

CUET 2026 May 19 Shift 1 Chemistry

Question Paper (Memory-Based) with Solutions

Conducted by National Testing Agency (NTA)



General Instructions

- (i) The examination will be conducted in Computer-Based Test (CBT) mode.
- (ii) Each question carries +5 marks for correct answer and -1 mark for wrong answer.
- (iii) The total number of questions are 50.
- (iv) Duration of the exam is 1 hour (60 minutes).

1. For a first-order reaction, if the time taken for 90% completion is t , what will be the approximate time taken for 99.9% completion of the same reaction?

- (A) $2t$
- (B) $3t$
- (C) $4t$
- (D) $1.5t$

Correct Answer: (B) $3t$

Solution:

Concept: For a first-order kinetic process, the integrated rate equation is defined as:

$$k = \frac{2.303}{t} \log \left(\frac{[A]_0}{[A]_t} \right)$$

Where $[A]_0$ is the initial concentration and $[A]_t$ is the remaining reactant concentration at time t .

Step 1: Expressing time for 90% completion ($t_{90\%}$).

When the reaction is 90% complete, the remaining concentration is $[A]_t = [A]_0 - 0.90[A]_0 = 0.10[A]_0$.

$$t = \frac{2.303}{k} \log \left(\frac{[A]_0}{0.10[A]_0} \right) = \frac{2.303}{k} \log(10) = \frac{2.303}{k} \dots (1)$$

Step 2: Expressing time for 99.9% completion ($t_{99.9\%}$).

When the reaction is 99.9% complete, the remaining concentration is $[A]_t = [A]_0 - 0.999[A]_0 = 0.001[A]_0 = 10^{-3}[A]_0$.

$$t_{99.9\%} = \frac{2.303}{k} \log\left(\frac{[A]_0}{10^{-3}[A]_0}\right) = \frac{2.303}{k} \log(10^3) = 3 \times \frac{2.303}{k} \quad \dots(2)$$

Substituting equation (1) into equation (2) directly yields $t_{99.9\%} = 3t$.

Quick Tip: For first-order kinetics, logarithmic ratios simplify to highly structured scaling constants:

$$t_{99.9\%} = 3 \times t_{90\%} \text{ and } t_{99\%} = 2 \times t_{90\%}.$$

2. According to collision theory, increasing the starting concentration of a collection of reacting molecules directly results in a change in which of the following system factors?

- (A) Activation energy
- (B) Collision frequency
- (C) Rate constant
- (D) Fraction of molecules with energy greater than activation energy

Correct Answer: (B) Collision frequency

Solution:

Concept: Collision theory models reaction rates based on effective interactions between molecules per unit volume per second, mathematically formulated as:

$$\text{Rate} = Z_{AB} \cdot e^{-\frac{E_a}{RT}}$$

Where Z_{AB} is the collision frequency factor.

Step 1: Analyzing the effect of crowded molecular environments.

Increasing reactant concentration places more molecules inside the same spatial boundaries. This physical crowding directly maximizes structural encounters, leading to a major increase in the collision frequency (Z_{AB}). Factors like activation energy (E_a) and the energetic fraction depend exclusively on temperature and catalysts.

Quick Tip: Concentration adjustments physically manipulate the **collision frequency** (Z). Changing the temperature adjusts both the **rate constant** (k) and the **fraction of high-energy molecules**.

3. What is the cell potential (E_{cell}) for a concentration cell consisting of two hydrogen electrodes at 298 K, where the anode compartment is at $\text{pH} = 3$ and the cathode compartment is at $\text{pH} = 1$ under standard pressure conditions?

- (A) 0.0591 V
- (B) 0.1182 V
- (C) -0.1182 V
- (D) 0.0000 V

Correct Answer: (B) 0.1182 V

Solution:

Concept: For identical chemical electrodes forming a concentration cell, $E_{\text{cell}}^{\circ} = 0$ V. The overall potential is generated by concentration gradients according to the Nernst Equation:

$$E_{\text{cell}} = -\frac{0.0591}{n} \log \left(\frac{[\text{H}^+]_{\text{anode}}}{[\text{H}^+]_{\text{cathode}}} \right)$$

Step 1: Convert pH indices to active ion molarity.

Using the standard relationship $\text{pH} = -\log[\text{H}^+]$:

$$[\text{H}^+]_{\text{anode}} = 10^{-3} \text{ M}, \quad [\text{H}^+]_{\text{cathode}} = 10^{-1} \text{ M}$$

Step 2: Calculate potential with single-electron transfer ($n = 1$).

$$E_{\text{cell}} = -\frac{0.0591}{1} \log \left(\frac{10^{-3}}{10^{-1}} \right) = -0.0591 \log(10^{-2})$$

$$E_{\text{cell}} = -0.0591 \times (-2) = 0.1182 \text{ V}$$

Quick Tip: For symmetrical hydrogen ion concentration cells at 298 K, you can use this simple shortcut:

$$E_{\text{cell}} = 0.0591 \times (\text{pH}_{\text{anode}} - \text{pH}_{\text{cathode}}).$$

4. Which of the following expressions correctly relates the limiting molar conductivity (Λ_m°)

of aluminum sulfate, $\text{Al}_2(\text{SO}_4)_3$, to its individual ionic components according to Kohlrausch's Law?

- (A) $\Lambda_m^\circ = \lambda^\circ(\text{Al}^{3+}) + \lambda^\circ(\text{SO}_4^{2-})$
(B) $\Lambda_m^\circ = 2\lambda^\circ(\text{Al}^{3+}) + 3\lambda^\circ(\text{SO}_4^{2-})$
(C) $\Lambda_m^\circ = 3\lambda^\circ(\text{Al}^{3+}) + 2\lambda^\circ(\text{SO}_4^{2-})$
(D) $\Lambda_m^\circ = \frac{1}{2}\lambda^\circ(\text{Al}^{3+}) + \frac{1}{3}\lambda^\circ(\text{SO}_4^{2-})$

Correct Answer: (B) $\Lambda_m^\circ = 2\lambda^\circ(\text{Al}^{3+}) + 3\lambda^\circ(\text{SO}_4^{2-})$

Solution:

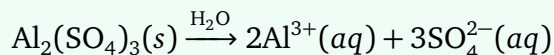
Concept: Kohlrausch's law of independent migration of ions states that the total limiting molar conductivity of an electrolyte equals the sum of the individual contributions from its cations and anions:

$$\Lambda_m^\circ = \nu_+ \lambda_+^\circ + \nu_- \lambda_-^\circ$$

Where ν_+ and ν_- denote the stoichiometric coefficients of the positive and negative ions.

Step 1: Analyze the complete dissociation process.

One formula unit of aluminum sulfate dissociates completely in water according to this equilibrium:



Here, $\nu_+ = 2$ and $\nu_- = 3$. Substituting these values yields:

$$\Lambda_m^\circ = 2\lambda^\circ(\text{Al}^{3+}) + 3\lambda^\circ(\text{SO}_4^{2-})$$

Quick Tip: Always scale the individual ionic values by the balance coefficients for **molar** conductivity. For **equivalent** conductivity, these stoichiometric coefficients are normalized.

5. What is the correct increasing order of basic strength for the following amines when measured inside an aqueous medium?

(I) CH_3NH_2 , (II) $(\text{CH}_3)_2\text{NH}$, (III) $(\text{CH}_3)_3\text{N}$, (IV) NH_3

- (A) $\text{IV} < \text{III} < \text{I} < \text{II}$
(B) $\text{IV} < \text{I} < \text{II} < \text{III}$
(C) $\text{III} < \text{I} < \text{II} < \text{IV}$

(D) I < II < III < IV

Correct Answer: (A) IV < III < I < II

Solution:

Concept: In an aqueous medium, the basicity of aliphatic amines depends on three competing structural factors: inductive electron donation (+I), steric hindrance, and hydration stabilization of the resulting conjugate cation via hydrogen bonding.

Step 1: Evaluate the combined trends for methyl-substituted amines.

- **Inductive effect trend:** Secondary > Tertiary > Primary ($2^\circ > 3^\circ > 1^\circ$).
- **Hydration energy trend:** Primary > Secondary > Tertiary ($1^\circ > 2^\circ > 3^\circ$).

Combining these factors creates an energy balance, giving an absolute basicity sequence of $2^\circ > 1^\circ > 3^\circ > \text{NH}_3$. Arranging these from lowest to highest yields: $\text{NH}_3 < (\text{CH}_3)_3\text{N} < \text{CH}_3\text{NH}_2 < (\text{CH}_3)_2\text{NH}$. This matches sequence IV < III < I < II.

Quick Tip: Remember these structural trends for aqueous amines to save time: For **Methyl** groups, use sequence **213** ($2^\circ > 1^\circ > 3^\circ$). For **Ethyl** groups, use sequence **231** ($2^\circ > 3^\circ > 1^\circ$).

6. An organic compound with the molecular formula $\text{C}_7\text{H}_8\text{O}$ is completely insoluble in water but dissolves readily in an aqueous NaOH solution. When treated with bromine water, it forms a white precipitate. Identify the compound.

- (A) Benzyl alcohol
- (B) Anisole
- (C) *o*-Cresol
- (D) Methoxybenzene

Correct Answer: (C) *o*-Cresol

Solution:

Concept: We can determine structural properties based on characteristic solubility trends:

- Phenols are acidic enough to react with strong bases like NaOH, forming water-soluble sodium phenoxide salts. Alcohols and ethers do not react.

- The strongly activating hydroxyl group on the ring drives extremely rapid electrophilic substitution reactions.

Step 1: Narrow down functional classes based on basic solubility.

The formula C_7H_8O matches structural isomers like benzyl alcohol, anisole, and cresols. Because this compound reacts and dissolves in NaOH, it must be a phenol variant (*o*-cresol).

Step 2: Verify electrophilic addition behavior.

Treating *o*-cresol with bromine water causes rapid ring bromination at available ortho and para positions, generating a characteristic halogenated white precipitate.

Quick Tip: Organic molecules that dissolve cleanly in aqueous NaOH but fail to react or evolve gas in weaker $NaHCO_3$ contain a **phenolic hydroxyl group**.

7. Which of the following coordination complex ions exhibits structural asymmetry leading to optical isomerism?

- (A) $trans - [Co(en)_2Cl_2]^+$
(B) $cis - [Co(en)_2Cl_2]^+$
(C) $[Co(NH_3)_4Cl_2]^+$
(D) $[Cr(NH_3)_5Cl]^{2+}$

Correct Answer: (B) $cis - [Co(en)_2Cl_2]^+$

Solution:

Concept: A coordination complex displays optical activity if it forms non-superimposable mirror images. This structural condition requires the compound to lack an internal plane of symmetry (σ) and a center of inversion (i).

Step 1: Evaluate internal geometric symmetry elements.

The $trans - [Co(en)_2Cl_2]^+$ configuration distributes its ligands directly opposite each other across a central inversion plane, making it symmetrical and optically inactive.

In the $cis - [Co(en)_2Cl_2]^+$ isomer, the bidentate ethylenediamine ligands are placed adjacent to each other. This geometry removes all internal symmetry planes, resulting in a chiral core that forms stable *d*- and *l*- mirror image pairs.

Quick Tip: Octahedral metal configurations of the general type $[M(AA)_2X_2]$ with bidentate chelating rings display optical activity exclusively in their **cis** arrangements.

8. Using Crystal Field Theory (CFT), what is the correct electronic configuration and magnetic behavior of the high-spin complex $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$?

- (A) $t_{2g}^4 e_g^2$, Paramagnetic
- (B) $t_{2g}^6 e_g^0$, Diamagnetic
- (C) $t_{2g}^3 e_g^3$, Paramagnetic
- (D) $t_{2g}^5 e_g^1$, Paramagnetic

Correct Answer: (A) $t_{2g}^4 e_g^2$, Paramagnetic

Solution:

Concept: In an octahedral coordination field, d -orbitals split into lower energy t_{2g} and higher energy e_g levels. Weak-field ligands have a splitting energy smaller than the pairing energy ($\Delta_o < P$), which creates a high-spin configuration.

Step 1: Find the oxidation state and valence electrons.

Water is a neutral ligand, meaning Fe has an oxidation state of +2. The electron configuration of an Fe^{2+} ion is $[\text{Ar}]3d^6$.

Step 2: Distribute electrons based on weak-field rules.

Because H_2O is a weak-field ligand, electrons fill all five orbital sub-levels singly before any pairing occurs:

- Place the first 3 electrons singly in the lower tier: t_{2g}^3
- Place the next 2 electrons singly in the upper tier: e_g^2
- Place the final 6th electron in the lower tier to pair up: $t_{2g}^4 e_g^2$

This arrangement results in 4 unpaired electrons, making the complex paramagnetic.

Quick Tip: For d^4 through d^7 metals, look at the ligand field strength: Weak-field ligands keep systems in a high-spin state ($\Delta_o < P$), while strong-field ligands force low-spin configurations ($\Delta_o > P$).

9. Which of the following alkyl halides will undergo the fastest rate of nucleophilic substitution

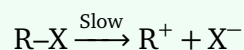
via an S_N1 mechanism when treated with an aqueous nucleophile?

- (A) CH_3Cl
- (B) $(\text{CH}_3)_3\text{CCl}$
- (C) $\text{CH}_3\text{CH}_2\text{Cl}$
- (D) $(\text{CH}_3)_2\text{CHCl}$

Correct Answer: (B) $(\text{CH}_3)_3\text{CCl}$

Solution:

Concept: The rate-determining step of an S_N1 substitution mechanism is the unimolecular dissociation of the leaving group to form a carbocation intermediate:



The overall reaction rate depends directly on the stability of this intermediate carbocation.

Step 1: Evaluate intermediate carbocation stability trends.

Comparing the carbocations formed when the leaving groups dissociate:

- $\text{CH}_3\text{Cl} \rightarrow \text{CH}_3^+$ (Methyl carbocation, highly unstable)
- $\text{CH}_3\text{CH}_2\text{Cl} \rightarrow \text{CH}_3\text{CH}_2^+$ (1° Primary carbocation)
- $(\text{CH}_3)_2\text{CHCl} \rightarrow (\text{CH}_3)_2\text{CH}^+$ (2° Secondary carbocation)
- $(\text{CH}_3)_3\text{CCl} \rightarrow (\text{CH}_3)_3\text{C}^+$ (3° Tertiary carbocation, stabilized by 9 hyperconjugative α -hydrogens)

The tertiary halide dissociates fastest because it forms the most stable intermediate carbocation.

Quick Tip: Carbocation stability and S_N1 reaction rates follow the exact same structural trend: Tertiary (3°) > Secondary (2°) > Primary (1°) > Methyl.

10. When phenol is treated with chloroform (CHCl_3) in the presence of an aqueous sodium hydroxide solution followed by acidification, a prominent aromatic aldehyde is generated. What is the name of this organic reaction?

- (A) Kolbe's Reaction
- (B) Reimer-Tiemann Reaction

- (C) Rosenmund Reduction
(D) Friedel-Crafts Acylation

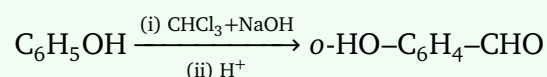
Correct Answer: (B) Reimer-Tiemann Reaction

Solution:

Concept: Treating phenol with chloroform in an alkaline medium introduces a formyl functional group ($-\text{CHO}$) ortho to the hydroxyl group. This transformation proceeds via a highly reactive dichlorocarbene ($:\text{CCl}_2$) electrophilic intermediate.

Step 1: Trace the reaction mechanism steps.

Phenol reacts with NaOH and CHCl_3 to produce an intermediate benzal chloride derivative on the ring. Subsequent alkaline hydrolysis and acidification yield 2-hydroxybenzaldehyde, commonly known as salicylaldehyde.



This classic synthetic transformation is named the Reimer-Tiemann reaction.

Quick Tip: Use the reagents to easily distinguish between these similar reactions of phenol: Phenol + $\text{CHCl}_3/\text{NaOH} \rightarrow$ **Salicylaldehyde** (Reimer-Tiemann). Phenol + $\text{CO}_2/\text{NaOH} \rightarrow$ **Salicylic Acid** (Kolbe's).