GAT B Chemistry

Sample Paper – 6

Duration: 23 Minutes **Maximum Marks: 15**

Instructions

- This paper contains **15** Multiple Choice Questions (Single Correct Answer), modelled on the Chemistry portion of **GAT B** entrance.
- Each correct answer carries **+1 marks**. There is **a deduction of 0.5 marks for each incorrect answer**.
- Only **one** option is correct. Choose carefully.
- Syllabus level: **NCERT Class 11 & 12 Chemistry — Physical, Organic, and Inorganic Chemistry.**
- Use of mobile phones, calculators, or electronic gadgets is strictly prohibited.

Questions

Q1. Which of the following statements **correctly** describes the structural difference between cellulose and starch (amylose)?

(A) Cellulose has α-1,4 glycosidic bonds, while amylose (starch) has β-1,4 glycosidic bonds.

(B) Both cellulose and amylose consist of α-D-glucose units and differ only in molecular weight.

(C) Starch contains β-1,6 branch points while cellulose has only α-1,4 glycosidic bonds.

(D) Cellulose has β-1,4 glycosidic bonds, while amylose (starch) has α-1,4 glycosidic bonds, leading to very different structural and functional properties.

Q2. Which of the following correctly describes the structure and function of transfer RNA (tRNA) in protein synthesis?

(A) tRNA possesses an **anticodon loop** that base-pairs with the complementary mRNA codon, and carries the cognate amino acid esterified to the hydroxyl group at the **CCA-3′** terminus.

(B) tRNA carries amino acids at its 5′-phosphate end and recognises codons through a stem-loop structure located at the centre of the molecule.

(C) The anticodon of tRNA is located at the 3′ end, and the amino acid is attached at the CCA sequence at the 5′ terminus.

(D) tRNA functions during transcription in the nucleus to ferry amino acids to the growing pre-mRNA strand.

Q3. Which statement **correctly** distinguishes a cofactor from a coenzyme?

(A) Cofactors are always organic molecules; coenzymes are always inorganic metal ions.

(B) *Cofactor* is a broader term encompassing both inorganic metal ions and organic molecules; *coenzyme* refers specifically to the **organic cofactors**, many of which are derived from vitamins.

(C) Coenzymes are permanently and covalently attached to the enzyme (prosthetic group), while cofactors can freely dissociate.

(D) Both cofactors and coenzymes are proteins that associate non-covalently with the enzyme active site.

Q4. 50 mL of 0.2 M HCl is titrated with 0.2 M NH_3 ($K_b = 1.0 \times 10^{-5}$ at 298 K). What is the **pH at the equivalence point**?

(A) 7.00

(B) 9.00

(C) 5.00

(D) 11.00

Q5. An aqueous solution contains 0.1 M Cl^- and 0.1 M I^- ions. When $AgNO_3$ solution is added dropwise with stirring, which ion is precipitated **first**?

$[\,K_{sp}(\text{AgCl}) = 1.8 \times 10^{-10};\quad K_{sp}(\text{AgI}) = 8.5 \times 10^{-17}\,]$

(A) Cl^-, because it is more commonly encountered and reacts faster with Ag^+.

(B) Both Cl^- and I^- simultaneously, since their concentrations are equal.

(C) Cl^-, because AgCl is less soluble than AgI.

(D) I^-, because AgI has a much smaller K_{sp}, so a far lower $[Ag^+]$ is required to initiate its precipitation.

Q6. For a reaction: $\Delta H^\circ = -30$ kJ mol^{-1} and $\Delta S^\circ = -100$ J mol^{-1}K^{-1}. Using $\Delta G = \Delta H - T\Delta S$, at what temperature (in K) is $\Delta G = 0$, and **below** what temperature is the reaction spontaneous?

(A) $T = 300$ K; the reaction is spontaneous **below** 300 K.

(B) $T = 300$ K; the reaction is spontaneous **above** 300 K.

(C) $T = 3000$ K; the reaction is spontaneous above 3000 K.

(D) $T = 3000$ K; the reaction is spontaneous at all temperatures since $\Delta H < 0$.

Q7. The standard molar enthalpy of neutralisation of a **strong acid** with a **strong base** at 298 K is approximately:

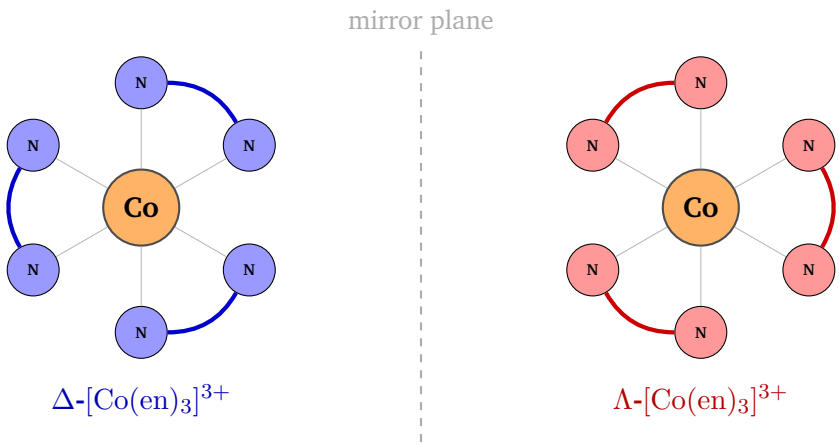
(A) -13.7 kJ mol^{-1}

(B) -57.3 kJ mol^{-1}

(C) -46.0 kJ mol^{-1}

(D) -285.8 kJ mol^{-1}

Q8. The schematic trigonal projections below show the two non-superimposable mirror images (Δ and Λ forms) of a tris-bidentate octahedral cobalt complex. Which of the following complexes **exhibits optical isomerism**?



(Schematic top-view: each thick arc represents one ethylenediamine ligand)

(A) $[Co(NH_3)_4Cl_2]^+$

(B) $[PtCl_4]^{2-}$

(C) $[Co(en)_3]^{3+}$

(D) $[Ni(CO)_4]$

Q9. According to the **18-electron rule** (effective atomic number rule), which of the following metal carbonyls does **NOT** obey it?

(A) $Ni(CO)_4$

(B) $Fe(CO)_5$

(C) $Cr(CO)_6$

(D) $V(CO)_6$

Q10. Ethylmagnesium bromide (CH_3CH_2MgBr) is treated first with dry CO_2 gas, then worked up with dilute H_3O^+. What is the **major organic product**?

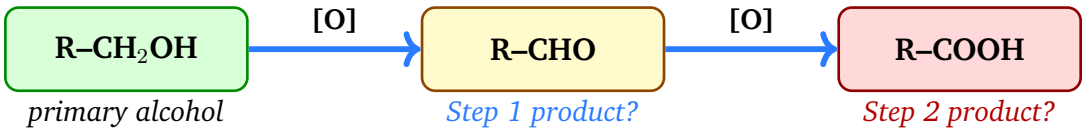
(A) Propanoic acid (CH_3CH_2COOH)

(B) Propanal (CH_3CH_2CHO)

(C) 1-Propanol ($CH_3CH_2CH_2OH$)

(D) Ethanol (CH_3CH_2OH)

Q11. The diagram below illustrates the stepwise oxidation of a primary alcohol. The products formed in the **first** and **second** oxidation steps are, respectively:



(A) Ketone, then carboxylic acid

(B) Aldehyde, then carboxylic acid

(C) Ether, then ketone

(D) Aldehyde, then ester

Q12. Which of the following correctly expresses the standard thermodynamic relationships among ΔG°, the standard cell potential E°_{cell}, and the equilibrium constant K?

(A) $\Delta G^\circ = +nFE^\circ = +RT\ln K$

(B) $\Delta G^\circ = -nFE^\circ = +RT\ln K$

(C) $\Delta G^\circ = -nFE^\circ = -RT\ln K$

(D) $\Delta G^\circ = +nFE^\circ = -RT\ln K$

Q13. A plot of $\ln k$ versus $1/T$ for a reaction gives a straight line with slope $= -9600$ K. What is the **activation energy** (E_a) of the reaction?
($R = 8.314$ J mol^{-1} K^{-1})

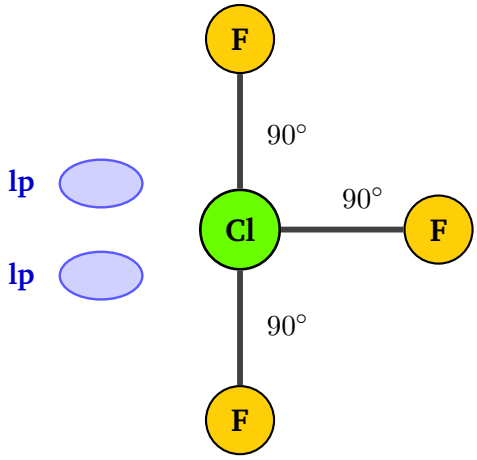
(A) 9600 J mol^{-1}

(B) 1154 J mol^{-1}

(C) 120 kJ mol^{-1}

(D) 79.8 kJ mol^{-1}

Q14. The diagram below depicts the molecular geometry of an interhalogen compound containing one chlorine and three fluorine atoms. Identify the compound and its **correct molecular geometry**:



Molecular geometry of the interhalogen compound

(A) ClF_3; pyramidal geometry due to one lone pair on chlorine

(B) ClF_3; T-shaped geometry arising from two equatorial lone pairs on chlorine

(C) ClF_3; trigonal planar geometry with all bond angles 120°

(D) Cl_3F; linear geometry with chlorine at the centre

Q15. Which of the following **correctly** identifies the monomers of **Nylon-6,6** and the type of linkage formed during polymerisation?

(A) Caprolactam alone; amide linkage by ring-opening polymerisation.

(B) Adipic acid and ethylene glycol; ester linkage (polyester).

(C) Adipic acid $[HOOC(CH_2)_4COOH]$ and hexamethylenediamine $[H_2N(CH_2)_6NH_2]$ **amide** linkage.

(D) Hexamethylenediamine and sebacic acid $[HOOC(CH_2)_8COOH]$; amide linkage.

Detailed Solutions

Q1.

Solution

Concept — Polysaccharide Stereochemistry: Cellulose and starch are both homopolymers of glucose, but the configuration at the anomeric carbon (C-1) of the glycosidic bond produces completely different structures and biological roles.

Step 1 — Starch (Amylose): Amylose is composed of α-D-glucose units joined by **α-1,4 glycosidic bonds**. The α configuration bends the chain, causing it to coil into a helix (useful for energy storage; digested by amylase enzymes).

Step 2 — Cellulose: Cellulose is composed of β-D-glucose units joined by **β-1,4 glycosidic bonds**. Each glucose unit is "flipped" 180° relative to its neighbour, producing a straight, rigid chain that forms inter-chain hydrogen bonds — hence its structural role in plant cell walls. Humans cannot digest cellulose because they lack β-glucosidase.

Why other options are wrong:

- Option A: Reverses the bond types — cellulose is β-1,4 and amylose is α-1,4, not the other way round.
- Option B: Only starch uses α-D-glucose; cellulose uses β-D-glucose. They differ in linkage configuration, not just molecular weight.
- Option C: It is amylopectin (branched starch) that has α-1,6 branch points (not β-1,6); cellulose has β-1,4 bonds, not α-1,4.
- Option D: Correct in every detail.

Final Answer: Cellulose $=\beta$-1,4; amylose $=\alpha$-1,4 $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 1

Q2.

Solution

Concept — tRNA Architecture: tRNA is the adaptor molecule of translation, possessing two functionally critical sites: the anticodon loop (mRNA recognition) and the 3′-CCA terminus (amino acid attachment).

Step 1 — Anticodon Loop: The anticodon, a triplet of nucleotides, is located at the anticodon loop — roughly at the bottom of the L-shaped 3D structure. It forms Watson–Crick base pairs (antiparallel, 3′ $\rightarrow$5′) with the complementary mRNA codon on the ribosome.

Step 2 — CCA-3′ Terminus: All mature tRNA molecules share the universal 3′ terminal sequence . . .**CCA-3′**. Aminoacyl-tRNA synthetase attaches the correct amino acid via an ester bond to the 2′- or 3′-OH of the terminal adenosine, forming aminoacyl-tRNA.

Why other options are wrong:

- Option A: Correct — anticodon loop + amino acid at CCA-3′ end.
- Option B: Amino acid is attached at the **3′** end, not the 5′ end; and codon recognition occurs at the anticodon loop, not general stem-loops.
- Option C: The anticodon is at the anticodon loop (central region), not the 3′ end.
- Option D: tRNA functions in **translation** (cytoplasm/ribosome), not in transcription in the nucleus.

Final Answer: Anticodon loop reads mRNA; amino acid attached at CCA-3′ $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q 2

Q3.

Solution

Concept — Enzyme Auxiliary Molecules: Many enzymes require non-protein chemical species for catalytic activity. The term *cofactor* is the general name; *coenzyme* is a subset.

Step 1 — Cofactor (Broad Category): A *cofactor* is any non-protein component needed for enzyme activity. This includes:

- Inorganic metal ions: Zn^{2+} (carbonic anhydrase), Mg^{2+} (kinases), Fe^{2+}/Fe^{3+} (cytochromes).
- Organic molecules (coenzymes): NAD^{+}, FAD, Coenzyme A, etc.

Step 2 — Coenzyme (Organic Subset): A *coenzyme* is specifically an **organic cofactor**, usually a vitamin derivative. Coenzymes that bind loosely and transiently are cosubstrates; those bound permanently are *prosthetic groups*. Thus: coenzyme $\subset$ cofactor.

Why other options are wrong:

- Option A: Reverses the definitions; cofactors include inorganic ions, while coenzymes are organic.

- Option B: Correct — cofactor is broader; coenzyme is the organic subset, often vitamin-derived.
- Option C: It is the *prosthetic group* (a specific class of cofactor) that is permanently bound. Coenzymes typically dissociate after each reaction cycle.
- Option D: Cofactors and coenzymes are **not** proteins; they are non-protein helper molecules.

Final Answer: Cofactor (broad) $\supset$ metal ions + coenzymes; coenzyme = organic cofactor $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q 3

Q4.

Solution

Concept — Equivalence Point pH (Strong Acid + Weak Base): At the equivalence point of HCl vs. NH_3, all base is converted to the salt NH_4Cl. The solution is acidic because NH_4^+ (the conjugate acid) hydrolyses.

Step 1 — Composition at Equivalence Point:

$$n_{HCl} = 0.050\,\text{L} \times 0.2\,\text{M} = 0.010\,\text{mol}; \quad n_{NH_3} = 0.050\,\text{L} \times 0.2\,\text{M} = 0.010\,\text{mol}$$

They react completely: HCl + $NH_3 \rightarrow NH_4Cl$. Total volume = 100 mL.

$$[NH_4^+] = \frac{0.010\,\text{mol}}{0.100\,\text{L}} = 0.10\,\text{M}$$

Step 2 — Hydrolysis of NH_4^+:

$$K_a(NH_4^+) = \frac{K_w}{K_b} = \frac{1.0 \times 10^{-14}}{1.0 \times 10^{-5}} = 1.0 \times 10^{-9}$$

$$[H^+] = \sqrt{K_a \cdot C} = \sqrt{1.0 \times 10^{-9} \times 0.10} = \sqrt{1.0 \times 10^{-10}} = 1.0 \times 10^{-5}\,\text{M}$$

$$\text{pH} = -\log(1.0 \times 10^{-5}) = \mathbf{5.00}$$

Why other options are wrong:

- Option A: pH 7.00 applies only to strong acid–strong base neutralisation (no hydrolysis of salt).
- Option B: pH 9.00 would be expected at the equivalence point of a *weak acid*–strong base titration.

- Option C: pH 5.00 is the correct result.
- Option D: pH 11.00 is strongly alkaline; this titration gives an acidic salt at equivalence.

Final Answer: pH $= 5.00 \Rightarrow$ C

Answer: (C) Go Back to Q 4

Q5.

Solution

Concept — Selective Precipitation by Competing Equilibria: When two anions compete for the same cation, the one that requires the *lower* free-cation concentration to exceed its K_{sp} precipitates first.

Step 1 — Minimum [Ag^+] Needed for Each Precipitate:

$$[Ag^+]_{AgCl} = \frac{K_{sp}(AgCl)}{[Cl^-]} = \frac{1.8 \times 10^{-10}}{0.1} = 1.8 \times 10^{-9}\,M$$

$$[Ag^+]_{AgI} = \frac{K_{sp}(AgI)}{[I^-]} = \frac{8.5 \times 10^{-17}}{0.1} = 8.5 \times 10^{-16}\,M$$

Step 2 — Comparison: Since $8.5 \times 10^{-16} \ll 1.8 \times 10^{-9}$, AgI begins to precipitate when [Ag^+] is still far below the threshold for AgCl. Therefore $\mathbf{I^-}$ precipitates first. Cl^- remains in solution until [Ag^+] rises to 1.8×10^{-9} M.

Why other options are wrong:

- Option A: Kinetic speed is irrelevant here; selective precipitation is governed by thermodynamics (K_{sp} values).
- Option B: Equal concentrations do not cause simultaneous precipitation when K_{sp} values differ by ~ 7 orders of magnitude.
- Option C: AgCl ($K_{sp} = 1.8 \times 10^{-10}$) is *more* soluble than AgI ($K_{sp} = 8.5 \times 10^{-17}$), so Cl^- precipitates *later*.
- Option D: Correct — AgI has the smaller K_{sp}; I^- precipitates first.

Final Answer: I^- precipitates first (smaller K_{sp} for AgI) $\Rightarrow$ D

Answer: (D) Go Back to Q 5

Q6.

Solution

Concept — Gibbs–Helmholtz Equation: When both ΔH and ΔS are negative, $\Delta G = \Delta H - T\Delta S$ changes sign at a specific temperature $T^* = \Delta H/\Delta S$. The reaction is spontaneous only below T^*.

Step 1 — Temperature at $\Delta G = 0$:

$$0 = \Delta H^\circ - T^*\Delta S^\circ \implies T^* = \frac{\Delta H^\circ}{\Delta S^\circ} = \frac{-30{,}000\,\text{J mol}^{-1}}{-100\,\text{J mol}^{-1}\text{K}^{-1}} = 300\,\text{K}$$

Step 2 — Spontaneity Range:

$$\Delta G = (-30{,}000) - T(-100) = -30{,}000 + 100\,T$$

- $T < 300\,\text{K}$: $\Delta G = -30{,}000 + 100T < 0 \Rightarrow$ **spontaneous**.
- $T > 300\,\text{K}$: $\Delta G > 0 \Rightarrow$ non-spontaneous.

Why other options are wrong:

- Option A: Correct — $T^* = 300$ K; spontaneous below 300 K.
- Option B: When $\Delta H < 0$ and $\Delta S < 0$, spontaneity holds at *low* temperature, not high.
- Option C and D: Arithmetic error by a factor of 10: $(-30{,}000)/(-100) = 300$, not 3000.

Final Answer: $T^* = 300\,\text{K}$; spontaneous below 300 K $\Rightarrow$ A

Answer: (A) Go Back to Q 6

Q7.

Solution

Concept — Standard Enthalpy of Neutralisation: For any strong acid–strong base pair, both are fully dissociated, so the net ionic equation is always the same: $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$. The enthalpy change is therefore constant and independent of which strong acid or base is used.

Step 1 — Net Ionic Equation and Value:

$$H^+(aq) + OH^-(aq) \longrightarrow H_2O(\ell), \quad \Delta H^\circ_{\text{neut}} \approx -57.3\,\text{kJ mol}^{-1}$$

This value is the standard result quoted in NCERT and all major physical chemistry references.

Step 2 — Identifying the Distractors:

- $-13.7\,\text{kJ mol}^{-1}$: No standard thermodynamic significance in this context.
- $-46.0\,\text{kJ mol}^{-1}$: Approximate value for neutralisation involving a weak acid or weak base (energy is consumed to complete ionisation of the weak species, reducing $|\Delta H|$).
- $-285.8\,\text{kJ mol}^{-1}$: This is $\Delta H_f^\circ(\text{H}_2\text{O}, \ell)$ from elements — an entirely different reaction.

Why other options are wrong:

- Option A: $-13.7\,\text{kJ mol}^{-1}$ is incorrect; no known standard value here.
- Option B: $-57.3\,\text{kJ mol}^{-1}$ is the correct standard enthalpy of neutralisation.
- Option C: $-46.0\,\text{kJ mol}^{-1}$ applies to weak acid/weak base systems, not strong/strong.
- Option D: $-285.8\,\text{kJ mol}^{-1}$ is ΔH_f° of liquid water, not neutralisation enthalpy.

Final Answer: $\Delta H^\circ_{\text{neut}} = -57.3\,\text{kJ mol}^{-1} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 7

Q8.

Solution

Concept — Optical Isomerism in Coordination Compounds: A complex is optically active (chiral) if it lacks an improper rotation axis (S_n, including mirror planes and inversion centres). Tris-bidentate octahedral complexes $[\text{M(AA)}_3]^{n+}$ with D_3 symmetry are always chiral.

Step 1 — Analysis of Each Complex:

- $[\text{Co(NH}_3)_4\text{Cl}_2]^+$: Both cis and trans forms have mirror planes (C_{2v} and D_{4h} symmetry, respectively) — optically **inactive**.
- $[\text{PtCl}_4]^{2-}$: Square-planar with D_{4h} symmetry; multiple mirror planes — optically **inactive**.
- $[\text{Co(en)}_3]^{3+}$: Octahedral, three bidentate ethylenediamine ligands, D_3 symmetry. No mirror planes, no S_4 axis. Exists as non-superimposable Δ and Λ enantiomers (shown in the diagram) — optically **active**.

- $[Ni(CO)_4]$: Tetrahedral with T_d symmetry; has S_4 axis — optically **inactive**.

Step 2 — Confirming $[Co(en)_3]^{3+}$ via the Diagram: The Δ-form (blue arcs, clockwise) and Λ-form (red arcs, counterclockwise) shown are mirror images that cannot be superimposed by any rotation, confirming chirality.

Why other options are wrong:

- Option A: $[Co(NH_3)_4Cl_2]^+$ possesses mirror planes in both geometric forms; achiral.
- Option B: $[PtCl_4]^{2-}$ is square-planar with D_{4h} symmetry; achiral.
- Option C: $[Co(en)_3]^{3+}$ is D_3-symmetric and chiral — **correct**.
- Option D: $[Ni(CO)_4]$ is tetrahedral (T_d); achiral.

Final Answer: $[Co(en)_3]^{3+}$ (D_3 symmetry, no mirror planes) $\Rightarrow$ C

Answer: (C) Go Back to Q 8

Q9.

Solution

Concept — 18-Electron Rule in Metal Carbonyls: Each CO donates 2 electrons to the metal centre. A stable metal carbonyl satisfies: metal valence electrons (= Group number) + electrons from CO = 18.

Step 1 — Electron Count:

Carbonyl	Metal valence e^-	CO donation	Total
$Ni(CO)_4$	10 (Group 10)	$4 \times 2 = 8$	18 ✓
$Fe(CO)_5$	8 (Group 8)	$5 \times 2 = 10$	18 ✓
$Cr(CO)_6$	6 (Group 6)	$6 \times 2 = 12$	18 ✓
$V(CO)_6$	5 (Group 5)	$6 \times 2 = 12$	17 ×

Step 2 — Conclusion: $V(CO)_6$ has only **17 electrons**. It is paramagnetic (one unpaired electron) and is the textbook example of a kinetically stable 17-electron complex that violates the 18-electron rule. It does not dimerize (unlike 17-electron $Mn_2(CO)_{10}$) due to steric protection by the six CO groups.

Why other options are wrong:

- Option A: $Ni(CO)_4$ — $10 + 8 = 18$ electrons. Obeys the rule.
- Option B: $Fe(CO)_5$ — $8 + 10 = 18$ electrons. Obeys the rule.
- Option C: $Cr(CO)_6$ — $6 + 12 = 18$ electrons. Obeys the rule.
- Option D: $V(CO)_6$ — $5 + 12 = 17$ electrons. Does **not** obey the rule.

Final Answer: $V(CO)_6$ has 17 electrons; violates the 18-electron rule $\Rightarrow$ D

Answer: (D) Go Back to Q 9

Q10.

Solution

Concept — Grignard Reagent with CO_2 (Carboxylation): A Grignard reagent (RMgX) is a strong carbon nucleophile (carbanion equivalent). Reaction with CO_2 inserts a $-COO^-$ group; acid workup gives a carboxylic acid one carbon longer than the original alkyl group.

Step 1 — Nucleophilic Addition to CO_2:

$$CH_3CH_2^{\delta-}MgBr^{\delta+} + \underset{\text{electrophilic C}}{CO_2} \longrightarrow CH_3CH_2{-}C\begin{pmatrix} O^- \\ O \end{pmatrix}MgBr^+$$

The ethyl carbanion attacks the electrophilic carbon of CO_2, forming a magnesium carboxylate.

Step 2 — Acid Workup:

$$CH_3CH_2COO^-MgBr^+ \xrightarrow{H_3O^+} \underbrace{CH_3CH_2COOH}_{\text{propanoic acid}} + Mg(OH)Br$$

Net result: C_2 (ethyl) Grignard + CO_2 $\rightarrow$ C_3 carboxylic acid (one carbon added).

Why other options are wrong:

- Option A: Propanoic acid (CH_3CH_2COOH) — **correct product** of carboxylation.
- Option B: Propanal (CH_3CH_2CHO) — requires reaction with DMF or formamide, not CO_2.
- Option C: 1-Propanol ($CH_3CH_2CH_2OH$) — would arise from Grignard reaction with *formaldehyde* (HCHO) followed by acid workup.
- Option D: Ethanol (CH_3CH_2OH) — formed by protonation of the Grignard with water; no CO_2 involved, no chain extension.

Final Answer: $CH_3CH_2MgBr + CO_2 \xrightarrow{H_3O^+} CH_3CH_2COOH \Rightarrow$ A

Answer: (A) Go Back to Q 10

Q11.

Solution

Concept — Stepwise Oxidation of Primary Alcohols: Primary alcohols are oxidised in two stages: first to an aldehyde (by mild oxidants such as PCC, Swern, or pyridinium dichromate), then further to a carboxylic acid (by strong oxidants such as acidic $KMnO_4$ or $K_2Cr_2O_7/H^+$).

Step 1 — First Oxidation: Primary Alcohol $\rightarrow$ Aldehyde:

$$R\text{–}CH_2OH \xrightarrow{[O],\ \text{mild}} R\text{–}CHO + H_2O$$

Two hydrogen atoms are removed (one from C–H, one from O–H at the α-carbon). Mild oxidants stop here.

Step 2 — Second Oxidation: Aldehyde $\rightarrow$ Carboxylic Acid:

$$R\text{–}CHO \xrightarrow{[O],\ \text{strong}} R\text{–}COOH$$

The aldehyde is oxidised further; the carbonyl carbon's oxidation state increases from $+1$ to $+3$.

Why other options are wrong:

- Option A: Ketones arise from oxidation of *secondary* alcohols; a primary alcohol cannot directly give a ketone.
- Option B: Aldehyde then carboxylic acid — **correct sequence**.
- Option C: Ether formation requires acid-catalysed dehydration (H_2SO_4, 140°C), not oxidation.
- Option D: Ester formation requires the combined action of a carboxylic acid and an alcohol (Fischer esterification); sequential oxidation alone cannot yield an ester.

Final Answer: $R\text{–}CH_2OH \xrightarrow{[O]} R\text{–}CHO \xrightarrow{[O]} R\text{–}COOH \Rightarrow \boxed{B}$

Answer: (B) Go Back to Q 11

Q12.

Solution

Concept — Interrelationship of ΔG°, E°, and K: Three pivotal equations of physical chemistry connect these quantities. Knowing the sign conventions and derivations eliminates all distractors.

Step 1 — Derivation of $\Delta G^\circ = -RT\ln K$: At equilibrium, $\Delta G = 0$ and the reaction quotient $Q = K$. Using $\Delta G = \Delta G^\circ + RT\ln Q$:

$$0 = \Delta G^\circ + RT\ln K \implies \Delta G^\circ = -RT\ln K$$

(If $K > 1$, products are favoured and $\Delta G^\circ < 0$; if $K < 1$, $\Delta G^\circ > 0$.)

Step 2 — Derivation of $\Delta G^\circ = -nFE^\circ$: The maximum non-expansion (electrical) work an electrochemical cell can do equals the drop in Gibbs energy:

$$w_{\text{elec,max}} = -\Delta G^\circ = nFE^\circ \implies \Delta G^\circ = -nFE^\circ$$

(A positive E° drives a spontaneous cell, $\Delta G^\circ < 0$.)

Combined: $\Delta G^\circ = -nFE^\circ = -RT\ln K$.

Why other options are wrong:

- Option A: Both terms have the wrong sign; $+nFE^\circ$ and $+RT\ln K$ are both incorrect.
- Option B: $-nFE^\circ$ is correct but $+RT\ln K$ has the wrong sign.
- Option C: $\Delta G^\circ = -nFE^\circ = -RT\ln K$ — **correct**.
- Option D: $\Delta G^\circ = +nFE^\circ$ has the wrong sign for the electrochemical relation.

Final Answer: $\Delta G^\circ = -nFE^\circ = -RT\ln K \Rightarrow$ C

Answer: (C) Go Back to Q 12

Q13.

Solution

Concept — Arrhenius Plot and Activation Energy: The Arrhenius equation in linear form is $\ln k = \ln A - \dfrac{E_a}{R}\cdot\dfrac{1}{T}$. A graph of $\ln k$ vs. $1/T$ yields a straight line with slope $= -E_a/R$, from which E_a is extracted.

Step 1 — Extract E_a from the Slope:

$$\text{slope} = -\frac{E_a}{R} = -9600\,\text{K} \implies E_a = 9600\,\text{K} \times R = 9600\,\text{K} \times 8.314\,\text{J mol}^{-1}\text{K}^{-1}$$

$$E_a = 79{,}814\,\text{J mol}^{-1} \approx 79.8\,\text{kJ mol}^{-1}$$

Step 2 — Unit Check: $[\text{slope}] = \text{K}$; $[R] = \text{J mol}^{-1}\text{K}^{-1}$; $[E_a] = \text{K} \times \text{J mol}^{-1}\text{K}^{-1} = \text{J mol}^{-1}$. Units are consistent.

Why other options are wrong:

- Option A: $9600\,\text{J mol}^{-1}$ is the numerical value of the slope alone, forgetting to multiply by R.
- Option B: $1154\,\text{J mol}^{-1}$ results from dividing by R instead of multiplying ($9600/8.314 \approx 1154$).
- Option C: $120\,\text{kJ mol}^{-1}$ is arithmetically wrong; $9600 \times 8.314 = 79{,}814\,\text{J mol}^{-1} \neq 120{,}000$.
- Option D: $79.8\,\text{kJ mol}^{-1}$ is the correct result ($9600 \times 8.314 = 79{,}814 \approx 79.8\,\text{kJ mol}^{-1}$).

Final Answer: $E_a = 9600 \times 8.314 \approx 79.8\,\text{kJ mol}^{-1} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 13

Q14.

Solution

Concept — VSEPR Theory Applied to ClF_3: Cl has 7 valence electrons; it forms 3 bonds with F and retains 2 lone pairs. The VSEPR notation is AB_3E_2: electron-pair geometry is *trigonal bipyramidal* (5 pairs), and lone pairs preferentially occupy equatorial positions to minimise repulsion. The resulting molecular geometry is **T-shaped**.

Step 1 — Valence Electron Count for Cl in ClF_3:

Cl valence electrons $= 7$; Shared in 3 bonds: 3; Non-bonding: $7-3 = 4 \rightarrow 2$ lone pairs

Total electron pairs on Cl $= 3(\text{bonding}) + 2(\text{lone pairs}) = 5 \rightarrow$ trigonal bipyramidal arrangement.

Step 2 — Lone-Pair Position and Molecular Shape: Lone pairs require more angular space than bonding pairs. In a trigonal bipyramid, equatorial positions

(three positions, 120° apart) have less repulsion than axial (two positions, 90° interactions). Both lone pairs occupy equatorial positions. The three F atoms are placed at: top axial, bottom axial, and one equatorial (right). The molecule looks like a "T"; bond angles $\approx 87.5^\circ$ (slightly compressed by lone-pair repulsion).

Why other options are wrong:

- Option A: Pyramidal geometry (AB_3E_1) has 3 bonds + **1** lone pair (e.g., NH_3); ClF_3 has **2** lone pairs.
- Option B: T-shaped with 2 lone pairs at equatorial positions — **correct**.
- Option C: Trigonal planar requires 0 lone pairs (e.g., BF_3, 120° bond angles); ClF_3 has 2 lone pairs and bond angles $\approx 87.5^\circ$.
- Option D: Cl_3F is not a real chemical formula. ClF_3 is the correct formula and it is not linear.

Final Answer: ClF_3; T-shaped geometry (AB_3E_2, 2 equatorial lone pairs) $\Rightarrow$ B

Answer: (B) Go Back to Q 14

Q15.

Solution

Concept — Condensation Polymers (Nylon-6,6): Nylon-6,6 is a polyamide formed by condensation of a dicarboxylic acid and a diamine. The name "6,6" refers to the six carbon atoms in each monomer unit.

Step 1 — Identifying the Monomers:

- **Adipic acid** (hexanedioic acid): HOOC–$(CH_2)_4$–COOH $\rightarrow$ **6 carbons**.
- **Hexamethylenediamine** (1,6-diaminohexane): H_2N–$(CH_2)_6$–NH_2 $\rightarrow$ **6 carbons**.

Hence the name Nylon-**6,6** (diamine 6C, diacid 6C).

Step 2 — Linkage Type: Each –COOH reacts with –NH_2, eliminating water and forming an **amide bond** (–CO–NH–):

$$\cdots\text{–COOH} + \text{H}_2\text{N–}\cdots \longrightarrow \cdots\text{–CO–NH–}\cdots + \text{H}_2\text{O}$$

The repeating amide units (–CO–NH–) allow extensive hydrogen bonding between chains, giving nylon high tensile strength and melting point.

Why other options are wrong:

- Option A: Caprolactam (ring-opening) gives **Nylon-6** (one monomer, 6-membered ring with 6 carbons/N), not Nylon-6,6.
- Option B: Adipic acid + ethylene glycol (2 carbons in diol) gives a **polyester** (–COO– linkage), not a polyamide; and ethylene glycol is not hexamethylenediamine.
- Option C: Adipic acid + hexamethylenediamine with amide linkage — **correct for Nylon-6,6**.
- Option D: Sebacic acid (decanedioic acid, **10** carbons) + hexamethylenediamine (6 carbons) gives **Nylon-6,10**, not Nylon-6,6.

Final Answer: Adipic acid + hexamethylenediamine; amide bond $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q 15

Answer Key

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