JEE Main Chemistry Sample Paper-20

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. An organic compound (A) C_8H_{10} on oxidation with acidic $KMnO_4$ gives (B) $C_8H_6O_4$. (B) on heating with NH_3 gives (C), which on further strong heating gives (D) $C_8H_5NO_2$. Compound (D) reacts with KOH followed by Ethyl iodide to give (E). The compound (E) is: [JEE Main 2021]

(A) N-Ethylphthalimide

(B) Ethylbenzoate

(C) N-Ethylbenzamide

(D) o-Ethylaniline

Q2. The total number of stereoisomers (including enantiomers and meso forms) for the compound $CH_3 - CH(OH) - CH(OH) - CH(OH) - CH_3$ is: [JEE Main 2022]

(A) 2

(B) 4

(C) 6

(D) 8

Q3. 0.5 g of an organic compound containing C, H, and O was analyzed by the combustion method. It gave 0.793 g of CO_2 and 0.442 g of H_2O. The percentage of Oxygen in the compound is: [JEE Main 2023]

(A) 32.5

(B) 25.4

(C) 46.2

(D) 56.8

Q4. The major product of the reaction: $Toluene \xrightarrow{Cl_2/FeCl_3} A \xrightarrow{KMnO_4/OH^-} B \xrightarrow{HNO_3/H_2SO_4} C$. 'C' is: [JEE Main 2019]

(A) 2-chloro-4-nitrobenzoic acid

(B) 3-chloro-4-nitrobenzoic acid

(C) 4-chloro-3-nitrobenzoic acid

(D) 2-chloro-5-nitrobenzoic acid

Q5. Arrange the following in decreasing order of their rate of reaction towards nucleophilic substitution (S_N2):
(I) 1-Bromobutane
(II) 1-Bromo-2,2-dimethylpropane
(III) 1-Bromo-2-methylbutane
(IV) 1-Bromo-3-methylbutane [JEE Main 2021]

(A) I > IV > III > II

(B) I > II > III > IV

(C) II > III > IV > I

(D) IV > III > II > I

Q6. A decapeptide (Mol. wt. 796) on complete hydrolysis gives glycine (Mol. wt. 75) and alanine (Mol. wt. 89). If the glycine content is 47%, the number of alanine units in the peptide is: [JEE Main 2020]

(A) 4

(B) 5

(C) 6

(D) 3

Q7. Which of the following sequence of reagents is best for the conversion of Benzene to m-Dibromobenzene? [JEE Main 2024]

(A) $Br_2/Fe \rightarrow HNO_3/H_2SO_4 \rightarrow Sn/HCl \rightarrow NaNO_2/HCl \rightarrow CuBr$

(B) $HNO_3/H_2SO_4 \rightarrow Br_2/Fe \rightarrow Sn/HCl \rightarrow NaNO_2/HCl \rightarrow CuBr$

(C) $CH_3Cl/AlCl_3 \rightarrow Br_2/Fe \rightarrow KMnO_4 \rightarrow Br_2/Fe$

(D) $Br_2/Fe \rightarrow Br_2/Fe$

Q8. The magnetic moment of a transition metal complex is 5.92 B.M. The metal ion in the complex among $Mn^{2+}, Fe^{2+}, Cu^{2+}$, and Cr^{3+} is: [JEE Main 2021]

(A) Mn^{2+}

(B) Fe^{2+}

(C) Cu^{2+}

(D) Cr^{3+}

Q9. XeF_6 on partial hydrolysis yields 'A' and HF. 'A' on further hydrolysis yields 'B' and HF. The hybridization of 'Xe' in 'A' and 'B' are respectively: [JEE Main 2022]

(A) sp^3d^2 and sp^3d

(B) sp^3d^2 and sp^3

(C) sp^3d^3 and sp^3d^2

(D) sp^3d^2 and sp^3d^2

Q10. The correct order of the oxidation states of Nitrogen in NO, N_2O, NO_2 and N_2O_3 is: [JEE Main 2023]

(A) $NO_2 > N_2O_3 > NO > N_2O$

(B) $N_2O > NO > N_2O_3 > NO_2$

(C) $NO_2 > NO > N_2O_3 > N_2O$

(D) $N_2O_3 > NO_2 > NO > N_2O$

Q11. For the reaction $[Co(en)_2Cl_2]Cl$, the number of possible geometrical isomers and optical isomers (total stereoisomers) are: [JEE Main 2020]

(A) 2, 2

(B) 2, 3

(C) 3, 3

(D) 2, 4

Q12. Which property of the group 16 elements correctly follows the order $O < S < Se < Te$? [JEE Main 2022]

(A) Electron gain enthalpy (negative)

(B) Melting point

(C) Ionization enthalpy

(D) Electronegativity

Q13. The Bond Dissociation Energy of H_2, Cl_2 and HCl are 434, 242 and 431 kJ/mol respectively. The enthalpy of formation of HCl is: [JEE Main 2021]

(A) $-93\,kJ/mol$

(B) $+245\,kJ/mol$

(C) $+93\,kJ/mol$

(D) $-245\,kJ/mol$

Q14. For a reaction $2A + B \rightarrow 3C$, the rate of appearance of C is $1.2 \times 10^{-2}\,mol\,L^{-1}s^{-1}$. The rate of disappearance of A is: [JEE Main 2024]

(A) 8.0×10^{-3}

(B) 1.8×10^{-2}

(C) 1.2×10^{-2}

(D) 4.0×10^{-3}

Q15. The wavelength of the radiation emitted when an electron falls from $n = 4$ to $n = 2$ in Li^{2+} is: (Given $R_H = 1.09 \times 10^7\,m^{-1}$) [JEE Main 2023]

(A) $40.5\,nm$

(B) $121.5\,nm$

(C) $486.1\,nm$

(D) $13.5\,nm$

Q16. The correct order of ionic mobility in aqueous solution is: [JEE Main 2021]

(A) $Li^+ < Na^+ < K^+ < Rb^+$

(B) $Rb^+ < K^+ < Na^+ < Li^+$

(C) $Li^+ < K^+ < Na^+ < Rb^+$

(D) $Na^+ < Li^+ < K^+ < Rb^+$

Q17. Silver atom has completely filled d-orbitals ($4d^{10}$) in its ground state. How can you say it is a transition element? [JEE Main 2022]

(A) It forms Ag^{2+} in AgF_2

(B) It forms Ag^+ ions

(C) It is a noble metal

(D) It has high luster

Q18. The pH of a solution obtained by mixing 50 mL of 0.2 M HCl and 50 mL of 0.1 M $NaOH$ is: [JEE Main 2019]

(A) 1.30

(B) 1.00

(C) 0.70

(D) 2.00

Q19. At 298 K, the Henry's law constant for N_2 in water is $7.6 \times 10^4\, atm$. The mole fraction of N_2 in solution if partial pressure of N_2 is 0.76 atm is: [JEE Main 2023]

(A) 1×10^{-5}

(B) 1×10^{-4}

(C) 1×10^{-6}

(D) 1×10^{-3}

Q20. For a reaction $X + Y \rightleftharpoons 2Z$, the equilibrium constant K_c is 10^{-2} at 300 K. The ΔG^o for the reaction is: (Take $R = 8.314, \ln 10 = 2.3$) [JEE Main 2021]

(A) $+11.48\, kJ/mol$

(B) $-11.48\, kJ/mol$

(C) $+5.74\, kJ/mol$

(D) $-5.74\, kJ/mol$

Section B — Numerical Questions

Q21. 10 g of a non-volatile solute (Mol. wt. 100) is dissolved in 180 g of water. The relative lowering of vapor pressure is $x \times 10^{-2}$. Find x. [JEE Main 2022]

Q22. A current of 2.0 A is passed for 5 hours through a molten metal salt to deposit 22.2 g of metal (At. wt. 177). The oxidation state of the metal in the salt is ____. [JEE Main 2023]

Q23. In the reaction $I_2 + 10HNO_3 \rightarrow 2HIO_3 + 10NO_2 + 4H_2O$, the change in the oxidation state of Iodine per molecule of I_2 is ____. [JEE Main 2024]

Q24. 20 mL of 0.1 M H_2SO_4 is completely neutralized by 'V' mL of 0.2 M NaOH. The value of 'V' is ____. [JEE Main 2021]

Q25. For the reaction $2NO(g) + Cl_2(g) \rightarrow 2NOCl(g)$, when the concentration of NO is doubled, the rate becomes 4 times. When both concentrations are doubled, the rate becomes 8 times. The overall order of the reaction is ____. [JEE Main 2025]

Detailed Solutions

Q1.

Solution

Concept: The organic compound undergoes oxidation to form a carboxylic acid and further reactions lead to the formation of a compound containing nitrogen.

Solution: - The given organic compound is a hydrocarbon. Upon oxidation with $KMnO_4$, it forms a benzene-1,2-dicarboxylic acid (phthalic acid). - Phthalic acid reacts with ammonia to form phthalimide, which upon further strong heating gives N-ethylphthalimide, which is the final product.

Conclusion: The compound (E) is N-Ethylphthalimide.

Final Answer: (A)

Answer: (A)

Q2.

Solution

Concept: The compound has three hydroxyl groups. The presence of multiple chiral centers leads to stereoisomerism.

Solution: - The given compound is a pentose with three hydroxyl groups. It has multiple chiral centers and thus can exhibit stereoisomerism. - By considering all possible spatial arrangements of the groups around the chiral centers, we find that there are 8 stereoisomers, including enantiomers and meso forms.

Conclusion: The total number of stereoisomers is 8.

Final Answer: (D)

Answer: (D)

Q3.

Solution

Concept: The percentage of oxygen can be calculated by subtracting the masses of carbon and hydrogen from the total mass.

Solution: - Mass of carbon is calculated from the CO_2 produced, and the mass of hydrogen is calculated from the H_2O produced. - The mass of oxygen is the remainder after subtracting the masses of carbon and hydrogen from the total mass.

Conclusion: The percentage of oxygen in the compound is 46.2

Final Answer: (C)

Answer: (C)

Q4.

Solution

Concept: The reaction involves electrophilic substitution followed by oxidation and nitration to form the final product.

Solution: - Toluene undergoes chlorination in the presence of $FeCl_3$ to form a chloro derivative. - The chloro derivative undergoes oxidation with $KMnO_4$ to form a carboxylic acid group. - Finally, the product undergoes nitration with HNO_3/H_2SO_4 to form a nitro derivative, resulting in 2-chloro-4-nitrobenzoic acid.

Conclusion: The final product (C) is 2-chloro-4-nitrobenzoic acid.

Final Answer: (A)

Answer: (A)

Q5.

Solution

Concept: The rate of reaction in S_N2 depends on the size of the alkyl groups attached to the carbon center.

Solution: - The 1-Bromobutane undergoes S_N2 substitution faster due to less steric hindrance. - The 1-Bromo-2,2-dimethylpropane undergoes S_N2 substitution more slowly due to the bulky groups. - The correct order of reactivity towards S_N2 is $I > IV > III > II$.

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

Final Answer: (A)

Answer: (A)

Q6.

Solution

Concept: The number of alanine units can be determined by using the molar mass and the glycine content.

Solution: - The total mass of the peptide is 796, and the glycine content is 47- The number of glycine units is $\frac{374.92}{75} \approx 5$. - The remaining mass is alanine, and the number of alanine units is $\frac{796-374.92}{89} \approx 5$.

Conclusion: The number of alanine units is 5.

Final Answer: (B)

Answer: (B)

Q7.

Solution

Concept: The synthesis of m-Dibromobenzene from benzene involves multiple steps.
Solution: - The reaction sequence starts with HNO_3/H_2SO_4 for nitration of benzene. - Then, Br_2/Fe is used for bromination to form 3-chloro-4-nitrobenzoic acid. - Finally, Sn/HCl and $NaNO_2/HCl steps lead to the formation of m-Dibromobenzene.$
Conclusion: The correct sequence of reagents is option (B).
Final Answer: (B)

Answer: (B)

Q8.

Solution

Concept: The magnetic moment of a transition metal complex depends on the number of unpaired electrons.
Solution: - A magnetic moment of 5.92 B.M. corresponds to 4 unpaired electrons, which is consistent with the d^5 configuration of Mn^{2+}.
Conclusion: The metal ion in the complex is Mn^{2+}.
Final Answer: (A)

Answer: (A)

Q9.

Solution

Concept: The hybridization of xenon in hydrolyzed XeF_6 is determined by the number of bonding pairs and lone pairs.
Solution: - In A, the hybridization of Xenon is sp^3d^2 and in B, it is sp^3.
Conclusion: The hybridization in 'A' and 'B' are sp^3d^2 and sp^3, respectively.
Final Answer: (B)

Answer: (B)

Q10.

Solution

Concept: Oxidation states of nitrogen can be determined based on its bonding.
Solution: - The oxidation states of nitrogen in NO, N_2O, NO_2 and N_2O_3 can be determined by considering the bonding with oxygen and the formal charge on nitrogen.
Conclusion: The correct order of oxidation states is $NO_2 > NO > N_2O_3 > N_2O$.
Final Answer: (C)

Answer: (C)

Q11.

Solution

Concept: Geometrical isomers are possible due to the different spatial arrangements of the ligands around the central metal.

Solution: - The complex $[Co(en)_2Cl_2]Cl$ can have geometrical isomers as well as optical isomers.

Conclusion: The number of possible stereoisomers is 2 geometrical and 2 optical isomers.

Final Answer: (A)

Answer: (A)

Q12.

Solution

Concept: The properties of group 16 elements, including electron gain enthalpy, depend on their atomic size and electron configuration.

Solution: - The electron gain enthalpy becomes more negative as we move down the group from oxygen to tellurium, due to the increasing size of the atoms. - Therefore, the correct order follows the trend $O < S < Se < Te$.

Conclusion: The property that correctly follows the order $O < S < Se < Te$ is electron gain enthalpy.

Final Answer: (A)

Answer: (A)

Q13.

Solution

Concept: Bond dissociation energy is related to the strength of the bond between atoms, and enthalpy of formation can be calculated using bond dissociation energies.

Solution: - The enthalpy of formation of HCl can be calculated using the bond dissociation energies of H_2, Cl_2, and HCl. - The enthalpy of formation is ΔH_f° = Bond dissociation energy of H_2 + Bond dissociation energy of Cl_2 − Bond dissociation energy of HCl.

Conclusion: The enthalpy of formation of HCl is $-93\,kJ/mol$.

Final Answer: (A)

Answer: (A)

Q14.

Solution

Concept: The rate of reaction is related to the stoichiometric coefficients and the rate of appearance of products.

Solution: - For the reaction $2A + B \rightarrow 3C$, the rate of appearance of C is $1.2 \times 10^{-2}\, mol\, L^{-1} s^{-1}$. - Since two moles of A are consumed for every mole of C formed, the rate of disappearance of A is $\frac{1}{2} \times$ rate of appearance of C.

Conclusion: The rate of disappearance of A is $6.0 \times 10^{-3}\, mol\, L^{-1} s^{-1}$.

Final Answer: (D)

Answer: (D)

Q15.

Solution

Concept: The wavelength of the radiation emitted can be determined using the Rydberg formula for hydrogen-like ions.

Solution: - The formula for the wavelength of radiation emitted when an electron falls from one energy level to another is given by:

$$\frac{1}{\lambda} = R_H \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$$

- For the transition from $n = 4$ to $n = 2$ in Li^{2+}, the wavelength is calculated to be $40.5\, nm$.

Conclusion: The wavelength of the radiation emitted is 40.5 nm.

Final Answer: (A)

Answer: (A)

Q16.

Solution

Concept: Ionic mobility in aqueous solution depends on the size of the ion and its charge.

Solution: - The mobility of ions decreases as the size increases. Therefore, the order of ionic mobility is $Li^+ < Na^+ < K^+ < Rb^+$, because lithium has the smallest ionic radius and the highest mobility.

Conclusion: The correct order of ionic mobility is $Li^+ < Na^+ < K^+ < Rb^+$.

Final Answer: (A)

Answer: (A)

Q17.

Solution

Concept: Transition elements are those that have partially filled d-orbitals in at least one of their oxidation states.
Solution: - Silver has a completely filled d-orbital in its ground state ($4d^{10}$), but it can lose electrons from its d-orbital, forming the Ag^{2+} ion in AgF_2. - Therefore, it qualifies as a transition element, as it has a d-orbital that participates in chemical reactions.
Conclusion: Silver is a transition element because it forms Ag^{2+} in AgF_2.
Final Answer: (A)

Answer: (A)

Q18.

Solution

Concept: The pH of a solution is determined by the amount of acid and base mixed, and the concentration of ions.
Solution: - The strong acid HCl and strong base $NaOH$ neutralize each other in a 1:1 ratio. - After mixing 50 mL of 0.2 M HCl and 50 mL of 0.1 M $NaOH$, the resulting solution is acidic, and the pH is calculated to be 1.00.
Conclusion: The pH of the solution is 1.00.
Final Answer: (B)

Answer: (B)

Q19.

Solution

Concept: Henry's law relates the solubility of a gas in a liquid to its partial pressure.
Solution: - The mole fraction of N_2 in solution is given by:

$$X_{N_2} = \frac{P_{N_2}}{K_H}$$

- Using Henry's law constant $K_H = 7.6 \times 10^4\, atm$ and partial pressure $P_{N_2} = 0.76\, atm$, the mole fraction is calculated to be 1×10^{-4}.
Conclusion: The mole fraction of N_2 in solution is 1×10^{-4}.
Final Answer: (B)

Answer: (B)

Q20.

Solution

Concept: The change in Gibbs free energy is related to the equilibrium constant by the equation:

$$\Delta G^o = -RT \ln K_c$$

Solution: - The equilibrium constant $K_c = 10^{-2}$ and using the given values for R and $\ln 10$, the change in Gibbs free energy ΔG^o is calculated to be $-11.48\,kJ/mol$.
Conclusion: The value of ΔG^o is $-11.48\,kJ/mol$.
Final Answer: (B)

Answer: (B)

Q21.

Solution

Concept: The relative lowering of vapor pressure is given by the formula:

$$\text{Relative lowering of vapor pressure} = \frac{\Delta P}{P_0} = \frac{n_{\text{solute}}}{n_{\text{solvent}}}$$

where n_{solute} is the number of moles of solute and n_{solvent} is the number of moles of solvent.
Solution: - Given: - Mass of solute = 10 g, molecular weight = 100, so moles of solute $= \frac{10}{100} = 0.1$ mol. - Mass of water = 180 g, molecular weight of water = 18, so moles of solvent $= \frac{180}{18} = 10$ mol. - The relative lowering of vapor pressure is:

$$\frac{0.1}{10} = 0.01$$

- So, $x = 1$.
Conclusion: The value of x is 1.
Final Answer: (1)

Answer: (1)

Q22.

Solution

Concept: The amount of metal deposited is related to the charge passed using Faraday's law of electrolysis:

$$Q = I \times t$$

where Q is the charge, I is the current, and t is the time.

Solution: - Given: - Current $I = 2.0\,\text{A}$, - Time $t = 5\,\text{hours} = 5 \times 3600 = 18000\,\text{seconds}$, - Mass of metal deposited = 22.2 g, - Atomic weight of metal = 177 g/mol. - The moles of metal deposited are:

$$\frac{22.2}{177} = 0.125\,\text{mol}$$

- The charge Q required to deposit 0.125 mol of metal is:

$$Q = n \times z \times F = 0.125 \times z \times 96500$$

where z is the oxidation state of the metal and F is Faraday's constant. - The charge passed is also given by:

$$Q = I \times t = 2.0 \times 18000 = 36000\,\text{C}$$

- Equating the two expressions for Q:

$$0.125 \times z \times 96500 = 36000$$

$$z = \frac{36000}{0.125 \times 96500} = 3$$

Conclusion: The oxidation state of the metal is 3.

Final Answer: (3)

Answer: (3)

Q23.

Solution

Concept: The change in oxidation state is calculated by comparing the oxidation states of iodine in the reactants and products.

Solution: - In the reaction $I_2 + 10HNO_3 \rightarrow 2HIO_3 + 10NO_2 + 4H_2O$, the iodine in I_2 has an oxidation state of 0. - In HIO_3, the oxidation state of iodine is +5. - The change in oxidation state for each iodine atom is $5 - 0 = +5$.

Conclusion: The change in the oxidation state of iodine per molecule of I_2 is 5.

Final Answer: (5)

Answer: (5)

Q24.

Solution

Concept: The neutralization reaction follows the formula $n_1M_1V_1 = n_2M_2V_2$, where n_1 and n_2 are the number of equivalents of acid and base, and M_1, M_2 are the molarities of the acid and base, and V_1, V_2 are their volumes.
Solution: - Given: - Volume of $H_2SO_4 = 20$ mL, molarity of $H_2SO_4 = 0.1$ M, - Molarity of $NaOH = 0.2$ M. - The number of equivalents for H_2SO_4 is:

$$n_1 = M_1V_1 = 0.1 \times 20 = 2\,\text{meq}$$

- For neutralization, the number of equivalents for $NaOH$ is equal to 2. - The volume of $NaOH$ required is:

$$n_2 = M_2V_2 = 2\,\text{meq}$$

$$V_2 = \frac{2}{0.2} = 10\,\text{mL}$$

Conclusion: The volume of $NaOH$ required is 10 mL.
Final Answer: (10)

Answer: (10)

Q25.

Solution

Concept: The overall order of a reaction can be determined using the rate law expression, which is based on the effect of changing concentrations.
Solution: - Let the rate law be Rate $= k[NO]^m[Cl_2]^n$. - When the concentration of NO is doubled, the rate becomes 4 times, which gives:

$$2^m = 4 \implies m = 2$$

- When both $[NO]$ and $[Cl_2]$ are doubled, the rate becomes 8 times, so:

$$2^m \times 2^n = 8$$

Since $m = 2$, we have:

$$2^2 \times 2^n = 8 \implies 4 \times 2^n = 8 \implies 2^n = 2 \implies n = 1$$

- The overall order is $m + n = 2 + 1 = 3$.
Conclusion: The overall order of the reaction is 3.
Final Answer: (3)

Answer: (3)

Answer Key — Section A

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

Answer Key — Section B

Q	Ans	Q	Ans
21	1	22	3
23	5	24	10
25	3		