CUET 2026 May 19 Shift 1 Chemisty

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 $[A]_t = [A]_0 - 0.90[A]_0 = 0.10[A]_0$.

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

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

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

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

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

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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**.

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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 pH $= 3$ and the cathode compartment is at 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, $E^\circ_{\text{cell}} = 0$ 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: $E_{\text{cell}} = 0.0591 \times (\text{pH}_{\text{anode}} - \text{pH}_{\text{cathode}})$.

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

of aluminum sulfate, $Al_2(SO_4)_3$, to its individual ionic components according to Kohlrausch's Law?

(A) $\Lambda^\circ_m = \lambda^\circ(Al^{3+}) + \lambda^\circ(SO_4^{2-})$

(B) $\Lambda^\circ_m = 2\lambda^\circ(Al^{3+}) + 3\lambda^\circ(SO_4^{2-})$

(C) $\Lambda^\circ_m = 3\lambda^\circ(Al^{3+}) + 2\lambda^\circ(SO_4^{2-})$

(D) $\Lambda^\circ_m = \frac{1}{2}\lambda^\circ(Al^{3+}) + \frac{1}{3}\lambda^\circ(SO_4^{2-})$

Correct Answer: (B) $\Lambda^\circ_m = 2\lambda^\circ(Al^{3+}) + 3\lambda^\circ(SO_4^{2-})$

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:

$$\Lambda^\circ_m = \nu_+\lambda^\circ_+ + \nu\_\lambda^\circ\_$$

Where ν_+ and $\nu\_$ 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:

$$Al_2(SO_4)_3(s) \xrightarrow{H_2O} 2Al^{3+}(aq) + 3SO_4^{2-}(aq)$$

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

$$\Lambda^\circ_m = 2\lambda^\circ(Al^{3+}) + 3\lambda^\circ(SO_4^{2-})$$

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

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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) $(CH_3)_2NH$, (III) $(CH_3)_3N$, (IV) NH_3

(A) IV < III < I < II

(B) IV < I < II < III

(C) III < I < II < 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 $2^\circ > 1^\circ > 3^\circ > NH_3$. Arranging these from lowest to highest yields: $NH_3 < (CH_3)_3N < CH_3NH_2 < (CH_3)_2NH$. 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** ($2^\circ > 3^\circ > 1^\circ$).

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6. An organic compound with the molecular formula C_7H_8O 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**.

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

(A) $\text{trans}-[\text{Co(en)}_2\text{Cl}_2]^+$

(B) $\text{cis}-[\text{Co(en)}_2\text{Cl}_2]^+$

(C) $[\text{Co(NH}_3)_4\text{Cl}_2]^+$

(D) $[\text{Cr(NH}_3)_5\text{Cl}]^{2+}$

Correct Answer: (B) $\text{cis}-[\text{Co(en)}_2\text{Cl}_2]^+$

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 $\text{trans}-[\text{Co(en)}_2\text{Cl}_2]^+$ configuration distributes its ligands directly opposite each other across a central inversion plane, making it symmetrical and optically inactive.

In the $\text{cis}-[\text{Co(en)}_2\text{Cl}_2]^+$ 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**.

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8. Using Crystal Field Theory (CFT), what is the correct electronic configuration and magnetic behavior of the high-spin complex $[Fe(H_2O)_6]^{2+}$?

(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 $[Ar]3d^6$.

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 ($\Delta_o > P$).

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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) $(CH_3)_3CCl$

(C) CH_3CH_2Cl

(D) $(CH_3)_2CHCl$

Correct Answer: (B) $(CH_3)_3CCl$

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:

$$R\text{–}X \xrightarrow{\text{Slow}} R^+ + X^-$$

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:

- $CH_3Cl \rightarrow CH_3^+$ (Methyl carbocation, highly unstable)
- $CH_3CH_2Cl \rightarrow CH_3CH_2^+$ (1° Primary carbocation)
- $(CH_3)_2CHCl \rightarrow (CH_3)_2CH^+$ (2° Secondary carbocation)
- $(CH_3)_3CCl \rightarrow ($
  $textCH_3)_3C^+$ (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 (—CHO) ortho to the hydroxyl group. This transformation proceeds via a highly reactive dichlorocarbene ($: CCl_2$) 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.

$$C_6H_5OH \xrightarrow[\text{(ii) } H^+]{\text{(i) } CHCl_3 + NaOH} o\text{-}HO\text{–}C_6H_4\text{–}CHO$$

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 + $CHCl_3/NaOH \rightarrow$ **Salicylaldehyde** (Reimer-Tiemann). Phenol + $CO_2/NaOH \rightarrow$ **Salicylic Acid** (Kolbe's).