UP Board Class 12 Chemistry Question Paper with Solutions

General Instructions

1. The question paper consists of six sections — Section A to Section F.
2. Time allowed is **3 hours 15 minutes** and the maximum marks are **90**.
3. All questions are compulsory unless otherwise stated.
4. Section A contains Multiple Choice Questions (MCQs). Choose the correct answer from the given options.
5. Section B includes:
   - True/False questions
   - Fill in the blanks
   - Very short answer questions (one or two words)
6. Section C contains short answer type questions.
7. Section D contains long descriptive questions with internal choices.
8. Section E contains long answer questions. Attempt the required number as instructed.
9. Section F consists of Map Work. Mark and label the places correctly on the outline map of India.
10. Figures to the right indicate full marks for each question.
11. Write neatly and draw diagrams wherever necessary.
12. Write answers only in the space provided or as instructed.

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1. If the rate law of a reaction is Rate $= K[A]^2[B]^0$, then what will be the order of the reaction?
(i) Zero order
(ii) First order
(iii) Second order
(iv) Third order

Correct Answer: (iii) Second order

Solution:

Step 1: Understanding the Concept:
The order of a reaction is the sum of the powers (exponents) of the concentration terms in the rate law equation.

Step 2: Detailed Explanation:
Given rate law:

$$\text{Rate} = K[A]^2[B]^0$$

Here,
Order with respect to $A = 2$
Order with respect to $B = 0$

Total order of the reaction $= 2 + 0 = 2$

Step 3: Final Answer:
The total order of the reaction is **2**. Hence, it is a **Second order reaction**.

Quick Tip

Any concentration term raised to the power zero equals 1. So, $[B]^0 = 1$ and does not affect the rate of reaction.

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2. For which of the following ions will the magnetic moment (μ) be maximum?
(i) Zn^{2+}
(ii) Fe^{2+}
(iii) Co^{2+}
(iv) Ni^{2+}

Correct Answer: (ii) Fe^{2+}

Solution:

Step 1: Understanding the Concept:
Magnetic moment (μ) depends on the number of unpaired electrons present in the ion.
It is calculated using the spin-only formula:

$$\mu = \sqrt{n(n+2)} \text{ B.M.}$$

where n = number of unpaired electrons.

Step 2: Electronic Configuration and Unpaired Electrons:

Zn^{2+}:
Electronic configuration of Zn $= [Ar]3d^{10}4s^2$
For Zn^{2+}: $[Ar]3d^{10}$
Unpaired electrons $= 0$

Fe^{2+}:
Electronic configuration of Fe $= [Ar]3d^6 4s^2$
For Fe^{2+}: $[Ar]3d^6$

Unpaired electrons = 4

Co^{2+}:
Electronic configuration of Co = $[Ar]3d^7 4s^2$
For Co^{2+}: $[Ar]3d^7$
Unpaired electrons = 3

Ni^{2+}:
Electronic configuration of Ni = $[Ar]3d^8 4s^2$
For Ni^{2+}: $[Ar]3d^8$
Unpaired electrons = 2

Since Fe^{2+} has the maximum number of unpaired electrons (4), it will have the maximum magnetic moment.

Step 3: Final Answer:
The magnetic moment will be maximum for Fe^{2+}.

Quick Tip

Greater the number of unpaired electrons, greater will be the magnetic moment.

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3. The increasing order of reactivity of the following compounds in S_N1 reaction is:
Compounds:
A. $(CH_3)_3CBr$
B. $CH_3CH_2CH_2CH_2Br$
C. $(CH_3)_2CHCH_2Br$
D. $CH_3CH(Br)CH_2CH_3$

(i) $A < B < C < D$
(ii) $B < C < D < A$
(iii) $D < C < B < A$
(iv) $B < D < A < C$

Correct Answer: (ii) $B < C < D < A$

Solution:

Step 1: Understanding the Concept:
In an S_N1 reaction, the rate depends on the stability of the carbocation formed after the leaving group departs.
Greater the stability of the carbocation, greater will be the reactivity.

Carbocation stability order:

$$3^\circ > 2^\circ > 1^\circ$$

Step 2: Classification of Given Compounds:

A. $(CH_3)_3CBr$
Forms a tertiary (3°) carbocation $\rightarrow$ Most stable.

B. $CH_3CH_2CH_2CH_2Br$
Forms a primary (1°) carbocation $\rightarrow$ Least stable.

C. $(CH_3)_2CHCH_2Br$
Also forms a primary (1°) carbocation $\rightarrow$ Slightly more stable than straight chain due to inductive effect, but still primary.

D. $CH_3CH(Br)CH_2CH_3$
Forms a secondary (2°) carbocation $\rightarrow$ More stable than primary.

Thus, increasing order of reactivity in S_N1 reaction:

$$1^\circ < 2^\circ < 3^\circ$$

So,

$$B < C < D < A$$

Step 3: Final Answer:
The correct increasing order of reactivity in S_N1 reaction is $B < C < D < A$.

Quick Tip

S_N1 reactions proceed through carbocation formation. Stability of carbocation determines the reaction rate.

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4. Does the half-life of a first-order reaction depend on the initial concentration of the reaction? Explain.

Correct Answer: No, it does not depend on the initial concentration.

Solution:

Step 1: Rate Constant Equation
For a first-order reaction, the integrated rate equation is:

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

Where:

- $[R]_0$ is the initial concentration.
- $[R]$ is the final concentration at time t.
- k is the rate constant.

Step 2: Half-Life Derivation
At half-life ($t_{1/2}$), the final concentration $[R]$ becomes half of the initial concentration ($[R]_0/2$). Substituting this into the equation:

$$t_{1/2} = \frac{2.303}{k} \log \frac{[R]_0}{[R]_0/2}$$

$$t_{1/2} = \frac{2.303}{k} \log 2$$

Since $\log 2 = 0.3010$:

$$t_{1/2} = \frac{2.303 \times 0.3010}{k}$$

$$t_{1/2} = \frac{0.693}{k}$$

Step 3: Conclusion
The formula $t_{1/2} = \frac{0.693}{k}$ contains only constant values and does not include the initial concentration term ($[R]_0$). Therefore, the half-life of a first-order reaction is independent of the initial concentration.

Quick Tip

Remember the distinction:

- Zero Order: $t_{1/2} \propto [R]_0$ (Directly proportional).
- First Order: $t_{1/2}$ is independent of $[R]_0$.
- Second Order: $t_{1/2} \propto \frac{1}{[R]_0}$ (Inversely proportional).

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5. Write the definition of electrode potential and cell electromotive force (emf).

Solution:

1. Electrode Potential:
When a metal rod is dipped into a solution of its own ions, a potential difference develops at the interface between the metal electrode and the electrolyte (solution). This potential difference is called the Electrode Potential.

- If the metal has a tendency to oxidize (lose electrons), it is Oxidation Potential.
- If metal ions have a tendency to reduce (gain electrons), it is Reduction Potential.

2. Cell Electromotive Force (emf):
The electromotive force (emf) of a cell is the potential difference between the two electrodes of a galvanic cell when no current is drawn from the cell (open circuit). It is the maximum voltage the cell can deliver.

$$E_{cell} = E_{cathode} - E_{anode}$$

Quick Tip

Key difference: Cell Potential is measured when the circuit is closed (current flows), whereas EMF is measured when the circuit is open (no current flows). EMF is always slightly higher than cell potential due to internal resistance.

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6. $[NiCl_4]^{2-}$ is paramagnetic while $[Ni(CO)_4]$ is diamagnetic even though both are tetrahedral. Why?

Solution:

Step 1: Analyze $[NiCl_4]^{2-}$

- **Oxidation State of Ni:** $x + 4(-1) = -2 \Rightarrow x = +2$. So, Ni^{2+}.
- **Configuration:** Ni ($Z = 28$) is $[Ar]3d^8 4s^2$. Ni^{2+} is $[Ar]3d^8$.
- **Ligand Nature:** Cl^- is a weak field ligand (Spectrochemical series). It does not cause pairing of electrons.
- **Orbital Filling:** The $3d^8$ electrons remain arranged as 3 pairs and 2 unpaired electrons according to Hund's rule.
- **Hybridization:** sp^3 (Tetrahedral).
- **Result:** Due to the presence of 2 unpaired electrons, it is Paramagnetic.

Step 2: Analyze $[Ni(CO)_4]$

- **Oxidation State of Ni:** $x + 4(0) = 0 \Rightarrow x = 0$. So, neutral Ni.
- **Configuration:** Ni ($Z = 28$) is $[Ar]3d^8 4s^2$.
- **Ligand Nature:** CO is a strong field ligand. It causes strong repulsion and forces electrons to pair up.
- **Rearrangement:** Under the influence of CO, the two $4s$ electrons are pushed into the $3d$ orbitals to pair up with the unpaired $3d$ electrons. The configuration becomes $3d^{10}4s^0$.
- **Hybridization:** sp^3 (Tetrahedral).
- **Result:** All electrons are paired ($3d^{10}$). Due to the absence of unpaired electrons, it is Diamagnetic.

Quick Tip

Weak Field Ligands (e.g., Cl^-, F^-, H_2O): Usually high spin, no forced pairing.
Strong Field Ligands (e.g., CN^-, CO, NH_3): Usually low spin, forced pairing occurs.

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7. Write the IUPAC nomenclature of the following organic compounds:

(i) $CH_3 - CH_2 - \overset{\overset{O}{\|}}{C} - CH_2 - \underset{\underset{CH_3}{|}}{CH} - CH_3$

(ii) $Ph - CH = CH - CHO$

Solution:

(i) Structure Analysis:

$$\text{Structure:} \quad CH_3 - CH_2 - C(=O) - CH_2 - CH(CH_3)_2$$

- **Longest Chain:** 6 Carbons containing the ketone group.
- **Numbering:** Start from the left to give the Ketone (functional group) the lowest number.
  - C1: CH_3
  - C2: CH_2
  - C3: $C = O$ (Ketone)
  - C4: CH_2
  - C5: CH (with a methyl substituent)
  - C6: CH_3
- **Substituent:** Methyl group at position 5.
- **IUPAC Name: 5-Methylhexan-3-one**

(ii) Structure Analysis:

$$\text{Structure:} \quad C_6H_5 - CH = CH - CHO$$

- **Principal Group:** Aldehyde ($-CHO$). Carbon of CHO is always C1.
- **Chain:** Propene chain.
- C1: CHO
- C2: $CH =$
- C3: $= CH-$ (attached to Phenyl ring)
- **Substituent:** Phenyl group ($Ph-$) at C3.
- **Unsaturation:** Double bond starts at C2.
- **IUPAC Name: 3-Phenylprop-2-enal** (Also commonly known as Cinnamaldehyde).

Quick Tip

Priority Order for Numbering: Functional Group > Double Bond > Triple Bond > Substituents. Always start numbering to give the principal functional group the lowest possible locant.

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8. Write the mechanism of bimolecular nucleophilic substitution reaction (S_N2) of alkyl halide.

Solution:

The S_N2 Mechanism (Substitution Nucleophilic Bimolecular):
This reaction proceeds in a single concerted step (one-step mechanism) without the formation of any intermediate.
Key Features:

1. **Attack of Nucleophile:** The incoming nucleophile (Nu^-) attacks the carbon atom bonded to the halogen (leaving group) from the side opposite to the leaving group (back-side attack).
2. **Transition State:** A transition state is formed where the bond between the carbon and nucleophile starts forming, and the bond between carbon and halogen starts breaking simultaneously. In this state, the carbon atom is partially bonded to five atoms.
3. **Stereochemistry:** The reaction results in the inversion of configuration (Walden inversion), similar to an umbrella turning inside out in a gale.

Mechanism Diagram:

$$\mathrm{Nu^- + C - X \longrightarrow [Nu \ldots C \ldots X]^{\ddagger} \longrightarrow Nu - C + X^-}$$

Example: Reaction of Chloromethane (CH_3Cl) with Hydroxide ion (OH^-).

$$OH^- + CH_3Cl \longrightarrow CH_3OH + Cl^-$$

Quick Tip

Order of Reactivity for S_N2: **Methyl** $> 1^\circ > 2^\circ > 3^\circ$. This is because bulky groups hinder the back-side attack of the nucleophile (Steric Hindrance).

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9. What is a peptide bond? Explain with an example.

Solution:

Definition:
A peptide bond is a chemical bond formed between two amino acid molecules when the carboxyl

group ($-COOH$) of one amino acid reacts with the amino group ($-NH_2$) of another, releasing a molecule of water (H_2O). It is an amide linkage ($-CO-NH-$).
Explanation with Example:
Consider the formation of a dipeptide Glycylalanine (Gly-Ala) from Glycine and Alanine.

- **Glycine:** H_2N-CH_2-COOH
- **Alanine:** $H_2N-CH(CH_3)-COOH$

Reaction:

$$H_2N-CH_2-COOH+H_2N-CH(CH_3)-COOH \xrightarrow{-H_2O} H_2N-CH_2-\mathbf{CO-NH}-CH(CH_3)-COOH$$

Here, the $-\mathbf{CO-NH}-$ linkage connecting the two amino acid residues is the Peptide Bond.

Quick Tip

Proteins are essentially long chains of amino acids linked together by peptide bonds. This is a dehydration synthesis reaction (condensation).

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10. (i) Write the electronic configuration of the element with atomic number 24.
(ii) Find the number of unpaired electrons in Co^{2+} ion.
(iii) Why is the range of oxidation states greater in the actinoid series compared to the lanthanoid series?

Solution:

(i) Element with Z = 24 (Chromium):
Expected Configuration: $[Ar]3d^4 4s^2$
Actual Configuration: $[Ar]3d^5 4s^1$
(Reason: Half-filled d-orbitals provide extra stability).
(ii) Unpaired electrons in Co^{2+}:
Atomic number of Cobalt (Co) = 27. Configuration of Co: $[Ar]3d^7 4s^2$. Configuration of Co^{2+}: $[Ar]3d^7$. Orbital representation of $3d^7$: $\boxed{\uparrow\downarrow}\ \boxed{\uparrow\downarrow}\ \boxed{\uparrow}\ \boxed{\uparrow}\ \boxed{\uparrow}$ Number of unpaired electrons = **3**.
(iii) Oxidation States in Actinoids vs Lanthanoids:
The actinoids show a greater range of oxidation states than lanthanoids because the energy gap between the 5f, 6d, and 7s subshells is very small. This allows electrons from all these subshells to participate in bond formation. In contrast, the 4f orbitals in lanthanoids are buried deep inside and participate less in bonding, limiting their oxidation states primarily to +3.

Quick Tip

Remember the exceptions in electronic configurations for transition metals: Cr (24) and Cu (29) both promote an s-electron to the d-subshell to achieve half-filled (d^5) or fully-filled (d^{10}) stability.

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11. What happens when aniline reacts with the following:
(i) Bromine water
(ii) $(CH_3CO)_2O$ **/ Pyridine**
(iii) $HNO_2 + HCl(0^\circ - 5^\circ C)$

Solution:

(i) Reaction with Bromine water:
Aniline reacts with bromine water at room temperature to give a white precipitate of 2,4,6-Tribromoaniline. The amino group strongly activates the benzene ring, leading to poly-substitution.

$$C_6H_5NH_2 + 3Br_2(aq) \longrightarrow 2,4,6\text{-Tribromoaniline} + 3HBr$$

(ii) Reaction with Acetic Anhydride/Pyridine (Acetylation):
Aniline undergoes acetylation to form Acetanilide (N-phenylethanamide). This reaction protects the amino group and decreases the activating power of the $-NH_2$ group.

$$C_6H_5NH_2 + (CH_3CO)_2O \xrightarrow{\text{Pyridine}} C_6H_5NHCOCH_3 + CH_3COOH$$

(iii) Reaction with $HNO_2 + HCl$ **(Diazotization):**
Aniline reacts with nitrous acid (HNO_2, generated in situ from $NaNO_2 + HCl$) at low temperature ($0 - 5^\circ C$ or 273-278 K) to form Benzene diazonium chloride.

$$C_6H_5NH_2 + NaNO_2 + 2HCl \xrightarrow{0-5^\circ C} C_6H_5N_2^+Cl^- + NaCl + 2H_2O$$

Quick Tip

To get a monobromo derivative of aniline, you must first protect the $-NH_2$ group by acetylation (reaction ii), then brominate, and finally hydrolyze. Direct bromination always yields the tribromo product.

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12. Write the structures of (A), (B), and (C) in the following reaction:
Reaction Scheme:

$$(C) \xleftarrow{\text{conc. } HNO_3} \text{Phenol} \xrightarrow{\text{dil. } HNO_3} (A) + (B)$$

Solution:

Analysis of the Reaction:
This question deals with the Nitration of Phenol. The product depends on the concentration of the acid used.

1. **Reaction with Dilute** HNO_3**:**
   When phenol is treated with dilute nitric acid at low temperature (298 K), it undergoes mono-nitration to yield a mixture of ortho- and para- isomers.
   - **(A) o-Nitrophenol:** The $-NO_2$ group attaches at the ortho position (adjacent to $-OH$).

- **(B) p-Nitrophenol:** The $-NO_2$ group attaches at the para position (opposite to $-OH$).

2. **Reaction with Concentrated HNO_3:**
   With concentrated nitric acid, the reaction is vigorous, and poly-nitration occurs at all activating positions (ortho and para).

   - **(C) 2,4,6-Trinitrophenol:** Commonly known as **Picric Acid**.

Structures:

- **(A):** o-Nitrophenol ($C_6H_4(OH)(NO_2)$ - ortho isomer)
- **(B):** p-Nitrophenol ($C_6H_4(OH)(NO_2)$ - para isomer)
- **(C):** 2,4,6-Trinitrophenol (Picric Acid)

Quick Tip

Distinction: o-Nitrophenol is steam volatile due to intramolecular hydrogen bonding (chelation), whereas p-Nitrophenol is less volatile due to intermolecular hydrogen bonding (association). They can be separated by steam distillation.

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13. Write the structures of (A), (B), and (C) in the following reaction:

$$C_6H_5NO_2 \xrightarrow{Fe/HCl} (A) \xrightarrow[273\text{ K}]{NaNO_2+HCl} (B) \xrightarrow[\Delta]{H_2O/H^+} (C)$$

Solution:

Step-by-Step Analysis:
Step 1: Reduction of Nitrobenzene
Reactant: Nitrobenzene ($C_6H_5NO_2$)
Reagent: Fe/HCl (Acidic reduction)
Reaction: Nitro group ($-NO_2$) is reduced to Amino group ($-NH_2$).
Structure (A): Aniline ($C_6H_5NH_2$)
Step 2: Diazotization
Reactant: Aniline (A)
Reagent: $NaNO_2 + HCl$ at $0 - 5°C$ (273 K)
Reaction: The primary aromatic amine reacts with nitrous acid to form a diazonium salt.
Structure (B): Benzene Diazonium Chloride ($C_6H_5N_2^+Cl^-$)
Step 3: Hydrolysis
Reactant: Benzene Diazonium Chloride (B)
Reagent: H_2O/H^+ with heat (Δ)
Reaction: The diazonium group ($-N_2^+Cl^-$) is an excellent leaving group and is replaced by the hydroxyl group ($-OH$) upon warming with water. N_2 gas is evolved.
Structure (C): Phenol (C_6H_5OH)
Summary of Structures:

- **(A):** Aniline
- **(B):** Benzene Diazonium Chloride
- **(C):** Phenol

Quick Tip

Temperature control is crucial in Step 2. If the temperature rises above $5°C$, the diazonium salt becomes unstable and hydrolyzes directly to Phenol, evolving Nitrogen gas.
