that donate electrons (through resonance or induction) activate the ring toward electrophilic attack, while groups that withdraw electrons deactivate it.

Solution:

1. Benzene: The baseline for comparison. 2. Toluene: Contains a methyl ($-CH_3$) group, which is an electron-donating group (EDG) due to hyperconjugation and $+I$ effect. It increases the electron density on the ring. 3. Benzoic acid: Contains a carboxyl ($-COOH$) group, which is an electron-withdrawing group (EWG) due to the $-M$ effect. It deactivates the ring. 4. Nitrobenzene: Contains a nitro ($-NO_2$) group, which is a very strong electron-withdrawing group ($-M$ and $-I$). It is the most deactivated among the choices. 5. Order of reactivity: Toluene > Benzene > Benzoic acid > Nitrobenzene.

Final Answer: Toluene is the most reactive toward electrophilic nitration.

Answer: (A)

Q39.

Solution

Concept:
Optical isomerism in coordination compounds occurs when the complex molecule is chiral (non-superimposable on its mirror image). This typically requires the absence of a plane of symmetry or a center of inversion. Octahedral complexes with bidentate ligands (like ethylenediamine, 'en') often show optical activity.

Solution:
1. $[Co(en)_3]^{3+}$: Has a tris-chelate structure (propeller shape). It has no plane of symmetry and exists as d and l isomers. 2. $[Co(en)_2Cl_2]^+$: The *cis*-isomer is chiral and shows optical isomerism. (Note: The *trans*-isomer has a plane of symmetry and is achiral). 3. $[Co(NH_3)_3Cl_3]^0$: This complex has two geometric isomers: **facial** (fac) and **meridional** (mer). Both the *fac* and *mer* isomers possess a plane of symmetry. Therefore, it is achiral and does not show optical isomerism. 4. $[Co(en)Cl_2(NH_3)_2]^+$: Several geometric isomers exist, and the *cis*-type arrangements are generally chiral. 5. Among the options, $[Co(NH_3)_3Cl_3]$ is the classic example of a complex with only monodentate ligands where geometric isomerism exists but optical isomerism is absent due to internal symmetry.

Final Answer: $[Co(NH_3)_3Cl_3]$ does not show optical isomerism.

Answer: (C)

Q40.

Solution

Concept:
Polymers are classified by their mode of polymerization: 1. **Addition Polymers:** Formed by repeated addition of monomer molecules possessing double or triple bonds without the loss of any small molecules (e.g., Polyethene, Teflon, Buna-S). 2. **Condensation Polymers:** Formed by the reaction between two different bi-functional or tri-functional monomeric units with the elimination of small molecules like water, alcohol, or HCl.

Solution:
1. Teflon (Polytetrafluoroethene): Formed by the addition polymerization of $CF_2 = CF_2$. 2. Buna-S: Formed by the addition polymerization of 1,3-butadiene and styrene. 3. Polyethene: Formed by the addition polymerization of ethene. 4. Nylon 6,6: Formed by the condensation polymerization of hexamethylenediamine and adipic acid.

$$nHOOC(CH_2)_4COOH + nH_2N(CH_2)_6NH_2 \longrightarrow \text{[Nylon 6,6]} + (2n-1)H_2O$$

5. The elimination of water molecules during the formation makes it a condensation polymer.

Final Answer: Nylon 6,6 is an example of a condensation polymer.

Answer: (A)

Q41.

Solution

Concept:

The first ionization enthalpy (IE_1) generally increases across a period from left to right due to the increase in nuclear charge. However, there are exceptions due to the stability of half-filled and fully-filled electronic configurations.

Solution:

1. In the second period, the general trend is: $Li < Be < B < C < N < O < F < Ne$. 2. **First Anomaly ($Be$ vs B):** Beryllium ($1s^2 2s^2$) has a fully filled $2s$ subshell, whereas Boron ($1s^2 2s^2 2p^1$) has one electron in a $2p$ orbital. It is harder to remove an electron from a stable s-subshell and the s-electrons provide more penetration than p-electrons. Thus, $IE_1(Be) > IE_1(B)$. 3. **Second Anomaly (N vs O):** Nitrogen ($1s^2 2s^2 2p^3$) has a stable half-filled $2p$ subshell. Oxygen ($1s^2 2s^2 2p^4$) has four electrons in the $2p$ subshell, where electron-electron repulsion makes it easier to remove one electron to reach a stable half-filled state. Thus, $IE_1(N) > IE_1(O)$. 4. Combining these exceptions into the trend: $Li < B < Be < C < O < N < F < Ne$.

Final Answer: The correct order of first ionization enthalpy is $Li < B < Be < C < O < N < F < Ne$.

Answer: (A)

Q42.

Solution

Concept:

The Iodoform test is used to identify the presence of the CH_3CO- (methyl ketone) group or the $CH_3CH(OH)-$ group. These groups, when reacted with I_2 and $NaOH$, produce a yellow precipitate of Iodoform (CHI_3).

Solution:

1. **Acetophenone ($C_6H_5COCH_3$):** Contains the CH_3CO- group. It gives a positive iodoform test. 2. **Ethanal (CH_3CHO):** This is the only aldehyde with a CH_3CO- group. It gives a positive test. 3. **Benzophenone ($C_6H_5COC_6H_5$):** It is a ketone, but it lacks a methyl group directly attached to the carbonyl carbon. It will not undergo the iodoform reaction. 4. **Ethanol (CH_3CH_2OH):** It contains the $CH_3CH(OH)-$ structure. Upon treatment with $I_2/NaOH$, it is oxidized to ethanal, which then undergoes the test. It gives a positive test. 5. Therefore, Benzophenone is the one that gives a negative result.

Final Answer: Benzophenone will not give the iodoform test.

Answer: (C)

Q43.

Solution

Concept:

The cell constant (G^*) of a conductivity cell is defined as the ratio of the distance between the electrodes (l) to the cross-sectional area of the electrodes (A):

$$G^* = \frac{l}{A}$$

Solution:

1. The distance (l) between the electrodes is fixed by the construction of the cell. 2. The area (A) of the electrodes is also fixed during manufacturing. 3. Since l and A are geometric properties of the physical cell, their ratio l/A does not change regardless of what solution is placed in the cell or at what temperature it is measured. 4. While the **conductivity** and **molar conductivity** change with concentration and temperature, the cell constant itself remains constant for a specific cell. 5. It is determined by calibrating the cell with a standard solution of known conductivity (usually KCl).

Final Answer: The cell constant remains constant for a specific conductivity cell.

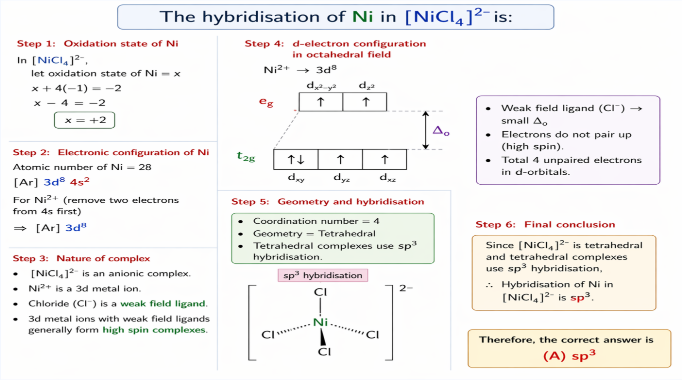
Answer: (D)

Q44.

Solution

Concept:

The hybridization of a complex depends on the coordination number and the nature of the ligands. Chloride (Cl^-) is a weak field ligand. According to Crystal Field Theory, weak field ligands do not cause electron pairing in the $3d$ subshell.



The hybridisation of Ni in $[NiCl_4]^{2-}$ is:

Step 1: Oxidation state of Ni

In $[NiCl_4]^{2-}$,
let oxidation state of Ni = x
$x + 4(-1) = -2$
$x - 4 = -2$
$\boxed{x = +2}$

Step 2: Electronic configuration of Ni

Atomic number of Ni = 28
[Ar] $3d^8\ 4s^2$
For Ni^{2+} (remove two electrons from 4s first)
$\Rightarrow$ [Ar] $3d^8$

Step 3: Nature of complex

- $[NiCl_4]^{2-}$ is an anionic complex.
- Ni^{2+} is a 3d metal ion.
- Chloride (Cl^-) is a weak field ligand.
- 3d metal ions with weak field ligands generally form high spin complexes.

Step 4: d-electron configuration in octahedral field

$Ni^{2+} \rightarrow 3d^8$

- Weak field ligand (Cl^-) → small Δ_o
- Electrons do not pair up (high spin).
- Total 4 unpaired electrons in d-orbitals.

Step 5: Geometry and hybridisation

- Coordination number = 4
- Geometry = Tetrahedral
- Tetrahedral complexes use sp^3 hybridisation.

Step 6: Final conclusion

Since $[NiCl_4]^{2-}$ is tetrahedral and tetrahedral complexes use sp^3 hybridisation,
∴ Hybridisation of Ni in $[NiCl_4]^{2-}$ is sp^3.

Therefore, the correct answer is
(A) sp^3

Solution:

1. Oxidation state of Ni in $[NiCl_4]^{2-}$: $x + 4(-1) = -2 \Rightarrow x = +2$. 2. Electronic configuration of Ni^{2+}: $[Ar]3d^8$. 3. Orbital arrangement: In the presence of the weak field ligand Cl^-, the two unpaired electrons in the $3d$ orbitals do not pair up. 4. Coordination Number: There are 4 Cl^- ligands, so the coordination number is 4. 5. Hybridization: Since the $3d$ orbitals are not available for hybridization (due to being partially filled), the metal uses one $4s$ and three $4p$ orbitals. Hybridization = sp^3. 6. Geometry: sp^3 hybridization corresponds to a tetrahedral geometry.
Final Answer: The hybridization of Ni in $[NiCl_4]^{2-}$ is sp^3.

Answer: (A)

Q45.

Solution

Concept:

Amino acids contain both a basic amino group ($-NH_2$) and an acidic carboxyl group ($-COOH$). In aqueous solution, the carboxyl group can lose a proton and the amino group can accept a proton in an internal acid-base reaction. The resulting dipolar ion is called a Zwitterion.

Solution:

1. At a specific pH (the isoelectric point), the amino acid exists primarily as a Zwitterion. 2. The acidic group ($COOH$) donates H^+ to become a carboxylate ion ($-COO^-$). 3. The basic group (NH_2) accepts H^+ to become an ammonium ion ($-NH_3^+$). 4. Therefore, the Zwitterion contains the functional groups $-NH_3^+$ and $-COO^-$. 5. This structure explains why amino acids are crystalline solids with high melting points and high solubility in water, acting more like salts than typical organic molecules.
Final Answer: The functional groups present in the Zwitterion are $-NH_3^+$ and $-COO^-$.

Answer: (B)

Answer Key

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