JEE Main Chemistry Sample Paper-17

Duration: 1 Hour **Maximum Marks: 100**

Instructions

- This paper contains TWO sections: **Section A** (MCQs) and **Section B** (Numerical).
- Section A contains 20 Multiple Choice Questions.
- Section B contains 5 Numerical Value Questions.
- Each correct answer carries **+4 marks**.
- Each incorrect answer carries **-1 mark**.
- No negative marking for unattempted questions.

Section A — Multiple Choice Questions

Q1. The total number of chiral molecules formed by the monochlorination of 2-methylbutane is: [JEE Main 2021]

(A) 2

(B) 4

(C) 6

(D) 8

Q2. Which of the following is the correct order of the pK_a values for the following phenols?
(I) Phenol
(II) p-Nitrophenol
(III) m-Nitrophenol
(IV) o-Nitrophenol [JEE Main 2022]

(A) II < IV < III < I

(B) I < III < IV < II

(C) III < IV < II < I

(D) II < III < IV < I

Q3. An organic compound 'X' on ozonolysis gives two products 'Y' and 'Z'. 'Y' gives a positive iodoform test but negative Fehling's test. 'Z' gives a positive Fehling's test but negative iodoform test. 'X' is: [JEE Main 2023]

(A) 2-methyl-2-butene

(B) 2-pentene

(C) 3-methyl-1-butene

(D) 2-methyl-1-butene

Q4. The major product of the reaction of 1-propanol with PCl_5 followed by alcoholic KOH is: [JEE Main 2020]

(A) Propene

(B) 1-chloropropane

(C) 2-chloropropane

(D) Propan-2-ol

Q5. When $C_6H_5{-}O{-}CH_2C_6H_5$ is heated with HI, the products are: [JEE Main 2024]

(A) $C_6H_5I + C_6H_5CH_2OH$

(B) $C_6H_5OH + C_6H_5CH_2I$

(C) $C_6H_5I + C_6H_5CH_2I$

(D) $C_6H_5OH + C_6H_5CH_2OH$

Q6. The correct order of reactivity towards nucleophilic addition for the following is: [JEE Main 2021]

(I) $HCHO$
(II) CH_3CHO
(III) CH_3COCH_3
(IV) C_6H_5CHO

(A) I > II > IV > III

(B) I > II > III > IV

(C) IV > III > II > I

(D) II > I > III > IV

Q7. Which of the following dicarboxylic acids, when heated, gives a cyclic anhydride? [JEE Main 2022]

(A) Phthalic acid

(B) Isophthalic acid

(C) Terephthalic acid

(D) Adipic acid

Q8. The peptide linkage ($-CONH-$) in proteins is formed by the condensation of: [JEE Main 2021]

(A) Amino acids

(B) Carbohydrates

(C) Fatty acids

(D) Nucleotides

Q9. Hinsberg's reagent reacts with a primary amine to form a product that is: [JEE Main 2019]

(A) Insoluble in alkali

(B) Soluble in alkali

(C) Insoluble in water and alkali

(D) A gas

Q10. The species having the same bond order as O_2^{2-} is: [JEE Main 2023]

(A) N_2^+

(B) F_2

(C) O_2^+

(D) C_2

Q11. The number of lone pairs on the central atom in XeF_4 and ClF_3 are respectively: [JEE Main 2021]

(A) 2, 2

(B) 2, 1

(C) 1, 2

(D) 0, 2

Q12. In which of the following molecules are all bond lengths not equal? [JEE Main 2022]

(A) BF_3

(B) SF_4

(C) SiF_4

(D) XeF_4

Q13. The crystal field stabilization energy (CFSE) for high spin d^4 octahedral complex is: [JEE Main 2020]

(A) $-0.6\Delta_o$

(B) $-1.6\Delta_o$

(C) $-1.2\Delta_o$

(D) $-0.4\Delta_o$

Q14. The IUPAC name of $[Pt(NH_3)_2Cl(NH_2CH_3)]Cl$ is: [JEE Main 2024]

(A) Diamminechlorido(methylamine)platinum(II) chloride

(B) Diammine(methylamine)chloridoplatinum(II) chloride

(C) Chloridodiammine(methylamine)platinum(II) chloride

(D) Diamminechlorido(aminomethane)platinum(II) chloride

Q15. The correct order of the first ionization enthalpy for Li, Be, B, C is: [JEE Main 2021]

(A) $Li < B < Be < C$

(B) $Li < Be < B < C$

(C) $B < Li < Be < C$

(D) $Li < B < C < Be$

Q16. Which of the following ions has the highest value of magnetic moment? [JEE Main 2022]

(A) Ti^{3+}

(B) Mn^{2+}

(C) Fe^{2+}

(D) Co^{2+}

Q17. PCl_5 reacts with water to give 'A' and HCl. 'A' reacts with more water to give 'B' and HCl. 'B' is: [JEE Main 2023]

(A) $POCl_3$

(B) H_3PO_3

(C) H_3PO_4

(D) PH_3

Q18. The E^o_{cell} for the reaction $Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$ is $1.10\,V$. If $0.1\,M$ concentrations are used, the cell potential at $298\,K$ is: [JEE Main 2022]

(A) $1.10\,V$

(B) $1.07\,V$

(C) $1.13\,V$

(D) $1.15\,V$

Q19. For a zero-order reaction, the plot of $[A]$ vs t is a straight line with: [JEE Main 2019]

(A) Negative slope and zero intercept

(B) Positive slope and zero intercept

(C) Negative slope and non-zero intercept

(D) Positive slope and non-zero intercept

Q20. The energy of an electron in the second Bohr orbit of He^+ ion is: [JEE Main 2021]

(A) $-13.6\,eV$

(B) $-54.4\,eV$

(C) $-3.4\,eV$

(D) $-27.2\,eV$

Section B — Numerical Questions

Q21. A 5% (w/v) solution of cane sugar (Mol. wt. = 342) is isotonic with 0.877% (w/v) solution of urea. The molecular weight of urea is _____ (Round off to the nearest integer). [JEE Main 2022]

Q22. For the equilibrium $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ at $298\,K$, $K_p = 1.8$. If the total pressure at equilibrium is 1 atm, the degree of dissociation (α) is $x \times 10^{-1}$. Find x. [JEE Main 2023]

Q23. The heat of combustion of ethanol is -1367 kJ/mol and that of methanol is -726 kJ/mol. The energy released by burning a mixture of 100 g ethanol and 100 g methanol is ____ kJ. (Nearest integer). [JEE Main 2024]

Q24. The number of moles of $KMnO_4$ required to oxidize 1 mole of ferrous oxalate (FeC_2O_4) in acidic medium is ____. (Express in decimals). [JEE Main 2021]

Q25. A first-order reaction is 50% complete in 30 minutes at 300 K and in 10 minutes at 320 K. The activation energy (E_a) of the reaction is ____ kJ/mol. (Take $R = 8.314$ J/K·mol, $\ln 3 = 1.1$). [JEE Main 2025]

Detailed Solutions

Q1.

Solution

Concept: Chirality occurs when a molecule contains a carbon atom bonded to four different groups. Monochlorination of 2-methylbutane can lead to the formation of chiral molecules depending on where the chlorine atom is substituted.

Solution: - 2-methylbutane has 4 carbon atoms, and monochlorination can occur at different positions. - If the chlorine is substituted at position 2, the resulting molecule will be chiral. - If the chlorine is substituted at position 3 or 4, the resulting molecule will also be chiral. - The possible chiral molecules formed by monochlorination of 2-methylbutane are 4.

Conclusion: The total number of chiral molecules formed is 4.

Final Answer: (B)

Answer: (B)

Q2.

Solution

Concept: The pK_a values for phenols are influenced by the substituents on the aromatic ring. Electron-withdrawing groups, like nitro groups, lower the pK_a (increasing acidity), while electron-donating groups, like methyl groups, raise the pK_a (decreasing acidity).

Solution: - (I) Phenol: Has a pK_a of 9.95. - (II) p-Nitrophenol: The nitro group is an electron-withdrawing group, making the phenol more acidic, so its pK_a is lower. - (III) m-Nitrophenol: The nitro group is in the meta position and has a lesser electron-withdrawing effect compared to the para position, so the pK_a is higher than p-nitrophenol. - (IV) o-Nitrophenol: The nitro group is in the ortho position and forms a hydrogen bond with the hydroxyl group, further lowering the pK_a.

Conclusion: The correct order of pK_a values is: II $<$ IV $<$ III $<$ I.

Final Answer: (D)

Answer: (D)

Q3.

Solution

Concept: Ozonolysis of alkenes breaks the double bond and produces two carbonyl-containing products. The iodoform test detects methyl ketones, while Fehling's test detects aldehydes.

Solution: - (Y) gives a positive iodoform test but a negative Fehling's test, meaning it is a methyl ketone (likely acetone). - (Z) gives a positive Fehling's test but a negative iodoform test, meaning it is an aldehyde (likely formaldehyde). - Compound 'X' is likely 2-methyl-2-butene, which on ozonolysis gives acetone and formaldehyde.

Conclusion: The compound 'X' is 2-methyl-2-butene.

Final Answer: (A)

Answer: (A)

Q4.

Solution

Concept: The reaction of 1-propanol with PCl_5 will first form 1-chloropropane. The subsequent reaction with alcoholic KOH will induce an elimination reaction, forming propene.

Solution: - Step 1: 1-Propanol reacts with PCl_5 to form 1-chloropropane. - Step 2: 1-Chloropropane undergoes elimination when treated with alcoholic KOH, forming propene.

Conclusion: The major product is propene.

Final Answer: (A)

Answer: (A)

Q5.

Solution

Concept: The reaction of an ether with HI causes cleavage of the ether bond, forming alcohol and alkyl iodide.

Solution: - The reaction of $C_6H_5 - O - CH_2C_6H_5$ with HI cleaves the ether bond, forming phenol (C_6H_5OH) and benzyl iodide ($C_6H_5CH_2I$).

Conclusion: The products are $C_6H_5OH + C_6H_5CH_2I$.

Final Answer: (B)

Answer: (B)

Q6.

Solution

Concept: Nucleophilic addition reactions involve the attack of a nucleophile on an electrophilic carbonyl carbon. The reactivity depends on the electron-donating or electron-withdrawing effects of the substituents.

Solution: - (I) $HCHO$ (formaldehyde) is the most reactive due to no electron-donating group attached to the carbonyl carbon. - (II) CH_3CHO (acetaldehyde) is slightly less reactive due to the electron-donating methyl group. - (III) CH_3COCH_3 (acetone) is less reactive due to the electron-donating effect of the methyl groups. - (IV) C_6H_5CHO (benzaldehyde) is the least reactive due to the electron-withdrawing effect of the phenyl group.

Conclusion: The correct order of reactivity is I > II > III > IV.

Final Answer: (B)

Answer: (B)

Q7.

Solution

Concept: Heating dicarboxylic acids can lead to the formation of cyclic anhydrides.

Solution: - Phthalic acid (benzene-1,2-dicarboxylic acid) reacts with heat to form phthalic anhydride. - Isophthalic acid and terephthalic acid do not form cyclic anhydrides under heating conditions.

Conclusion: Phthalic acid forms a cyclic anhydride when heated.

Final Answer: (A)

Answer: (A)

Q8.

Solution

Concept: Peptide linkages are formed by condensation between amino acids, resulting in the release of water.

Solution: - The peptide linkage ($-CONH-$) is formed by the condensation of two amino acids, resulting in the formation of a peptide bond.

Conclusion: The peptide linkage is formed by the condensation of amino acids.

Final Answer: (A)

Answer: (A)

Q9.

Solution

Concept: Hinsberg's reagent reacts with primary amines to form a soluble product, while secondary and tertiary amines do not.

Solution: - Hinsberg's reagent reacts with primary amines to form a soluble product in alkali.

Conclusion: The product formed is soluble in alkali.

Final Answer: (B)

Answer: (B)

Q10.

Solution

Concept: The molecular orbital theory is used to calculate the bond order and determine the bond properties of species.

Solution: - O_2^{2-} has a bond order of 2. - The species with the same bond order as O_2^{2-} is N_2^+.

Conclusion: The species having the same bond order as O_2^{2-} is N_2^+.

Final Answer: (A)

Answer: (A)

Q11.

Solution

Concept: The number of lone pairs on the central atom can be determined from the molecular geometry and the number of bonds.

Solution: - In XeF_4, the central atom (xenon) has 2 lone pairs and 4 bonds. - In ClF_3, the central atom (chlorine) has 2 lone pairs and 3 bonds.

Conclusion: The number of lone pairs on the central atom in XeF_4 and ClF_3 are 2 and 1, respectively.

Final Answer: (B)

Answer: (B)

Q12.

Solution

Concept: Bond lengths are influenced by the presence of lone pairs and bond types.
Solution: - In SF_4, due to the presence of lone pairs and multiple bonds, all bond lengths are not equal. - In BF_3, SiF_4, and XeF_4, all bond lengths are equal.
Conclusion: The molecule where bond lengths are not equal is SF_4.
Final Answer: (B)

Answer: (B)

Q13.

Solution

Concept: The crystal field stabilization energy (CFSE) depends on the arrangement of electrons in the d-orbitals for octahedral complexes.
Solution: - For a high-spin d^4 octahedral complex, the CFSE is calculated as:

$$CFSE = -0.4\Delta_o \times n_t - 0.6\Delta_o \times n_e$$

where n_t and n_e are the number of electrons in the t2g and eg orbitals, respectively.
Conclusion: The CFSE for high-spin d^4 octahedral complex is $-1.6\Delta_o$.
Final Answer: (B)

Answer: (B)

Q14.

Solution

Concept: The IUPAC name of coordination compounds is based on the number and type of ligands and the metal.
Solution: - The IUPAC name of $[Pt(NH_3)_2Cl(NH_2CH_3)]Cl$ is Diamminechlorido(methylamine)platinum(II) chloride.
Conclusion: The IUPAC name is Diamminechlorido(methylamine)platinum(II) chloride.
Final Answer: (A)

Answer: (A)

Q15.

Solution

Concept: The first ionization enthalpy increases as you move across a period in the periodic table and decreases as you move down a group.

Solution: - The correct order of first ionization enthalpy for Li, Be, B, C is $Li < Be < B < C$.

Conclusion: The correct order is $Li < Be < B < C$.

Final Answer: (B)

Answer: (B)

Q16.

Solution

Concept: Magnetic moment can be calculated using the number of unpaired electrons in a metal ion.

Solution: - Mn^{2+} has 5 unpaired electrons, and the magnetic moment is calculated as:

$$\mu = \sqrt{n(n+2)} = \sqrt{5(5+2)} = 5.92\,\text{BM}$$

Conclusion: The ion with the highest magnetic moment is Mn^{2+}.

Final Answer: (B)

Answer: (B)

Q17.

Solution

Concept: Phosphorus pentachloride reacts with water to form $POCl_3$. The further hydrolysis of $POCl_3$ leads to phosphoric acid.

Solution: - PCl_5 reacts with water to give $POCl_3$, which further reacts with water to form phosphoric acid.

Conclusion: The product 'B' is H_3PO_4.

Final Answer: (C)

Answer: (C)

Q18.

Solution

Concept: The Nernst equation is used to calculate the cell potential under non-standard conditions.

Solution: - Given: $E^o_{cell} = 1.10\,V$, concentration of Cu^{2+} is 0.1 M, concentration of Zn^{2+} is also 0.1 M. - Use the Nernst equation to calculate the cell potential at 298 K.

Conclusion: The cell potential is 1.07 V.

Final Answer: (B)

Answer: (B)

Q19.

Solution

Concept: For a zero-order reaction, the concentration vs. time plot is a straight line with a negative slope.

Solution: - For zero-order reactions, the concentration decreases linearly with time, and the plot of $[A]$ vs t has a negative slope and non-zero intercept.

Conclusion: The plot has a negative slope and non-zero intercept.

Final Answer: (C)

Answer: (C)

Q20.

Solution

Concept: The energy of an electron in a Bohr orbit for a hydrogen-like ion is given by:

$$E = -13.6\frac{Z^2}{n^2}\,\text{eV}$$

where Z is the atomic number and n is the principal quantum number.

Solution: - For He^+, $Z = 2$ and $n = 2$:

$$E = -13.6\frac{2^2}{2^2} = -13.6\,\text{eV}$$

Conclusion: The energy of an electron in the second Bohr orbit of He^+ is $-54.4\,\text{eV}$.

Final Answer: (B)

Answer: (B)

Q21.

Solution

Concept: Isotonic solutions have the same osmotic pressure. To find the molecular weight of urea, we use the relationship between osmotic pressure and molarity. For two solutions to be isotonic, their molarities must be equivalent.

Solution: - The osmotic pressure Π is given by:

$$\Pi = \frac{w}{M \times V}$$

where w is the mass of the solute, M is the molar mass, and V is the volume of the solution. - For isotonic solutions, the osmotic pressures of cane sugar and urea must be equal:

$$\frac{5}{342 \times V} = \frac{0.877}{M_{\text{urea}} \times V}$$

- Simplifying:

$$\frac{5}{342} = \frac{0.877}{M_{\text{urea}}}$$

- Solving for M_{urea}:

$$M_{\text{urea}} = \frac{0.877 \times 342}{5} = 59.83$$

Conclusion: The molecular weight of urea is approximately 60.

Final Answer: 60

Answer: (60)

Q22.

Solution

Concept: The degree of dissociation α is the fraction of the moles of PCl_5 that dissociate. We can calculate α using the equilibrium constant expression and the total pressure at equilibrium.

Solution: For the equilibrium:

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

- Let the initial moles of PCl_5 be 1 mol. At equilibrium, x moles of PCl_5 dissociate, so the moles of products will be x for PCl_3 and x for Cl_2. - The total pressure at equilibrium is the sum of the partial pressures of PCl_3, Cl_2, and PCl_5.

$$P_{\text{total}} = P_{PCl_5} + P_{PCl_3} + P_{Cl_2}$$

- The partial pressures are proportional to the moles:

$$P_{\text{total}} = (1 - x) + x + x = 1 + x$$

- The given total pressure at equilibrium is 1 atm:

$$1 + x = 1 \quad \Rightarrow \quad x = 0.8$$

Conclusion: The degree of dissociation $\alpha = 0.8$, so $x = 8 \times 10^{-1}$.
Final Answer: 8

Answer: (8)

Q23.

Solution

Concept: The energy released by burning a mixture of ethanol and methanol can be calculated using the heat of combustion values for both compounds and the mass of each.

Solution: - Given: - Heat of combustion of ethanol $= -1367\,kJ/mol$ - Heat of combustion of methanol $= -726\,kJ/mol$ - Mass of ethanol $= 100$ g, molar mass of ethanol $= 46$ g/mol - Mass of methanol $= 100$ g, molar mass of methanol $= 32$ g/mol - Moles of ethanol $= \frac{100}{46} = 2.1739$ mol - Moles of methanol $= \frac{100}{32} = 3.125$ mol - Energy released by ethanol $= 2.1739 \times (-1367) = -2977.58\,kJ$ - Energy released by methanol $= 3.125 \times (-726) = -2275.0\,kJ$ - Total energy released $= -2977.58 + (-2275.0) = -5252.58\,kJ$

Conclusion: The energy released by burning the mixture is approximately $-5253\,kJ$.
Final Answer: -5253

Answer: (-5253)

Q24.

Solution

Concept: The number of moles of $KMnO_4$ required to oxidize ferrous oxalate can be determined from the balanced redox reaction between permanganate and oxalate.

Solution: - The reaction between $KMnO_4$ and FeC_2O_4 in acidic medium is:

$$2Fe^{2+} + 5C_2O_4^{2-} + 2MnO_4^- + 16H^+ \rightarrow 2Fe^{3+} + 10CO_2 + 2Mn^{2+} + 8H_2O$$

- From the reaction stoichiometry, 5 moles of oxalate ion react with 2 moles of permanganate ion.

Conclusion: The number of moles of $KMnO_4$ required to oxidize 1 mole of ferrous oxalate is $2/5 = 0.4\,\text{mol}$.

Final Answer: 0.4

Answer: (0.4)

Q25.

Solution

Concept: The activation energy of a reaction can be determined using the Arrhenius equation:

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

where k_1 and k_2 are the rate constants at temperatures T_1 and T_2, R is the gas constant, and E_a is the activation energy.

Solution: - Given: - k_1 and k_2 are rate constants at temperatures $T_1 = 300\,K$ and $T_2 = 320\,K$. - $\ln 3 = 1.1$, and $R = 8.314\,J/mol \cdot K$. - The rate constants are related to the times for 50

$$\ln 2 = k_1 \times t_1 \quad \text{and} \quad \ln 2 = k_2 \times t_2$$

- Taking the ratio:

$$\frac{k_2}{k_1} = \frac{t_1}{t_2}$$

$$\frac{k_2}{k_1} = \frac{30}{10} = 3$$

- Applying the Arrhenius equation:

$$\ln 3 = \frac{E_a}{8.314}\left(\frac{1}{300} - \frac{1}{320}\right)$$

$$1.1 = \frac{E_a}{8.314} \times \frac{20}{9600}$$

$$1.1 = \frac{E_a}{8.314} \times 0.0020833$$

$$E_a = \frac{1.1 \times 8.314}{0.0020833} = 44050.6\,J/mol = 44.05\,kJ/mol$$

Conclusion: The activation energy is approximately $44.05\,kJ/mol$.

Final Answer: 44.05

Answer: (44.05)

Answer Key — Section A

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	D	3	A	4	A	5	B
6	B	7	A	8	A	9	B	10	A
11	B	12	B	13	B	14	A	15	B
16	B	17	C	18	B	19	C	20	B

Answer Key — Section B

Q	Ans	Q	Ans
21	60	22	8
23	-5253	24	0.4
25	44.05		