JEE Main Chemistry Sample Paper-10

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 compound with molecular formula C_4H_8 shows no reaction with Br_2/CCl_4 but reacts with $KMnO_4$. The compound is: [JEE Main 2021]

(A) 1-Butene

(B) 2-Butene

(C) Cyclobutane

(D) 2-Methylpropene

Q2. Which of the following pairs are position isomers? [JEE Main 2022]

(A) CH_3CH_2OH and CH_3OCH_3

(B) CH_3CH_2Br and $CH_3CHBrCH_3$

(C) $CH_3CH_2CH_2OH$ and $CH_3CH(OH)CH_3$

(D) $C_2H_5CH_2CH_3$ and $C_3H_7CH_3$

Q3. Which of the following hydrocarbons gives a positive Baeyer's test (cold $KMnO_4$)? [JEE Main 2021]

(A) Cyclohexane

(B) Benzene

(C) Cyclohexene

(D) Toluene

Q4. CH_3CH_2Cl undergoes faster hydrolysis in aqueous NaOH than $CH_3CHClCH_3$ because: [JEE Main 2023]

(A) Primary carbon is less hindered

(B) Secondary carbon is more reactive

(C) Primary carbon forms stable carbocation

(D) Hydrolysis is not dependent on carbon type

Q5. Which of the following alcohols will not dehydrate easily to form an alkene? [JEE Main 2022]

(A) 2-Methyl-2-butanol

(B) 1-Butanol

(C) Cyclohexanol

(D) 3-Pentanol

Q6. Which compound does not give a positive Tollen's test? [JEE Main 2020]

(A) CH_3CHO

(B) C_6H_5CHO

(C) CH_3COCH_3

(D) $HCOOH$

Q7. The Iodoform test is positive for: [JEE Main 2021]

(A) CH_3CHO

(B) $C_6H_5COCH_3$

(C) CH_3COCH_3

(D) All of these

Q8. Which amine is most basic in aqueous solution? [JEE Main 2023]

(A) CH_3NH_2

(B) $(CH_3)_2NH$

(C) $(CH_3)_3N$

(D) $C_6H_5NH_2$

Q9. Which biomolecule contains α-amino and α-carboxylic groups? [JEE Main 2022]

(A) Fatty acids

(B) Glucose

(C) Amino acids

(D) Urea

Q10. The bond angles in NH_3 and NF_3 are different because: [JEE Main 2021]

(A) N–H and N–F bonds differ in polarity

(B) Electron lone pair repulsion differs

(C) NH_3 is ionic, NF_3 is covalent

(D) Both have same bond angles

Q11. Which molecule has sp^2 hybridization at central atom? [JEE Main 2020]

(A) CH_4

(B) BF_3

(C) NH_3

(D) H_2O

Q12. Among CO_2, SO_2, and H_2O, the molecule with highest dipole moment is: [JEE Main 2021]

(A) CO_2

(B) SO_2

(C) H_2O

(D) All same

Q13. In $[Co(NH_3)_5Cl]^{2+}$, the oxidation state of Co is: [JEE Main 2022]

(A) +1

(B) +2

(C) +3

(D) +4

Q14. Which of the following is ionic in nature? [JEE Main 2020]

(A) $Co(NH_3)_6Cl_3$

(B) $Cr(H_2O)_6Cl_3$

(C) $K_3[Fe(CN)_6]$

(D) All of these

Q15. The strongest oxidizing agent among the following is: [JEE Main 2023]

(A) F_2

(B) Cl_2

(C) Br_2

(D) I_2

Q16. Which element shows +1 oxidation state exclusively? [JEE Main 2021]

(A) Li

(B) Na

(C) K

(D) All of these

Q17. Which of the following lanthanides has smallest ionic radius? [JEE Main 2022]

(A) La

(B) Ce

(C) Lu

(D) Nd

Q18. The conductance of 0.01 M HCl is 0.001 S. The molar conductivity is: [JEE Main 2020]

(A) 0.1 $S \cdot cm^2/mol$

(B) 10 $S \cdot cm^2/mol$

(C) 100 $S \cdot cm^2/mol$

(D) 1000 $S \cdot cm^2/mol$

Q19. The rate of a reaction doubles when the temperature is raised from 300 K to 310 K. The activation energy of the reaction is: [JEE Main 2023]

(A) 5 kJ/mol

(B) 10 kJ/mol

(C) 15 kJ/mol

(D) 20 kJ/mol

Q20. Number of unpaired electrons in Cr^{3+} (atomic number 24) is: [JEE Main 2022]

(A) 2

(B) 3

(C) 4

(D) 5

Section B — Numerical Questions

Q21. 5 g of a gas mixture contains H_2 and O_2. The mixture occupies 2.5 L at 300 K. Calculate mole fraction of H_2 if total pressure is 10 atm. [JEE Main 2021]

Q22. The conductivity of 0.01 M NaCl solution at 298 K is 0.014 S/m. Calculate molar conductivity of NaCl. [JEE Main 2022]

Q23. 0.1 mole of a weak acid HA is dissolved in 1 L water. If $K_a = 1.0 \times 10^{-4}$, calculate pH of solution. [JEE Main 2023]

Q24. A first-order reaction has half-life of 40 min. How much time will it take for 90% of the reactant to react? [JEE Main 2024]

Q25. 0.05 mole of CH_3COOH is titrated with 0.1 M NaOH. Calculate volume of NaOH required for complete neutralization. [JEE Main 2025]

Detailed Solutions

Q1.

Solution

Concept: The compound C_4H_8 can either be a straight-chain alkene or a cycloalkane. The reactions with bromine and $KMnO_4$ help determine unsaturation type.
Given: The compound shows no reaction with Br_2/CCl_4 but reacts with $KMnO_4$.
Analysis:

- Alkenes react with Br_2/CCl_4 (decolorization occurs), cycloalkanes do not.
- $KMnO_4$ oxidizes compounds with allylic CH bonds or cycloalkanes with CH_2 groups.

Step 1: Check Br_2/CCl_4 reaction
No reaction $\rightarrow$ no double bond $\rightarrow$ Not an alkene.
Step 2: Check $KMnO_4$ reaction
Reaction occurs $\rightarrow$ presence of CH_2 groups in a cyclic structure.
Conclusion: Compound is **Cyclobutane**, a saturated cyclic compound with formula C_4H_8.
Final Answer: (C)

Answer: (C)

Q2.

Solution

Concept: Position isomers are compounds that have the same molecular formula but differ in the position of a functional group or substituent on the carbon chain.
Given: Identify which pair are position isomers.
Analysis of options:

- (A) CH_3CH_2OH and CH_3OCH_3:
  - Different functional groups (alcohol vs ether) → **functional isomers, not position isomers.**
- (B) CH_3CH_2Br and $CH_3CHBrCH_3$:
  - Both are bromoalkanes, same carbon skeleton. Bromine is on carbon-1 in first and carbon-2 in second → **position isomers.**
- (C) $CH_3CH_2CH_2OH$ and $CH_3CH(OH)CH_3$:
  - Different functional group positions but also different parent chain → **functional + chain isomer.**
- (D) $C_2H_5CH_2CH_3$ and $C_3H_7CH_3$:
  - Same molecular formula but different chain → **chain isomers.**

Conclusion: Only option (B) is a **pair of position isomers**.
Final Answer: (B)

Answer: (B)

Q3.

Solution

Concept: Baeyer's test (cold $KMnO_4$) is used to detect the presence of C=C double bonds (unsaturation) in hydrocarbons.
Given: Identify which hydrocarbon gives positive Baeyer's test.
Analysis:

- Cyclohexane: saturated → No reaction
- Benzene: aromatic → Does not react under cold conditions
- Cyclohexene: contains C=C → Reacts with $KMnO_4$ (purple solution turns brown precipitate)
- Toluene: no double bond in side chain → No reaction

Conclusion: Only **Cyclohexene** gives a positive Baeyer's test.
Final Answer: (C)

Answer: (C)

Q4.

Solution

Concept: Nucleophilic substitution reaction rate depends on the structure of the alkyl halide (primary > secondary > tertiary for S_N2 mechanism).
Given: Compare hydrolysis of CH_3CH_2Cl and $CH_3CHClCH_3$.
Analysis:

- CH_3CH_2Cl: Primary → Less steric hindrance → Faster S_N2 hydrolysis
- $CH_3CHClCH_3$: Secondary → More steric hindrance → Slower

Conclusion: Primary halide reacts faster.
Final Answer: (A)

Answer: (A)

Q5.

Solution

Concept: Dehydration of alcohols to alkenes depends on the stability of the carbocation formed.
Given: Identify alcohol that does not dehydrate easily.
Analysis:

- 2-Methyl-2-butanol: tertiary → easily forms stable carbocation → dehydrates easily
- 1-Butanol: primary → less stable carbocation → difficult
- Cyclohexanol: secondary in ring → moderate
- 3-Pentanol: secondary → moderate

Conclusion: 1-Butanol does not dehydrate easily.
Final Answer: (B)

Answer: (B)

Q6.

Solution

Concept: Tollen's test detects aldehydes but not ketones.
Given: Identify compound that does not give positive Tollen's test.
Analysis:

- CH_3CHO: Aldehyde $\rightarrow$ Positive
- C_6H_5CHO: Aldehyde $\rightarrow$ Positive
- CH_3COCH_3: Ketone $\rightarrow$ Negative
- HCOOH: Aldehyde functional $\rightarrow$ Positive

Conclusion: $\mathbf{CH_3COCH_3}$ does not react.
Final Answer: (C)

Answer: (C)

Q7.

Solution

Concept: Iodoform test detects methyl ketones (CH_3CO-) and ethanol-type structures.
Given: Identify compounds giving positive iodoform test.
Analysis:

- CH_3CHO: Contains CH_3CHO group $\rightarrow$ Positive
- $C_6H_5COCH_3$: Methyl ketone $\rightarrow$ Positive
- CH_3COCH_3: Methyl ketone $\rightarrow$ Positive

Conclusion: All listed compounds give positive iodoform test.
Final Answer: (D)

Answer: (D)

Q8.

Solution

Concept: Basicity of amines depends on availability of lone pair on nitrogen and electron-donating effects of alkyl groups.
Given: Compare amines in aqueous solution.
Analysis:

- CH_3NH_2: Primary → moderately basic
- $(CH_3)_2NH$: Secondary → electron-donating effect increases basicity → Most basic
- $(CH_3)_3N$: Tertiary → steric hindrance, less solvation → Less basic
- $C_6H_5NH_2$: Aromatic → lone pair delocalized → Least basic

Conclusion: **$(CH_3)_2NH$** is most basic.
Final Answer: (B)

Answer: (B)

Q9.

Solution

Concept: Amino acids contain both α-amino and α-carboxylic groups.
Given: Identify the biomolecule with both α-amino and α-carboxylic groups.
Analysis:

- Fatty acids: only carboxylic group → No
- Glucose: hydroxyl groups → No
- Amino acids: contain $-NH_2$ and –COOH on the same carbon → Yes
- Urea: $-NH_2$ and C=O, not on the α-carbon → No

Conclusion: **Amino acids** satisfy the criteria.
Final Answer: (C)

Answer: (C)

Q10.

Solution

Concept: Bond angles in molecules are affected by lone pair–bond pair repulsion and electronegativity differences.
Given: Compare NH_3 and NF_3 bond angles.
Analysis:

- NH_3: Lone pair repulsion pushes H–N–H bond angle → 107.8° (approx.)
- NF_3: Lone pair repulsion similar but F is more electronegative → bond angles slightly smaller (102°)

Conclusion: Bond angles differ due to **different lone pair–bond pair repulsion and electronegativity of substituents**.
Final Answer: (B)

Answer: (B)

Q11.

Solution

Concept: Hybridization of central atom depends on number of sigma bonds and lone pairs.
Given: Identify molecule with sp^2 hybridization at central atom.
Analysis:

- CH_4: sp^3 → No
- BF_3: 3 sigma bonds, no lone pair → sp^2 → Yes
- NH_3: sp^3 → No
- H_2O: sp^3 → No

Conclusion: **BF_3** has sp^2 hybridization.
Final Answer: (B)

Answer: (B)

Q12.

Solution

Concept: Dipole moment depends on molecular geometry and electronegativity differences.
Given: Compare CO_2, SO_2, and H_2O.
Analysis:

- CO_2: Linear → dipoles cancel → 0
- SO_2: Bent → dipoles partially cancel → moderate
- H_2O: Bent, highly electronegative O → maximum dipole moment

Conclusion: **H_2O** has highest dipole moment.
Final Answer: (C)

Answer: (C)

Q13.

Solution

Concept: Oxidation state of metal in coordination complex: use charge balance.
Given: $[Co(NH_3)_5Cl]^{2+}$
Solution:

$$x + (5 \times 0) + (-1) = +2 \implies x - 1 = 2 \implies x = +3$$

Conclusion: Oxidation state of Co is +3.
Final Answer: (C)

Answer: (C)

Q14.

Solution

Concept: Ionic complexes are those with counter ions outside coordination sphere.
Given: Identify ionic complex.
Analysis:

$Co(NH_3)_6$ Cl_3: 3 Cl^- outside → ionic → Yes

$Cr(H_2O)_6$ Cl_3: 3 Cl^- outside → ionic → Yes

- $K_3[Fe(CN)_6]$: 3 K^+ outside → ionic → Yes

Conclusion: All listed complexes are ionic.
Final Answer: (D)

Answer: (D)

Q15.

Solution

Concept: Strongest oxidizing agents are halogens; electronegativity and bond energy matter.
Given: Compare F_2, Cl_2, Br_2, I_2.
Analysis:

- F_2: Most electronegative, weakest F–F bond → strongest oxidizer
- Cl_2: Less than F_2
- Br_2: Weaker oxidizer
- I_2: Weakest oxidizer

Conclusion: $\mathbf{F_2}$ is strongest oxidizing agent.
Final Answer: (A)

Answer: (A)

Q16.

Solution

Concept: Group 1 elements (alkali metals) exhibit +1 oxidation state exclusively.
Given: Li, Na, K → Compare oxidation states.
Conclusion: All have +1 oxidation state.
Final Answer: (D)

Answer: (D)

Q17.

Solution

Concept: Ionic radius decreases across the lanthanide series due to lanthanide contraction.
Given: La, Ce, Lu, Nd → Compare ionic radii.
Conclusion: **Lu** has the smallest ionic radius.
Final Answer: (C)

Answer: (C)

Q18.

Solution

Concept: Molar conductivity: $\Lambda_m = \frac{\kappa \times 1000}{C}$
Given: Conductance $\kappa = 0.001\,\text{S}$, $C = 0.01\,\text{M}$
Solution:

$$\Lambda_m = \frac{0.001 \times 1000}{0.01} = 100\ \text{S} \cdot \text{cm}^2/\text{mol}$$

Conclusion: Molar conductivity $= 100\ \text{S} \cdot \text{cm}^2/\text{mol}$
Final Answer: (C)

Answer: (C)

Q19.

Solution

Concept: Arrhenius equation: $k = Ae^{-E_a/RT}$, doubling rate $\rightarrow$ calculate activation energy.
Given: Rate doubles when T increases 10 K (300→310 K)
Solution: Using approximate formula:

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

$$\ln 2 = \frac{E_a}{8.314}\left(\frac{1}{300} - \frac{1}{310}\right)$$

$$E_a \approx 55\ \text{kJ/mol (approx.)}$$

Final Answer: (C)

Answer: (C)

Q20.

Solution

Concept: Number of unpaired electrons determined from electronic configuration.
Given: Cr^{3+} (Z=24) $\rightarrow$ [Ar] $3d^3$
Analysis: 3 unpaired electrons in d-orbitals
Conclusion: Number of unpaired electrons = 3
Final Answer: (B)

Answer: (B)

Q21.

Solution

Concept: Mole fraction of a component in a gas mixture:

$$x_i = \frac{n_i}{n_{\text{total}}}$$

Given: Mass = 5 g, mixture H_2 + O_2, Volume = 2.5 L, Pressure = 10 atm, T = 300 K
Solution:

- Use ideal gas law: $PV = n_{\text{total}}RT$
- Total moles:
$$n_{\text{total}} = \frac{PV}{RT} = \frac{10 \times 2.5}{0.0821 \times 300} \approx 1.01 \text{ mol}$$
- Let moles $H_2 = n_1$, $O_2 = n_2 \Rightarrow n_1 + n_2 = 1.01$
- Mass relation: $2n_1 + 32n_2 = 5$
- Solve equations:

$$2n_1 + 32(1.01 - n_1) = 5 \implies 2n_1 + 32.32 - 32n_1 = 5$$

$$-30n_1 = -27.32 \implies n_1 \approx 0.911 \text{ mol}$$

- Mole fraction of H_2:
$$x_{H2} = \frac{0.911}{1.01} \approx 0.902$$

Final Answer: 0.902

Answer: (0.902)

Q22.

Solution

Concept: Molar conductivity:

$$\Lambda_m = \frac{\kappa \times 1000}{C}$$

Given: $\kappa = 0.014\,\text{S/m}$, $C = 0.01\,\text{M}$
Solution:

$$\Lambda_m = \frac{0.014 \times 1000}{0.01} = 1400\,\text{S} \cdot \text{cm}^2/\text{mol}$$

Conclusion: Molar conductivity = 1400 $\text{S} \cdot \text{cm}^2/\text{mol}$
Final Answer: 1400 $\text{S} \cdot \text{cm}^2/\text{mol}$

Answer: (1400)

Q23.

Solution

Concept: pH of weak acid:

$$\text{pH} = -\log[H^+], \quad [H^+] = \sqrt{K_a C_a}$$

Given: 0.1 M HA, $K_a = 1.0 \times 10^{-4}$

Solution:

$$[H^+] = \sqrt{K_a C_a} = \sqrt{1.0 \times 10^{-4} \times 0.1} = \sqrt{1.0 \times 10^{-5}} = 3.16 \times 10^{-3} \text{ M}$$

$$\text{pH} = -\log(3.16 \times 10^{-3}) \approx 2.5$$

Final Answer: 2.5

Answer: (2.5)

Q24.

Solution

Concept: First-order reaction:

$$t_{90\%} = \frac{\ln 10}{k}, \quad t_{1/2} = \frac{\ln 2}{k}$$

Given: $t_{1/2} = 40$ min

Solution:

$$k = \frac{\ln 2}{t_{1/2}} = \frac{0.693}{40} \approx 0.01733 \text{ min}^{-1}$$

$$t_{90\%} = \frac{\ln 10}{k} = \frac{2.303}{0.01733} \approx 133 \text{ min}$$

Final Answer: 133 min

Answer: (133)

Q25.

Solution

Concept: Titration: $n_{\text{acid}} = n_{\text{base}}$

Given: 0.05 mol CH_3COOH, 0.1 M NaOH

Solution:

$$n_{\text{NaOH}} = n_{\text{CH3COOH}} = 0.05 \text{ mol}$$

$$V = \frac{n}{C} = \frac{0.05}{0.1} = 0.5 \text{ L} = 500 \text{ mL}$$

Final Answer: 500 mL

Answer: (500)

Answer Key — Section A

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

Answer Key — Section B

Q	Ans	Q	Ans
21	0.902	22	1400
23	2.5	24	133
25	500		