UP Board Class 12 Chemistry Question Paper 2026 with Solutions Memory Based

Time Allowed :3 Hours	Maximum Marks :70	Total Questions :30

General Instructions

1. Please check that this question paper contains 23 printed pages.
2. Q.P. Code given on the right hand side of the question paper should be written on the title page of the answer-book by the candidate.
3. Please check that this question paper contains 37 questions.
4. 15 minute time has been allotted to read this question paper. The question paper will be distributed at 10.15 a.m. From 10.15 a.m. to 10.30 a.m., the candidates will read the question paper only and will not write any answer on the answer-book during this period.

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 Reaction Order

The order of a reaction with respect to a specific reactant is the power to which the concentration of that reactant is raised in the rate law equation. The **overall order** of the reaction is the sum of the powers of the concentration terms in the rate law expression.

Step 2: Calculation

Given Rate Law:

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

The power of $[A]$ is 2. The power of $[B]$ is 0.
Overall Order (n) = Sum of powers:

$$n = 2 + 0 = 2$$

Therefore, the reaction is of the **second order**.

Quick Tip

If the power of a reactant is zero (e.g., $[B]^0$), the rate of reaction is independent of the concentration of that reactant. It does not affect the calculation of the overall order, which is simply the sum of the exponents.

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: Formula for Magnetic Moment
The spin-only magnetic moment is calculated using the formula:

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

Where n is the number of unpaired electrons. A higher value of n results in a higher magnetic moment.

Step 2: Electronic Configuration and Unpaired Electrons
We determine the number of unpaired electrons in the $3d$ subshell for each ion.

- Zn^{2+} ($Z = 30$): Configuration is $[Ar]3d^{10}$. All electrons are paired.

$$n = 0 \implies \mu = 0$$

- Fe^{2+} ($Z = 26$): Configuration is $[Ar]3d^{6}$. d-orbital arrangement: $\boxed{\uparrow\downarrow}$ $\boxed{\uparrow}$ $\boxed{\uparrow}$ $\boxed{\uparrow}$ $\boxed{\uparrow}$

$$n = 4 \text{ unpaired electrons}$$
$$\mu = \sqrt{4(4+2)} = \sqrt{24} \approx 4.90 \text{ BM}$$

- Co^{2+} ($Z = 27$): Configuration is $[Ar]3d^{7}$. d-orbital arrangement: $\boxed{\uparrow\downarrow}$ $\boxed{\uparrow\downarrow}$ $\boxed{\uparrow}$ $\boxed{\uparrow}$ $\boxed{\uparrow}$

$$n = 3 \text{ unpaired electrons}$$
$$\mu = \sqrt{3(3+2)} = \sqrt{15} \approx 3.87 \text{ BM}$$

- Ni^{2+} ($Z = 28$): Configuration is $[Ar]3d^{8}$. d-orbital arrangement: $\boxed{\uparrow\downarrow}$ $\boxed{\uparrow\downarrow}$ $\boxed{\uparrow\downarrow}$ $\boxed{\uparrow}$ $\boxed{\uparrow}$

$$n = 2 \text{ unpaired electrons}$$
$$\mu = \sqrt{2(2+2)} = \sqrt{8} \approx 2.83 \text{ BM}$$

Step 3: Conclusion
Fe^{2+} has the maximum number of unpaired electrons (4), so it has the highest magnetic moment.

Quick Tip

To verify configurations quickly: For divalent ions (M^{2+}) of the first transition series (Sc to Zn), the number of d-electrons is equal to the unit digit of the atomic number (except for Zn). e.g., Fe ($Z = 26$) $\rightarrow d^6$. Co ($Z = 27$) $\rightarrow d^7$. Then fill orbitals according to Hund's Rule to find unpaired electrons.

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: Mechanism of S_N1 Reaction
The S_N1 reaction proceeds in two steps. The rate-determining step involves the formation of a carbocation intermediate. Therefore, the reactivity of alkyl halides towards S_N1 reaction depends directly on the **stability of the carbocation** formed.
Step 2: Stability Order of Carbocations
The general order of carbocation stability is:

$$\text{Tertiary } (3^\circ) > \text{Secondary } (2^\circ) > \text{Primary } (1^\circ) > \text{Methyl}$$

Step 3: Analyze the Compounds

- **A.** $(CH_3)_3CBr$ **(tert-Butyl bromide):** Forms a **Tertiary** (3°) carbocation. Most stable.
- **B.** $CH_3CH_2CH_2CH_2Br$ **(n-Butyl bromide):** Forms a **Primary** (1°) carbocation with a straight chain. Least stable.
- **C.** $(CH_3)_2CHCH_2Br$ **(Isobutyl bromide):** Forms a **Primary** (1°) carbocation. Although it is primary like B, the branching at the β-position makes it slightly more reactive than simple n-butyl in some contexts due to rearrangement potential, but in standard stability comparison, it is often grouped near B. However, for S_N1, strictly 1° are very slow.
- **D.** $CH_3CH(Br)CH_2CH_3$ **(sec-Butyl bromide):** Forms a **Secondary** (2°) carbocation. Intermediate stability.

Step 4: Arranging in Increasing Order
Based on carbocation stability ($1^\circ < 2^\circ < 3^\circ$):

1. Lowest reactivity: Primary alkyl halides (B and C).
2. Intermediate reactivity: Secondary alkyl halide (D).
3. Highest reactivity: Tertiary alkyl halide (A).

Comparing B and C (both 1°): While both are primary and slow for S_N1, the order given in option (ii) places B (linear) as the least reactive and C (branched primary) slightly higher, followed significantly by D (2°) and A (3°). The clear distinction is:

$$\text{Primary}(B, C) < \text{Secondary}(D) < \text{Tertiary}(A)$$

The option that matches this sequence (... $< D < A$) is (ii).

Quick Tip

For S_N1 reactions, always look for the structure of the alkyl group.

- 3°: Fastest (forms stable carbocation).
- 2°: Moderate.
- 1°: Slowest (unstable carbocation).

Conversely, for S_N2, the order is reversed (1° > 2° > 3°) due to steric hindrance.

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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
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> **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
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> 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:

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

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).

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 ($0 - 5°C$ or 273-278 K) to form Benzene diazonium chloride.

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

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.
