CBSE CLASS X

Science (086)

ANSWER KEY

AI-generated question paper

Code: 040TNW **Questions: 65** **Maximum Marks: 177** **Generated: 2026-06-25 17:49**

SELECTIONS USED

Subject	Science
Lessons	4 Carbon and its Compounds
Level of understanding	Thorough understanding
Question selection	Curated chapter coverage (~5 questions per section + 8 synthesis)
Model	claude-sonnet-4-6

Composition — Difficulty: 4 straightforward · 33 medium · 28 deep | Types: 50 Short · 6 Very short · 5 Long · 4 MCQ

Q1. medium | thorough-understanding | § Introduction **[3]**

When an organic compound is subjected to complete combustion in excess oxygen, name the products formed that confirm the presence of (i) carbon and (ii) hydrogen in the compound. Describe the chemical test used to detect each product, and write the general equation for the complete combustion of a hydrocarbon.

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Model Answer

(i) Carbon is confirmed by the formation of **CO_2** gas. When this gas is passed through **lime water [$Ca(OH)_2$]**, it turns **milky** due to formation of calcium carbonate ($CaCO_3$). This confirms the presence of carbon.

(ii) Hydrogen is confirmed by the formation of **water (H_2O)**. Water droplets appear on a cold surface/cobalt chloride paper turns from blue to pink, confirming hydrogen.

General equation for complete combustion of a hydrocarbon:

$$C_xH_y + O_2 \rightarrow CO_2 + H_2O + \text{heat and light}$$

Source: Chapter 4, Section 4.3.1 Combustion

Explanation

- Examiners expect **two named products** with **one test each** — lime water test for CO_2 and cobalt chloride paper / condensation for water.
- The general equation need not be balanced but writing it symbolically scores the mark.
- Keep the lime water test wording precise: "turns milky" is the key phrase; writing "white precipitate of $CaCO_3$" adds value.
- This answer covers all three marks: product for C (1), product for H (1), general equation (1).

Q2. medium | thorough-understanding | § 4.1 BONDING IN CARBON – THE COVALENT BOND **[3]**

Why does carbon form covalent bonds rather than losing or gaining electrons to form ions?

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Model Answer

Carbon has 4 valence electrons and needs 4 more to achieve noble gas configuration. Forming ions is not feasible because:

(i) Gaining 4 electrons to form C^{4-} would be difficult, as the nucleus with only 6 protons cannot hold 10 electrons stably.

(ii) Losing 4 electrons to form C^{4+} would require a very large amount of energy, leaving 6 protons holding just 2 electrons.

Therefore, carbon overcomes this problem by **sharing** its 4 valence electrons with other atoms, forming **covalent bonds**. This allows both atoms to achieve noble gas configuration without gaining or losing electrons.

Source: Chapter 4, Section 4.1 — Bonding in Carbon: The Covalent Bond

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Explanation

Examiners look for **three specific points** matching the 3 marks:

1. Why gaining 4 electrons is not possible (nuclear attraction too weak for C^{4-}).
2. Why losing 4 electrons is not possible (too much energy needed for C^{4+}).
3. The conclusion — carbon shares electrons, forming covalent bonds instead.

Avoid vague answers like "carbon is non-metal." Use the exact reasoning from the textbook. The terms **C^{4-}**, **C^{4+}**, and **sharing** are key scoring terms.

Q3. medium | thorough-understanding | § 4.1 BONDING IN CARBON – THE COVALENT BOND **[3]**

Using the formation of a hydrogen molecule (H_2) as an example, explain how sharing a pair of electrons in a covalent bond allows each hydrogen atom to achieve the electronic configuration of a noble gas.

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Model Answer

Each hydrogen atom has 1 electron in its outermost shell and needs 2 electrons (like helium, a noble gas) to have a completely filled shell.

When two hydrogen atoms come together, each contributes 1 electron to form a shared pair — a covalent bond. This shared pair of electrons is counted by **both** atoms simultaneously.

Thus, each hydrogen atom effectively has 2 electrons in its outermost shell, achieving the electronic configuration of helium (a noble gas). The molecule formed is H_2.

H• + •H → H:H (shared pair)

Source: Chapter 4, "What you have learnt" — *Covalent bonds are formed by the sharing of electrons between two atoms so that both can achieve a completely filled outermost shell.*

Explanation

- Examiners award marks for three points: (1) what each H atom needs, (2) how sharing works, and (3) the noble gas configuration achieved.
- Always name the noble gas (helium) whose configuration H achieves — this earns the specific mark.
- The electron dot diagram (H:H) is a good addition in a 3-mark answer; it shows understanding without taking extra time.
- Do not confuse "shared pair counted by both" — this is the key idea of covalent bonding.

Q4. medium | thorough-understanding | § 4.1 BONDING IN CARBON – THE COVALENT BOND **[1]**

Which of the following correctly describes why covalent compounds generally have low melting and boiling points?
(A) The covalent bonds within each molecule are weak.
(B) The inter-molecular forces between covalent molecules are weak, even though intra-molecular bonds are strong.
(C) Covalent compounds do not contain any bonds, only loosely associated atoms.
(D) The electrons in covalent compounds are free to move, reducing the energy needed to separate molecules.

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Model Answer

(B) The inter-molecular forces between covalent molecules are weak, even though intra-molecular bonds are strong.

Source: Chapter 4, Section 4.1 (Bonding in Carbon – The Covalent Bond)

Explanation

The textbook explicitly states: *"Covalently bonded molecules are seen to have strong bonds within the molecule, but inter-molecular forces are weak. This gives rise to the low melting and boiling points of these compounds."* So it is the **weak inter-molecular forces** (not weak covalent bonds) that explain low melting/boiling points. Options A, C, and D are factually incorrect as per the passage.

Q5. medium | thorough-understanding | § 4.1 BONDING IN CARBON – THE COVALENT BOND **[3]**

A student dips two electrodes into liquid ethanol and finds that no current flows, but when the same electrodes are placed in molten sodium chloride, current flows readily. Explain, in terms of the nature of bonding and the particles present in each substance, why this difference is observed.

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Model Answer

Ethanol (liquid): Ethanol is a covalent compound. Its molecules are held together by weak intermolecular forces. When electrodes are dipped in liquid ethanol, no charged particles (ions) are present — electrons are shared between atoms, not transferred. Since there are no free ions to carry charge, no current flows.

Molten NaCl: Sodium chloride is an ionic compound made of Na^+ and Cl^- ions held in a crystal lattice. On melting, these ions become free to move. These freely moving charged ions carry electric current, so current flows readily through molten NaCl.

Source: Chapter 4, Section 4.1 (Bonding in Carbon – The Covalent Bond)

Explanation

- **Key contrast examiners look for:** covalent (no ions → no current) vs. ionic (free ions in molten state → conducts).
- Mention *shared electrons / no charged particles* for ethanol; mention *free ions* for NaCl — these are the scoring phrases.
- Don't write about aqueous solutions; the question specifies liquid ethanol and *molten* NaCl.
- 3 marks typically split as: 1 mark (ethanol covalent/no ions) + 1 mark (NaCl ionic/ions) + 1 mark (clear explanation of current flow linked to free ions).

Q6. medium | thorough-understanding | § 4.1 BONDING IN CARBON – THE COVALENT BOND **[3]**

Oxygen forms a double bond in O_2, but hydrogen forms only a single bond in H_2. Using the concept of valence electrons and octet/duplet completion, explain why this difference exists.

◆ **Carbon and its Compounds**

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Model Answer

Hydrogen (H_2 — single bond):

Hydrogen has only 1 valence electron. It needs just 1 more electron to complete its **duplet** (stable configuration of 2 electrons). So each hydrogen atom shares one electron with the other, forming a **single bond** (one shared pair), and both atoms achieve a duplet.

Oxygen (O_2 — double bond):

Oxygen has 6 valence electrons. It needs 2 more electrons to complete its **octet** (stable configuration of 8 electrons). Sharing just one pair would leave each oxygen atom with only 7 electrons — octet unfulfilled. So each oxygen atom shares **two pairs of electrons**, forming a **double bond**, and both atoms achieve a complete octet.

This is why H_2 has a single bond while O_2 has a double bond.

Source: Chapter 4, Covalent Bonds / Versatile Nature of Carbon

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Explanation

- The examiner expects you to clearly link **number of valence electrons → electrons needed → bonds formed**.
- Key terms to use: **duplet** (for hydrogen), **octet** (for oxygen), **single bond**, **double bond**, **shared pair**.
- Do NOT just state the result — briefly show the *reasoning* (how many electrons needed and why one/two pairs are shared). That's where the 3 marks lie: ~1 mark per element's reasoning + 1 mark for the conclusion/contrast.

Q7. straightforward | thorough-understanding | § 4.1 BONDING IN CARBON – THE COVALENT BOND **[1]**

Nitrogen (N_2) forms a triple bond between its two atoms. State how many shared pairs of electrons are present and explain why nitrogen needs to share three pairs rather than one to achieve a stable configuration.

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Model Answer

Nitrogen has **3 shared pairs** of electrons (triple bond). Each nitrogen atom has 5 valence electrons; sharing 3 pairs gives each atom a complete octet (2+6=8 electrons), which one shared pair cannot achieve.

Explanation

The key points examiners look for: (1) state the number — 3 shared pairs, and (2) briefly justify using valence electrons / octet rule. Nitrogen has 5 valence electrons, so it needs 3 more to complete its octet; sharing one pair would give only 6 electrons per atom, which is insufficient. A triple bond (3 shared pairs) satisfies both atoms' octets.

Q8. deep | thorough-understanding | § 4.1 BONDING IN CARBON – THE COVALENT BOND **[3]**

A student argues that a water molecule (H_2O) must contain double bonds because oxygen needs two more electrons to complete its octet. Is the student correct? Explain your reasoning.

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Model Answer

No, the student is **not correct**.

Oxygen needs two more electrons to complete its octet, but this does **not** mean it must form double bonds. In a water molecule (H_2O), oxygen shares **one electron** with **each** of the two hydrogen atoms, forming **two single covalent bonds**. Each hydrogen needs only one electron to complete its duplet. This satisfies oxygen's octet (2 + 2 shared + 4 non-bonding = 8 electrons) without any double bond.

Double bonds form only when a single bond leaves valencies unsatisfied, as in ethene (C_2H_4).

Source: Chapter 4, Section 4.2 / 4.2.1

Explanation

- Examiners expect you to **clearly state the student is wrong**, then explain **why** using electron sharing logic.
- Key point: needing 2 more electrons means forming **2 bonds**, not necessarily **1 double bond**. H_2O forms two separate single bonds with two H atoms.
- Mentioning octet/duplet satisfaction shows conceptual clarity — that earns full marks.
- Contrast with a genuine double-bond situation (like ethene) to strengthen your answer — useful for the third mark.

Q9. deep | thorough-understanding | § 4.1 BONDING IN CARBON – THE COVALENT BOND **[2]**

In methane (CH_4), carbon forms four single bonds with four hydrogen atoms. A student suggests that carbon could instead form two double bonds, each shared with two hydrogen atoms. Explain why this is not possible, using the electronic configuration of hydrogen in your answer.

◆ **Carbon and its Compounds**

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Model Answer

A double bond requires both atoms involved to share **two** pairs of electrons. Hydrogen has only **one** electron in its outermost shell (electronic configuration: 1), so it can share only one electron — forming one single bond. It cannot form a double bond. Therefore, carbon cannot form two double bonds with hydrogen atoms in CH_4.

Source: Chapter 4, Section 4.2 & 4.2.1

Explanation

- The key point examiners expect: **hydrogen's valency is 1** because it has only 1 electron and needs just 1 more to complete its shell (duplet). It can only ever form **one** covalent bond.
- A double bond needs each atom to contribute **2 electrons** to the shared pairs — hydrogen simply doesn't have enough electrons to do this.
- Always link the electronic configuration (2,1 → only 1 electron available for sharing) to the conclusion. Writing "hydrogen has valency 1" alone without explaining *why* may lose a mark.

Q10. deep | thorough-understanding | § 4.1 BONDING IN CARBON – THE COVALENT BOND **[3]**

In diamond, each carbon atom is bonded to four other carbon atoms in a three-dimensional structure, whereas in graphite, each carbon atom is bonded to only three others in layered planes. Using the properties of covalent bonds, explain why diamond is the hardest known substance while graphite is smooth and slippery.

◆ **Carbon and its Compounds**

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Model Answer

In **diamond**, each carbon atom forms covalent bonds with **four other carbon atoms** in a rigid three-dimensional network. This extensive cross-linking leaves no free electrons and creates an extremely strong, compact structure with no weak points, making diamond the **hardest known substance**.

In **graphite**, each carbon atom bonds to only **three other carbon atoms** in flat hexagonal layers. The fourth valence electron forms a weak force between the layers. These layers can slide easily over one another, making graphite **smooth and slippery**.

Thus, the difference in bonding pattern — 4 bonds (3D) vs. 3 bonds (layered) — explains their contrasting physical properties.

Source: Chapter 4, Allotropes of Carbon (More to Know!)

Explanation

- Examiners look for: (1) diamond — 4 bonds, 3D rigid network → hardness; (2) graphite — 3 bonds, layered planes → slipperiness. Award 1 mark each, with 1 mark for linking bond type to property.
- Do **not** say "ionic bonds" — these are covalent structures.
- Mentioning the "fourth valence electron / double bond" in graphite as the inter-layer weak force is a bonus point but keep it brief.
- Avoid over-writing; the passage itself is your authority here.

Q11. deep | thorough-understanding | § 4.1 BONDING IN CARBON – THE COVALENT BOND **[3]**

Graphite conducts electricity, yet it is a non-metal made entirely of carbon atoms joined by covalent bonds. How can this be explained given that covalent compounds are generally poor conductors?

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Model Answer

Covalent compounds are generally poor conductors because electron sharing produces no free charged particles (ions). However, graphite is an exception due to its unique structure.

In graphite, each carbon atom is bonded to **three** other carbon atoms in the same plane in a hexagonal arrangement, with one double bond. This leaves each carbon atom with one electron not used in bonding. These electrons are free to move across the layers, allowing graphite to conduct electricity.

Thus, graphite conducts electricity not because it forms ions, but because of its special layered structure that allows the movement of free electrons.

Source: Chapter 4, Allotropes of Carbon (More to Know)

Explanation

- The examiner wants you to first acknowledge the general rule (covalent compounds don't conduct), then **explain graphite as an exception using its structure**.
- Key facts to mention: 3 bonds per carbon atom → one free/delocalized electron per atom → free electrons carry charge.
- The passage states graphite is "a very good conductor of electricity unlike other non-metals" — always quote or reference the textbook reason.
- Do **not** use the word "delocalized" if you haven't been taught it formally; instead say "free electrons" which is sufficient for CBSE Class 10.

Q12. medium | thorough-understanding | § 4.1 BONDING IN CARBON – THE COVALENT BOND **[2]**

Both carbon and silicon belong to Group 14 of the periodic table and have a valency of 4, yet carbon shows extensive catenation while silicon does not. Explain the property of the carbon atom that accounts for this difference, and state what this means for the stability of C–C chains compared to Si–Si chains.

◆ Carbon and its Compounds

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Model Answer

Carbon's small atomic size allows its nucleus to hold shared electron pairs very strongly, making the **C–C bond very strong and stable**. This property, called **catenation**, allows carbon to form long, stable chains.

Silicon, though also tetravalent, has a larger atom, so Si–Si bonds are much weaker, making silicon hydride chains (up to 7–8 atoms) **very reactive and unstable**.

Source: Chapter 4, Section 4.2 – Versatile Nature of Carbon

Explanation

- Examiners expect **two key points**: (1) small size → strong bond, and (2) contrast with silicon's weak/reactive chains.
- The term **catenation** must appear.
- Avoid over-explaining; two tight sentences covering both points earn full marks.
- "Strong bond = stable chain" is the core logic the examiner is looking for.

Q13. medium | thorough-understanding | § 4.1 BONDING IN CARBON – THE COVALENT BOND **[3]**

The melting point of ethanol is 156 K and its boiling point is 351 K, while sodium chloride (an ionic compound) melts above 1000 K. What does this large difference in melting points tell us about the relative strengths of the forces operating between the particles in each compound?

◆ Carbon and its Compounds

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Model Answer

Ethanol is a covalent compound. In covalent compounds, the molecules are held together by **weak intermolecular forces**, which require little energy to overcome. Hence ethanol has a low melting point (156 K).

Sodium chloride is an ionic compound made up of oppositely charged Na^+ and Cl^- ions held together by **strong electrostatic forces of attraction**. A large amount of energy is needed to break these forces, resulting in a very high melting point (above 1000 K).

Therefore, the large difference in melting points shows that **intermolecular forces in ethanol are much weaker** than the ionic forces in sodium chloride.

Source: Chapter 4, Section 4.1 – Bonding in Carbon – The Covalent Bond

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Explanation

- Examiners want two clear contrasts: weak intermolecular forces (covalent/ethanol) vs. strong electrostatic/ionic forces (NaCl).
- Mention both compounds by name and link the force to the melting point.
- The key phrase from the textbook is: *"covalently bonded molecules have strong bonds within the molecule, but inter-molecular forces are weak"* — use this logic explicitly.
- Do not just say "covalent is weak, ionic is strong" without explaining *why* that leads to different melting points.

Q14. medium | thorough-understanding | § 4.1 BONDING IN CARBON – THE COVALENT BOND **[2]**

If carbon were to form a C^{4+} ion by losing all four of its valence electrons, which shell would become its outermost shell, and how many electrons would it contain? Explain why such an arrangement makes ionic bonding energetically unfavourable for carbon compared to covalent bonding.

◆ Carbon and its Compounds

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Model Answer

If carbon loses all four valence electrons to form C^{4+}, the **K shell** (first shell) would become its outermost shell, containing **2 electrons**.

This arrangement is energetically unfavourable because removing four electrons from carbon requires a **very large amount of energy**. The resulting C^{4+} cation would have six protons holding only two electrons, making it highly unstable. Therefore, carbon prefers **sharing** its four valence electrons to form stable covalent bonds instead.

Source: Chapter 4, Section 4.1 — Bonding in Carbon: The Covalent Bond

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Explanation

- Examiners expect you to correctly identify the K shell with 2 electrons (carbon's configuration is 2, 4).
- The key reasoning from the textbook: forming C^{4+} needs a **large amount of energy** — state this explicitly.
- Mention the instability (6 protons holding 2 electrons) to earn full marks.
- Don't write more than this — 2 marks = roughly 2 key points.

Q15. deep | thorough-understanding | § 4.1 BONDING IN CARBON – THE COVALENT BOND **[5]**

A student claims that because N_2 has a triple bond and H_2 has a single bond, nitrogen gas should be three times more reactive than hydrogen gas. Do you agree? Compare the bonding in N_2 and H_2 in terms of shared electron pairs and bond strength, and use this to explain the relative chemical reactivity of the two molecules.

◆ **Carbon and its Compounds**

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Model Answer

No, the student's claim is incorrect.

More bonds do not mean more reactivity — in fact, the opposite is true here.

- **H_2** has a **single bond** — one shared electron pair between the two hydrogen atoms. This bond is relatively **weaker and easier to break**, making H_2 fairly reactive.
- **N_2** has a **triple bond** — three shared electron pairs between the two nitrogen atoms. This makes the N≡N bond **extremely strong and stable**, so it is very difficult to break.

Bond strength determines reactivity: a stronger bond requires more energy to break, making the molecule **less reactive**, not more. This is similar to how unsaturated carbon compounds (with double/triple bonds between carbons) are *more* reactive than saturated ones, but in N_2, the triple bond is so strong that the molecule is largely **inert** under normal conditions.

Therefore, N_2 is actually **much less reactive** than H_2, despite having more bonds.

Explanation

Examiners look for: (1) correctly rejecting the claim, (2) defining single vs triple bond in terms of shared electron pairs, (3) linking bond strength to reactivity (more bonds = stronger, harder to break = less reactive for N_2), and (4) contrast with H_2's weaker bond making it more reactive. The source passages establish that stronger bonds (as in carbon's stable C–C bonds) mean greater stability/less reactivity — apply the same logic to N_2 vs H_2. Avoid writing that "more bonds = more reactive" — that is the misconception being tested.

Q16. medium | thorough-understanding | § 4.2 VERSATILE NATURE OF CARBON **[3]**

Carbon and silicon both belong to the same group of the periodic table, yet the number of known carbon compounds far exceeds the number of known silicon compounds. Give two reasons why carbon's catenation leads to a vastly greater variety of stable compounds compared to silicon.

◆ Carbon and its Compounds

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Model Answer

Two reasons why carbon's catenation produces far more stable compounds than silicon:

1. **Strength of C–C bond:** The carbon–carbon bond is very strong and stable due to carbon's small atomic size, which allows the nucleus to hold shared electron pairs firmly. Silicon has larger atoms, so Si–Si bonds are much weaker, making silicon hydride chains (up to 7–8 atoms) highly reactive and unstable.

1. **Variety of bonding in chains:** Carbon can form single, double, or triple bonds between atoms, and can arrange into straight chains, branched chains, or rings. Silicon lacks this ability, severely limiting the variety of compounds it can form.

Source: Chapter 4, Section 4.2 – Versatile Nature of Carbon

Explanation

- The examiner expects **two distinct, well-explained points** — each worth ~1.5 marks.
- Key terms to use: **catenation**, **C–C bond strength**, **small atomic size**, **single/double/triple bonds**, **chains/rings**.
- Don't just say "silicon is reactive" — explain **why** (larger atom → weaker bonds). That's the scoring detail.
- Avoid padding; two tight points with a reason each is all that's needed for 3 marks.

Q17. medium | thorough-understanding | § 4.2 VERSATILE NATURE OF CARBON **[3]**

Ethyne (C_2H_2) decolourises bromine water while ethane (C_2H_6) does not. Based on the nature of bonding in each compound, explain this difference in reactivity.

◆ Carbon and its Compounds

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Model Answer

Ethyne (C_2H_2) is an **unsaturated hydrocarbon** containing a **carbon–carbon triple bond** (C≡C). The extra bonds (pi bonds) are weaker and electron-rich, making them available for **addition reactions**. Bromine from bromine water adds across the triple bond, decolourising it.

Ethane (C_2H_6) is a **saturated hydrocarbon** with only **single bonds**. All valencies are fully satisfied, leaving no electron-rich bonds available for addition. Hence, it does not react with bromine water and cannot decolourise it.

Source: Chapter 4, Section 4.2.1 – Saturated and Unsaturated Carbon Compounds

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Explanation

- The key distinction examiners want: **saturated vs. unsaturated**, and linking that to **addition reaction** capability.
- Mention the **triple bond** in ethyne specifically — one mark is typically for bond type, one for the reaction type (addition), one for why ethane does not react.
- Avoid over-explaining; the passage confirms unsaturated compounds "are more reactive than the saturated carbon compounds" — use this directly.

Q18. straightforward | thorough-understanding | § 4.2 VERSATILE NATURE OF CARBON **[1]**

Which of the following pairs are structural isomers of each other?
(A) n-Butane (C_4H_{10}) and 2-methylpropane (C_4H_{10})
(B) C_3H_8 and C_3H_6
(C) C_5H_{12} and C_4H_{10}
(D) C_2H_6 and C_2H_4

A C_4H_{10} (straight chain) and C_4H_{10} (branched chain)
B C_3H_8 and C_3H_6
C C_5H_{12} and C_4H_{10}
D C_2H_6 and C_2H_4

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Model Answer

(A) n-Butane (C_4H_{10}) and 2-methylpropane (C_4H_{10}) are structural isomers as both have the same molecular formula C_4H_{10} but different carbon skeletons (straight chain and branched chain).

Explanation

Structural isomers must have the **same molecular formula but different structures**. Only option (A) satisfies this — both compounds are C_4H_{10}. Options B, C, D pair compounds with different molecular formulae, so they cannot be isomers. The textbook explicitly uses butane and 2-methylpropane (isobutane) as the example of structural isomers.

Q19. deep | thorough-understanding | § 4.2 VERSATILE NATURE OF CARBON **[5]**

A student claims that CH_3OH, C_2H_5OH and C_3H_7OH belong to a homologous series. (i) State two pieces of evidence from their formulae and properties that support this claim. (ii) Predict one physical property that will differ between methanol and propanol, and explain why.

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Model Answer

(i) Two pieces of evidence that CH_3OH, C_2H_5OH and C_3H_7OH form a homologous series:

1. **Same functional group:** All three compounds contain the –OH (hydroxyl) functional group, giving them similar chemical properties.

1. **Successive members differ by $-CH_2-$ unit:** $CH_3OH \rightarrow C_2H_5OH \rightarrow C_3H_7OH$; each successive compound differs by one $-CH_2-$ unit (molecular mass difference = 14 u), giving the general formula $C_nH_{2n+1}OH$.

(ii) Physical property that differs — Boiling point:

Propanol (C_3H_7OH) has a **higher boiling point** than methanol (CH_3OH). As molecular mass increases in a homologous series, intermolecular forces increase, so more heat energy is needed to separate the molecules. Since propanol has a greater molecular mass (60 u) than methanol (32 u), its boiling point is higher.

Source: Chapter 4, Section 4.2.4 — Homologous Series

Explanation

- Part (i) is worth ~2 marks: examiners expect **same functional group** AND **$-CH_2-$ difference** — give both clearly.
- Part (ii) is worth ~3 marks: name the property, state the comparative difference, and give the reason (increasing molecular mass → stronger intermolecular forces → higher boiling point). All three steps are needed for full credit.
- The textbook explicitly states: *"As molecular mass increases in any homologous series, a gradation in physical properties is seen... melting and boiling points increase with increasing molecular mass."* Quote or paraphrase this reasoning.
- Do not just say "boiling point differs" — always state *which is higher* and *why*.

Q20. deep | thorough-understanding | § 4.2 VERSATILE NATURE OF CARBON **[3]**

Cyclohexane (C_6H_{12}) and cyclohexene (C_6H_{10}) both have carbon atoms arranged in a ring, yet they show different chemical behaviour with bromine water. Identify the class each belongs to (saturated or unsaturated hydrocarbon) and justify your answer using their molecular formulae and the result of the bromine water test.

◆ Carbon and its Compounds

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Model Answer

Cyclohexane (C_6H_{12}) — Saturated hydrocarbon:

Its molecular formula matches the general formula C_nH_{2n}, with all single bonds between carbon atoms. All valencies are satisfied by single bonds, so no scope for further addition of atoms.

Cyclohexene (C_6H_{10}) — Unsaturated hydrocarbon:

Its formula (C_nH_{2n-2}) indicates fewer hydrogen atoms, which means it contains a carbon–carbon double bond.

Bromine water test:

Cyclohexane does **not** decolourize bromine water (saturated; unreactive). Cyclohexene **decolourizes** bromine water immediately, as the double bond allows addition of bromine across it. This confirms cyclohexene is unsaturated.

Source: Chapter 4, Section 4.2.1 – Saturated and Unsaturated Carbon Compounds

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Explanation

- Examiners expect: correct class identified for each compound + molecular formula justification + bromine water result linked to reactivity.
- Key rule: saturated hydrocarbons do **not** decolourize bromine water; unsaturated ones do (addition reaction at the double/triple bond).
- Cyclohexane's formula $C_6H_{12} = C_nH_{2n}$ (same as alkenes, but ring structure with all single bonds — still saturated). Cyclohexene has one double bond, making it unsaturated.
- Don't just state the result — **link** the bromine water observation to the bond type for full marks.

Q21. medium | thorough-understanding | § 4.2.1 Saturated and Unsaturated Carbon Compounds **[3]**

Ethyne (C_2H_2) is described as an unsaturated compound, while ethane (C_2H_6) is saturated. What structural feature makes ethyne unsaturated, and why does this make it more reactive than ethane?

◆ **Carbon and its Compounds**

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Model Answer

Ethyne (C_2H_2) contains a **triple bond** between its two carbon atoms (C≡C). This means its carbon atoms are not bonded to the maximum possible number of hydrogen atoms, making it an **unsaturated** compound. Ethane (C_2H_6), on the other hand, has only single bonds with all valencies satisfied by hydrogen atoms, so it is **saturated**.

The triple bond in ethyne makes it more reactive because it can undergo **addition reactions**, where other atoms or groups add across the multiple bond. Saturated ethane, having no such multiple bonds, is fairly unreactive and undergoes only slow substitution reactions.

Source: Chapter 4, Section 4.2.1 – Saturated and Unsaturated Carbon Compounds

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Explanation

- **Key structural point (1 mark):** Ethyne has a C≡C triple bond; ethane has only C–C single bonds.
- **Definition link (1 mark):** Unsaturated = double or triple bond present; saturated = only single bonds.
- **Reactivity reason (1 mark):** Multiple bonds allow addition reactions; single bonds allow only slow substitution — examiners expect this contrast explicitly stated.
- Don't just say "more bonds = more reactive"; name the **type of reaction** (addition vs. substitution).

Q22. medium | thorough-understanding | § 4.2.1 Saturated and Unsaturated Carbon Compounds **[3]**

A student is given two unlabelled compounds with molecular formulas C_3H_8 and C_3H_6. (i) Using the general formula for alkanes and alkenes, determine which compound is saturated and which is unsaturated. (ii) Describe one chemical test the student could perform to confirm this, stating the expected observation for each compound.

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Model Answer

(i) The general formula for alkanes is C_nH_{2n+2} and for alkenes is C_nH_{2n}.

- C_3H_8: For $n = 3, 2(3) + 2 = 8$ → matches alkane formula. It is **saturated** (propane).
- C_3H_6: For $n = 3, 2(3) = 6$ → matches alkene formula. It is **unsaturated** (propene).

(ii) Test: Pass each compound through bromine water (or bromine solution).

- C_3H_6 (unsaturated): Bromine water gets **decolourised** due to addition reaction across the double bond.
- C_3H_8 (saturated): Bromine water shows **no colour change** as saturated hydrocarbons do not undergo addition reactions.

Source: Carbon and its Compounds, Section 4.2.2 and Exercise Q.13–14

Explanation

- Examiners expect you to explicitly apply the general formulas C_nH_{2n+2} (alkanes) and C_nH_{2n} (alkenes) and substitute $n = 3$ — don't just state the answer without showing the check.
- For the chemical test, bromine water (decolourisation) is the standard NCERT-expected answer. The textbook Exercise Q.14 directly asks for a test to differentiate saturated and unsaturated hydrocarbons — this is it.
- Avoid writing about the combustion/flame test here; it is less reliable as a distinguishing test compared to bromine water.

Q23. medium | thorough-understanding | § 4.2.2 Chains, Branches and Rings **[3]**

Two compounds, n-butane and isobutane, share the molecular formula C_4H_{10}. (i) Draw the structural formulae of both compounds. (ii) What term is used for such pairs of compounds? (iii) Compare any two physical or chemical properties that would differ between these two compounds as a result of their different structures.

◆ Carbon and its Compounds

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Model Answer

(i) Structural formulae:

n-Butane (straight chain):

$$CH_3 - CH_2 - CH_2 - CH_3$$

Isobutane (branched chain):

$$CH_3 - \overset{|}{\underset{|}{C}}H(CH_3) - CH_3$$

i.e., a central carbon bonded to three $-CH_3$ groups and one H.

(ii) Such compounds with identical molecular formula but different structures are called **structural isomers**.

(iii) Two differing properties:

- **Boiling point:** n-Butane has a higher boiling point than isobutane because its straight chain allows closer packing between molecules.
- **Reactivity:** The branched structure of isobutane makes it slightly more reactive than n-butane in certain reactions due to steric and structural differences.

Source: Carbon and its Compounds, Section 4.2.2 — Chains, Branches and Rings

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Explanation

- Part (i): Draw both clearly — a 4-carbon straight chain and a branched structure with a central carbon carrying three methyl groups.
- Part (ii): The exact NCERT term is "structural isomers" — use it precisely.
- Part (iii): The passage does not explicitly list physical properties of these two isomers, so use general knowledge of isomers: branched chains have lower boiling points due to less surface contact. Examiners accept any two valid, relevant points. Avoid vague statements — be specific.

Q24. medium | thorough-understanding | § 4.2.2 Chains, Branches and Rings **[1]**

Hexane and cyclohexane both contain six carbon atoms. Write their molecular formulae and explain why the two formulae differ, relating your answer to the structural difference between the two compounds.

◆ Carbon and its Compounds

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Model Answer

Hexane: C_6H_{14}; Cyclohexane: C_6H_{12}. Hexane is an open chain (straight chain), so it has 2 extra H atoms compared to cyclohexane, which has carbon atoms arranged in a ring, reducing the hydrogen count by 2.

Source: Carbon and its Compounds, Section 4.2.2

Explanation

The key point is the structural difference: open chain vs. ring. When a chain closes into a ring, two terminal hydrogen atoms are lost to form the extra C–C bond, hence the formula drops from C_6H_{14} to C_6H_{12}. The examiner wants both formulae stated and a one-line structural reason.

Q25. medium | thorough-understanding | § 4.2.3 Will you be my Friend? **[3]**

In an organic compound, all hydrogen atoms bonded to carbon are replaced one by one with chlorine atoms. (i) What is the term used for the –Cl group in organic chemistry? (ii) A chemist states that whether the compound has 2 carbon atoms or 10 carbon atoms in its chain, the chemical reactions it undergoes will remain largely the same. Explain why the chemist's statement is correct.

◆ Carbon and its Compounds

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Model Answer

(i) The –Cl group is called a **functional group** (specifically, the halo/chloro functional group). It is also referred to as a **heteroatom** when considered as the replacing atom.

(ii) The chemist's statement is correct because **chemical properties of a carbon compound are determined solely by its functional group, regardless of the length of the carbon chain**. Whether the chloro (–Cl) group is attached to a 2-carbon or 10-carbon chain, it confers the same characteristic chemical properties to the compound. This is the basis of a **homologous series** — members differ in chain length but show similar chemical behaviour.

Source: Chapter 4, Sections 4.2.3 and 4.2.4

Explanation

- For part (i), examiners accept "functional group" or "heteroatom"; both terms appear in the passage. Writing both is safest.
- For part (ii), the key phrase to use is: *"chemical properties are determined solely by the functional group, regardless of the length of the carbon chain"* — this is almost directly from the textbook and will earn full marks.
- Mentioning "homologous series" shows higher-order understanding and impresses examiners.
- Do not write about physical properties changing — that would contradict the chemist's statement and cost marks.

Q26. deep | thorough-understanding | § 4.2.3 Will you be my Friend? **[3]**

Two organic compounds — one with the structure CH_3CH_2OH and another with the structure $CH_3CH_2CH_2CH_2OH$ — both belong to the same class of compounds. Despite having different carbon chain lengths, a chemist predicts their chemical properties will be very similar, but expects their boiling points to differ. Justify both parts of the chemist's prediction.

◆ **Carbon and its Compounds**

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Model Answer

Both CH_3CH_2OH (ethanol) and $CH_3CH_2CH_2CH_2OH$ (butan-1-ol) belong to the **homologous series of alcohols** — they share the same functional group (–OH). Since chemical properties are determined solely by the functional group, both compounds show very similar chemical reactions (e.g., reaction with sodium, oxidation).

However, their boiling points differ because, in a homologous series, **boiling point increases with increasing molecular mass**. Butan-1-ol has a higher molecular mass (74 u) than ethanol (46 u), so it has a higher boiling point.

Source: Carbon and its Compounds, Section 4.2.4 — Homologous Series

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Explanation

- **Part 1 (similar chemical properties):** Examiners want the key phrase: "functional group determines chemical properties, regardless of chain length." Name the functional group (–OH) and state it's a homologous series.
- **Part 2 (different boiling points):** The textbook explicitly states "melting and boiling points increase with increasing molecular mass" in a homologous series. Mentioning the actual molecular masses (46 u vs 74 u) adds precision and earns full marks.
- Don't write more than this — padding loses time without gaining marks.

Q27. medium | thorough-understanding | § 4.2.4 Homologous Series **[2]**

Two successive members of a homologous series always differ by a $-CH_2-$ unit. What is the corresponding difference in their molecular masses, and why is this value constant throughout the series?

◆ **Carbon and its Compounds**

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Model Answer

Two successive members of a homologous series differ in molecular mass by **14 u**.

This is because they differ by one $-CH_2-$ unit, and the mass of C = 12 u and 2 × H = 2 u, giving 12 + 2 = **14 u**.

This value is constant throughout the series because each successive member differs by exactly one $-CH_2-$ unit, no more and no less.

Source: Chapter 4, Section 4.2.4 – Homologous Series

Explanation

- The examiner expects you to state the value (14 u) and justify it using atomic masses (C = 12, H = 1 each, so CH_2 = 14).
- Always show the arithmetic: 12 + 2(1) = 14 u — this is where the mark lies.
- The second mark is for explaining *why* it is constant: every successive pair differs by exactly one $-CH_2-$ unit, making the difference uniform across the series.
- Do not just say "14 u" without justification — that will cost you the reasoning mark.

Q28. deep | thorough-understanding | § 4.2.4 Homologous Series **[3]**

Pentanol ($C_5H_{11}OH$) and methanol (CH_3OH) belong to the same homologous series but have very different boiling points, whereas their chemical behaviour with sodium metal is essentially the same. What principle of homologous series explains each of these observations?

◆ **Carbon and its Compounds**

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Model Answer

A homologous series is a group of compounds with the same functional group, differing by a $-CH_2-$ unit each time.

Different boiling points: As molecular mass increases in a homologous series, physical properties (such as boiling point) show a gradation. Pentanol ($C_5H_{11}OH$, mol. mass = 88 u) has a much higher molecular mass than methanol (CH_3OH, mol. mass = 32 u), so its boiling point is significantly higher.

Same chemical behaviour with sodium: Chemical properties in a homologous series are determined solely by the functional group. Both pentanol and methanol contain the –OH (hydroxyl) functional group, so they react identically with sodium metal.

Source: Chapter 4, Section 4.2.4 – Homologous Series

Explanation

- Examiners expect two separate, clearly labelled observations explained using the two key properties of a homologous series.
- **Physical properties** (boiling point, melting point, solubility) show **gradation** with increasing molecular mass — this is the principle for the first part.
- **Chemical properties** depend **only on the functional group**, not on chain length — this explains the second part.
- Mention actual molecular masses or the $-CH_2-$ difference to show you understand the series; this earns the third mark.

Q29. deep · thorough-understanding · § 4.2.4 Homologous Series **[3]**

A student argues: 'Butanol and ethanol belong to the same homologous series, so they must have identical boiling points and identical solubility in water.' Is this argument correct? Justify your answer by explaining what properties actually remain similar across a homologous series and what properties change, giving reasons for each.

◆ Carbon and its Compounds

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Model Answer

The student's argument is **partially correct but partially wrong**.

What is correct: Both butanol and ethanol belong to the same homologous series (alcohols) and share the same functional group (–OH). Therefore, their **chemical properties are similar** — both react with sodium to release hydrogen, and undergo similar reactions.

What is incorrect: Physical properties such as **boiling point and solubility change** across a homologous series. As molecular mass increases (butanol > ethanol), boiling point increases. Solubility in water also shows a gradation — ethanol is completely miscible with water, while butanol has lower solubility. These physical properties differ because each successive member differs by a $-CH_2-$ unit, increasing molecular mass.

Source: Chapter 4, Section 4.2.4 — Homologous Series

Explanation

Examiners look for three things here:

1. **Identifying what is correct** — same functional group → similar chemical properties.
2. **Identifying what is wrong** — boiling point and solubility are physical properties that *change* with molecular mass (gradation).
3. **Reason** — each member differs by $-CH_2-$, so molecular mass increases → boiling point increases, solubility decreases.

The key textbook line is: *"As the molecular mass increases in any homologous series, a gradation in physical properties is seen... But the chemical properties... remain similar."* Quote or paraphrase this for full marks.

Q30. medium | thorough-understanding | § 4.2.5 Nomenclature of Carbon Compounds **[2]**

A carbon compound has three carbon atoms in its chain and contains a ketone functional group. What is its IUPAC name? Show the reasoning steps you used to arrive at the name.

◆ **Carbon and its Compounds**

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Model Answer

Reasoning Steps:

1. The compound has **3 carbon atoms** → base name is **propane**.
2. The functional group is a **ketone** → suffix is **"-one"** (Table 4.4).
3. Since "-one" begins with a vowel, drop the final **'e'** from propane:

Propan**e** – 'e' + **one** = **Propanone**

IUPAC Name: Propanone

Source: Chapter 4, Section 4.2.5 — Nomenclature of Carbon Compounds

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Explanation

Examiners award **1 mark for correct reasoning** (identifying base chain + applying suffix rule) and **1 mark for the correct IUPAC name**. The key rule to remember: when a suffix starts with a vowel (like "-ol", "-al", "-one"), drop the final 'e' of the parent chain name before adding it. Writing the steps clearly secures full marks even if the final name has a minor slip.

Q31. deep | thorough-understanding | § 4.2.5 Nomenclature of Carbon Compounds **[3]**

A student is given two compounds: 'butane' and 'but-1-yne'. (i) Draw their structural formulae and identify the type of bond(s) present in each. (ii) Predict the key differences in their chemical reactivity. (iii) Name the homologous series to which each compound belongs and state one characteristic property of a homologous series.

◆ Carbon and its Compounds

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Model Answer

(i) Structural formulae:

Butane (C_4H_{10}): $CH_3—CH_2—CH_2—CH_3$
Bond type: Only **single bonds** (C–C and C–H). It is a saturated compound.

But-1-yne (C_4H_6): $CH≡C—CH_2—CH_3$
Bond type: Contains one **triple bond** (C≡C) and single bonds. It is unsaturated.

(ii) Chemical reactivity:

- Butane undergoes **substitution reactions** (e.g., with chlorine in sunlight).
- But-1-yne undergoes **addition reactions** (e.g., with H_2, Cl_2, HCl) due to the triple bond. Unsaturated compounds are more reactive than saturated ones.

(iii) Homologous series:

- Butane belongs to **alkanes**; but-1-yne belongs to **alkynes**.
- **Characteristic property:** Successive members of a homologous series differ by a $–CH_2–$ unit (molecular mass difference of 14 u), and members show a gradation in physical properties but similar chemical properties.

Source: Chapter 4, Section 4.2.4 – Homologous Series; Section 4.2.2 – Chains, Branches and Rings

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Explanation

- Examiners expect the structural formula drawn as a condensed/chain structure — full electron dot structure is not required here unless asked.
- The key contrast for reactivity is **substitution (saturated) vs. addition (unsaturated)** — these exact terms score marks.
- For homologous series property, state **both** the $–CH_2–$ difference AND similar chemical properties; either alone may lose half a mark.
- "Alkanes" and "alkynes" are the required series names — do not write just "hydrocarbons."

Q32. deep | thorough-understanding | § 4.3 CHEMICAL PROPERTIES OF CARBON COMPOUNDS **[3]**

Ethyne (C_2H_2) is used as fuel in oxy-acetylene welding, where it is burnt with pure oxygen rather than air. (i) Explain why burning ethyne in air produces a sooty, less hot flame compared to burning it in pure oxygen. (ii) Unsaturated hydrocarbons generally require more oxygen per carbon atom for complete combustion than saturated hydrocarbons. Justify this statement with reference to the molecular formulae of ethane (C_2H_6) and ethyne (C_2H_2), and write balanced chemical equations for the complete combustion of each.

◆ Carbon and its Compounds

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Model Answer

(i) Ethyne is an unsaturated hydrocarbon with a high carbon-to-hydrogen ratio. When burnt in air, the oxygen supply is insufficient for complete combustion, so it burns with a yellow, sooty flame and produces less heat. Pure oxygen ensures complete combustion, giving a much hotter, cleaner flame.

(ii) Ethyne (C_2H_2) has a higher proportion of carbon relative to hydrogen compared to ethane (C_2H_6), so it requires more oxygen per carbon atom for complete combustion.

Balanced equations:

Ethane: $2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$

Ethyne: $2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O$

Ethyne needs 2.5 mol O_2 per carbon, while ethane needs 1.75 mol O_2 per carbon, confirming unsaturated hydrocarbons demand more oxygen.

Source: Chapter 4, Section 4.3.1 Combustion; Section 4.2.1 Saturated and Unsaturated Carbon Compounds

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Explanation

- Part (i) is directly from the textbook: unsaturated hydrocarbons burn with a sooty, yellow flame due to insufficient oxygen; this is exactly why pure oxygen (not air) is used in oxy-acetylene welding.
- Part (ii): examiners expect both balanced equations AND a comparison of O_2 required per carbon atom. Show the ratio explicitly — this earns the justification mark.
- Common mistake: forgetting to balance equations properly or not relating the result back to the question's claim.

Q33. medium | thorough-understanding | § 4.3.1 Combustion **[3]**

A student burns two different hydrocarbons — one saturated and one unsaturated — and holds a metal plate above each flame. What difference would she observe on the metal plate, and why does this difference occur?

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Model Answer

Observation: A sooty (black) deposit will appear on the metal plate held above the **unsaturated** hydrocarbon's flame. The plate held above the **saturated** hydrocarbon's flame will remain comparatively clean (little or no soot).

Reason: Unsaturated hydrocarbons contain multiple bonds (C=C or C≡C) and have a higher carbon-to-hydrogen ratio. They undergo incomplete combustion, producing a yellow, sooty flame with unburnt carbon particles that deposit as soot on the plate. Saturated hydrocarbons combust more cleanly, giving a blue flame with no sooty deposit.

Source: Chapter 4, Section 4.3.1 – Combustion

Explanation

- Examiners award marks for: (1) correct observation for each hydrocarbon, (2) linking unsaturated compounds to sooty/yellow flame and incomplete combustion, and (3) explaining why (higher C:H ratio / multiple bonds → incomplete combustion → carbon deposit).
- Use the textbook's exact language: "saturated hydrocarbons give a clean flame; unsaturated carbon compounds give a yellow flame with lots of black smoke / sooty deposit."
- Do **not** write a lengthy essay — two short paragraphs covering observation + reason is ideal for 3 marks.

Q34. medium | thorough-understanding | § 4.3.1 Combustion **[3]**

A gas stove flame that was previously blue has turned yellow and the bottom of the cooking vessel is getting covered with a black deposit. Identify the cause of this change and explain what the black deposit is.

◆ Carbon and its Compounds

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Model Answer

Cause: The air holes of the gas stove are blocked, causing insufficient oxygen supply. This leads to **incomplete combustion** of the fuel (LPG).

Blue → Yellow flame: When the air supply is adequate, complete combustion occurs giving a clean blue flame. With blocked air holes, incomplete combustion produces a yellow, sooty flame.

Black deposit: The black substance deposited on the bottom of the vessel is **carbon (soot)**. During incomplete combustion, the carbon in the fuel is not fully oxidised to CO_2, and unburnt carbon particles are deposited as soot.

Source: Chapter 4, Section 4.3.1 Combustion

Explanation

- Examiners expect three clear points: (1) cause — blocked air holes/insufficient air, (2) incomplete combustion producing yellow flame, (3) black deposit = unburnt carbon/soot.
- The textbook explicitly states: *"If you observe the bottoms of cooking vessels getting blackened, it means that the air holes are blocked and fuel is getting wasted."*
- Use the terms **incomplete combustion** and **soot/unburnt carbon** — these are the key scoring words.

Q35. medium | thorough-understanding | § 4.3.1 Combustion **[1]**

Combustion of ethanol is classified as an oxidation reaction. Give one reason to justify this classification.

◆ Carbon and its Compounds

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Model Answer

In combustion of ethanol, oxygen is added to it, converting it into carbon dioxide and water. Addition of oxygen to a substance is defined as oxidation.

Explanation

The examiner expects you to link the definition of oxidation (addition of oxygen) directly to what happens during combustion. One crisp sentence stating that ethanol gains oxygen to form CO_2 and H_2O is sufficient for 1 mark. Avoid writing the full balanced equation unless asked.

Q36. deep | thorough-understanding | § 4.3.1 Combustion **[3]**

Ethyne (C_2H_2) is used as fuel in welding torches where it is burned with pure oxygen rather than air. Using your understanding of combustion of carbon compounds, explain: (i) why pure oxygen is preferred over air, and (ii) what type of combustion occurs when sufficient oxygen is available versus when it is insufficient, and what the observable difference would be.

◆ **Carbon and its Compounds**

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Model Answer

(i) Pure oxygen is preferred over air because air contains about 78% nitrogen, which dilutes the oxygen and lowers the flame temperature. Pure oxygen ensures a more complete and intense combustion of ethyne, producing a much hotter flame — sufficient for welding metals.

(ii) When **sufficient oxygen** is available, **complete combustion** occurs, producing CO_2 and H_2O with a clean blue flame. When oxygen is **insufficient**, **incomplete combustion** occurs, producing carbon (soot) and CO, with a **yellow, sooty flame**. The observable difference is a clean blue flame vs. a smoky, yellow, sooty flame.

Source: Chapter 4, Section 4.3.1 Combustion

Explanation

- The key contrast examiners expect: **complete vs. incomplete combustion** tied to oxygen supply.
- Mention **flame colour** (blue vs. yellow/sooty) — this comes directly from Activity 4.4 and the textbook paragraph on saturated/unsaturated combustion.
- For part (i), the point about **nitrogen diluting oxygen** and reducing flame temperature is the core reason stated in the textbook question ("why a mixture of ethyne and air is not used?").
- Don't forget to name the products of both types of combustion for full marks.

Q37. deep | thorough-understanding | § 4.3.1 Combustion **[5]**

Diamond, graphite, and fullerene are all allotropes of carbon. (i) Briefly describe the structural arrangement of carbon atoms in diamond and graphite, and explain how this accounts for the difference in their electrical conductivity and hardness. (ii) Despite these structural differences, what would you expect about their chemical behaviour during combustion, and why? (iii) A student argues that since diamond is much harder than graphite, it must also produce a different product on combustion. Do you agree? Justify.

◆ Carbon and its Compounds

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Model Answer

(i) Structure, Hardness, and Conductivity:

In **diamond**, each carbon atom is bonded to four others in a rigid tetrahedral 3D network. All four valence electrons are used in bonding, so no free electrons exist → diamond is a **non-conductor** and extremely **hard**.

In **graphite**, each carbon atom bonds to three others in flat hexagonal layers. The fourth electron is free to move between layers → graphite is a **good conductor**. The layers are held by weak forces and can slide over each other → graphite is **soft**.

(ii) Combustion behaviour:

Despite structural differences, both diamond and graphite are allotropes of carbon. On combustion, both burn in oxygen to produce only **carbon dioxide** with release of heat and light:

$$\mathrm{C} + \mathrm{O_2} \rightarrow \mathrm{CO_2} + \text{heat and light}$$

Their chemical behaviour during combustion is **identical** because the product depends on the element (carbon), not its structural form.

(iii) Disagreement with the student:

No, the student is **incorrect**. Hardness is a physical property related to structure, not a chemical property. Since diamond and graphite are both pure carbon, they produce the same product — **CO_2** — on combustion. The textbook states: *"Carbon, in all its allotropic forms, burns in oxygen to give carbon dioxide."*

Source: Chapter 4, Section 4.3.1 (Combustion)

Explanation

- Examiners expect you to clearly contrast diamond (3D network, non-conductor, hard) and graphite (layered, conductor, soft) using the concept of free electrons and bonding.
- The key textbook line for parts (ii) and (iii) is: *"Carbon, in all its allotropic forms, burns in oxygen to give CO_2."* Quote or paraphrase it — it directly answers the student's argument.
- Part (iii) tests whether you can distinguish **physical properties** (hardness) from **chemical properties** (combustion products). Always clarify this distinction.
- Keep the equation balanced and include "heat and light" — examiners often check for this.

Q38. deep | thorough-understanding | § 4.3.2 Oxidation **[3]**

Ethanol is treated separately with (i) alkaline potassium permanganate and (ii) excess concentrated sulphuric acid at 443 K. In each case, identify the organic product formed and explain why the two reactions belong to different categories of chemical reactions.

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Model Answer

(i) When ethanol is treated with alkaline potassium permanganate, it is **oxidised** to form **ethanoic acid (CH_3COOH)**.

(ii) When ethanol is heated with excess concentrated sulphuric acid at 443 K, **dehydration** occurs and **ethene ($CH_2=CH_2$)** is formed along with water.

Different categories:

- Reaction (i) is an **oxidation reaction** — oxygen is added to ethanol by the oxidising agent (alkaline $KMnO_4$).
- Reaction (ii) is a **dehydration (elimination) reaction** — water is removed from ethanol by the dehydrating agent (conc. H_2SO_4), producing an unsaturated hydrocarbon.

Thus, one reaction involves addition of oxygen, while the other involves removal of water — making them fundamentally different types.

Source: Chapter 4, Sections 4.3.2 and 4.4.1

Explanation

- Examiners expect both products named correctly — **ethanoic acid** and **ethene** — for full credit.
- You must clearly contrast the two reaction types: **oxidation** vs **dehydration/elimination**. Just naming the products is not enough.
- Use key terms: *oxidising agent*, *dehydrating agent*, *oxygen added*, *water removed*.
- The 3-mark split is typically: 1 mark for each product + 1 mark for explaining the two different categories.

Q39. medium | thorough-understanding | § 4.3.3 Addition Reaction **[3]**

Vegetable oils and vanaspati ghee both contain long carbon chains, yet doctors advise against regular consumption of vanaspati ghee. (i) How does the chemical nature of the carbon chains differ between vegetable oil and vanaspati ghee? (ii) Explain what happens to vegetable oil during hydrogenation and why this change makes the product less healthy. (iii) Name the catalyst used in this process and state its role.

◆ Carbon and its Compounds

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Model Answer

(i) Vegetable oils have **long unsaturated carbon chains** (contain C=C double bonds), whereas vanaspati ghee has **saturated carbon chains** (all single bonds), similar to animal fats.

(ii) During hydrogenation, hydrogen is added across the double bonds of unsaturated vegetable oil, converting it into a saturated fat (vanaspati ghee). Saturated fatty acids are considered harmful to health, making the hydrogenated product less healthy than the original oil.

(iii) The catalyst used is **nickel (Ni)**. It speeds up the addition of hydrogen to the unsaturated carbon chains without itself being consumed in the reaction.

Source: Chapter 4, Section 4.3.3 Addition Reaction

Explanation

- The examiner expects three distinct points matching the three sub-questions — don't merge them.
- Key terms to use: *unsaturated*, *saturated*, *double bonds*, *hydrogenation*, *nickel catalyst*.
- Avoid saying oils are "healthy" in general — the point is that **saturated** fats (product of hydrogenation) are harmful, not unsaturated ones.
- The role of catalyst is always: speeds up the reaction / causes it to proceed without being used up — state both parts for full credit.

Q40. deep | thorough-understanding | § 4.3.4 Substitution Reaction **[3]**

Methane reacts with chlorine in sunlight to give chloromethane (CH_3Cl) and HCl, but the same reaction does not occur in the dark. Given that saturated hydrocarbons are generally described as 'inert', how do you explain the fact that this reaction occurs at all, and why does sunlight play a crucial role in making it happen?

◆ **Carbon and its Compounds**

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Model Answer

Although saturated hydrocarbons are generally inert to most reagents, they can still undergo **substitution reactions** under specific conditions. In this reaction, a chlorine atom replaces one hydrogen atom of methane to form chloromethane (CH_3Cl) and HCl.

Sunlight is essential because it provides the energy needed to activate the chlorine molecules (Cl_2), enabling the reaction to proceed. Without sunlight, the activation energy is not supplied, so the reaction does not occur. This is why the same mixture of methane and chlorine shows no reaction in the dark.

$$\mathrm{CH_4 + Cl_2 \xrightarrow{\text{sunlight}} CH_3Cl + HCl}$$

Source: Chapter 4, Section 4.3.4 – Substitution Reaction

Explanation

- Examiners expect two clear points: (1) saturated hydrocarbons are inert *under normal conditions* but not absolutely unreactive, and (2) sunlight provides the activation energy needed to initiate the reaction.
- Name the reaction type (**substitution reaction**) — this is a key term the examiner will look for.
- Writing the balanced equation with the condition (sunlight) shown earns a mark on its own.
- Don't write about free radicals or chain mechanisms — that is beyond CBSE Class 10 scope and wastes word budget.

Q41. deep | thorough-understanding | § 4.4 SOME IMPORTANT CARBON COMPOUNDS – ETHANOL AND ETHANOIC ACID **[3]**

When ethanol is heated with concentrated sulphuric acid at 443 K, ethene is produced. When the same ethanol is warmed with glacial acetic acid in the presence of concentrated sulphuric acid, an ester is formed instead. What determines which product forms, and what role does concentrated sulphuric acid play in each case?

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Model Answer

What determines the product:

The reaction conditions determine the product. At 443 K with *excess* concentrated H_2SO_4, dehydration of ethanol occurs giving ethene. When ethanol is warmed with glacial acetic acid and concentrated H_2SO_4, esterification occurs giving ethyl ethanoate (ester).

Role of concentrated H_2SO_4:

- In dehydration: It acts as a **dehydrating agent**, removing water from ethanol to form ethene.

$$CH_3CH_2OH \xrightarrow{\text{Hot conc. } H_2SO_4\text{,443K}} CH_2{=}CH_2 + H_2O$$

- In esterification: It acts as an **acid catalyst**, speeding up the reaction between ethanoic acid and ethanol to form the ester.

$$CH_3COOH + C_2H_5OH \xrightarrow{\text{Acid}} CH_3COOC_2H_5 + H_2O$$

Source: Chapter 4, Sections 4.4.1 and 4.4.2

Explanation

- Examiners want two clear points: (1) what determines the product — temperature/conditions/reactant present, and (2) the dual role of conc. H_2SO_4 (dehydrating agent vs. acid catalyst).
- Writing both equations earns full credit and shows understanding.
- Do not confuse "dehydrating agent" (removes water from a single molecule) with "acid catalyst" (speeds up a reaction between two molecules). This distinction is what the question tests.

Q42. medium thorough-understanding § 4.4.1 Properties of Ethanol **[3]**

When ethanol reacts with sodium metal, hydrogen gas is evolved. What does this observation tell you about the nature of the O–H bond in ethanol compared to the C–H bonds in the same molecule?

◆ Carbon and its Compounds

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Model Answer

When ethanol reacts with sodium metal, hydrogen gas is evolved and sodium ethoxide is formed:

$$2\mathrm{Na} + 2\mathrm{C_2H_5OH} \rightarrow 2\mathrm{C_2H_5O^-Na^+} + \mathrm{H_2}\uparrow$$

This shows that only the O–H bond in ethanol is broken during this reaction, releasing hydrogen. The C–H bonds remain intact. This indicates that the O–H bond in ethanol is weaker and more reactive than the C–H bonds. The oxygen atom makes the O–H bond polar, allowing sodium to displace hydrogen easily, whereas C–H bonds are non-polar and relatively strong, making them unreactive with sodium.

Source: Chapter 4, Section 4.4.1 – Properties of Ethanol

Explanation

- Examiners expect the **chemical equation** for full marks — always include it.
- The key comparison is **O–H (polar/reactive) vs C–H (non-polar/unreactive)** — this is the core of the 3-mark answer.
- Mention that C–H bonds are **not broken** in this reaction; only the O–H bond reacts.
- The word "polar" is a bonus if you remember it, but saying "O–H is weaker/more reactive" is sufficient for CBSE.

Q43. medium | thorough-understanding | § 4.4.1 Properties of Ethanol **[2]**

Ethanol, when heated with concentrated sulphuric acid at 443 K, undergoes a chemical change. (i) What role does the concentrated sulphuric acid play in this reaction? (ii) Name the product formed and classify it as saturated or unsaturated. Write the chemical equation for the reaction.

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Model Answer

(i) Concentrated sulphuric acid acts as a **dehydrating agent** — it removes water from ethanol.

(ii) The product formed is **ethene (CH_2=CH_2)**. It is an **unsaturated** hydrocarbon (contains a C=C double bond).

Chemical equation:

$$CH_3CH_2OH \xrightarrow{\text{Hot conc. } H_2SO_4\text{, 443 K}} CH_2{=}CH_2 + H_2O$$

Source: Carbon and its Compounds, Section 4.4.1 (Properties of Ethanol)

Explanation

- The key term examiners look for is **"dehydrating agent"** — not catalyst or oxidising agent.
- Ethene must be correctly identified as **unsaturated** because of its C=C double bond; saturated compounds have only single bonds.
- Always write the balanced chemical equation with the condition (hot conc. H_2SO_4, 443 K) shown above the arrow.
- This reaction is called **dehydration of ethanol**.

Q44. deep | thorough-understanding | § 4.4.1 Properties of Ethanol **[3]**

Methanol and ethanol are both alcohols, yet ingesting methanol in very small amounts can be fatal while ethanol, though harmful in excess, is not immediately lethal in dilute amounts. What accounts for the difference in their toxicity to humans?

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Model Answer

Both methanol and ethanol belong to the same homologous series, but they differ in toxicity due to their metabolic products.

- **Methanol** is oxidised in the liver to **methanal (formaldehyde)**, which reacts rapidly with cell components. It **coagulates the protoplasm** (similar to how heat coagulates egg white) and also damages the **optic nerve**, causing blindness and even death in very small quantities.
- **Ethanol**, when consumed in excess, slows metabolic processes and depresses the central nervous system, but it does not produce such immediately lethal metabolites in dilute amounts.

Thus, the extreme toxicity of methanol is due to its oxidation product — methanal — which is highly destructive to cells.

Source: Chapter 4, Section 4.4.1 (Do You Know? — How do alcohols affect living beings?)

Explanation

Examiners look for three key points here (1 mark each):

1. Methanol is oxidised to **methanal** in the liver.
2. Methanal **coagulates protoplasm** / reacts with cell components.
3. It also **damages the optic nerve**, causing blindness/death.

Do not write a general comparison of physical properties — the question is specifically about **toxicity mechanism**. Always anchor your answer to the metabolic/chemical difference, not just "methanol is poisonous."

Q45. medium | thorough-understanding | § 4.4.1 Properties of Ethanol **[1]**

Industrial ethanol is often mixed with small amounts of poisonous substances such as methanol before being sold. (i) What is this process called, and what is the mixture termed? (ii) Why is this done, and which government or industrial body mandates it? (iii) Name one harmful effect of the substance added to ethanol.

A Ethanol is mixed with water to reduce its concentration, making it taste unpleasant.
B Methanol and dyes are added to industrial ethanol to make it poisonous and identifiable, a product called denatured alcohol.
C Industrial ethanol is heated to high temperatures so that it decomposes before it can be consumed.
D Concentrated sulphuric acid is added to industrial ethanol, converting it entirely to ethene gas.

◆ Carbon and its Compounds

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Model Answer

Option B is correct. Methanol and dyes are added to industrial ethanol to make it poisonous and identifiable; this product is called **denatured alcohol**. Methanol causes blindness and can be lethal even in small quantities.

Source: Chapter 4, Section 4.4.1 (Properties of Ethanol)

Explanation

Although this question has three sub-parts, it is a 1-mark MCQ, so you only need to identify the correct option and briefly justify it. Option B matches the passage directly: the process is **denaturation**, the product is **denatured alcohol**, it is done to prevent misuse, and methanol (the added substance) affects the optic nerve causing **blindness**. The other options describe unrelated reactions (dehydration, oxidation, dilution) and are not supported by the passage.

Q46. deep | thorough-understanding | § 4.4.1 Properties of Ethanol **[3]**

Ethanol is used as a solvent in many medicines such as tincture iodine, and it is also completely miscible with water. Using your knowledge of ethanol's structure, explain why ethanol can (i) mix with water in all proportions, and (ii) dissolve many organic substances that water cannot dissolve.

◆ **Carbon and its Compounds**

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Model Answer

Ethanol (C_2H_5OH) has two parts in its structure: a **polar –OH (hydroxyl) group** and a **non-polar hydrocarbon (C_2H_5–) part**.

(i) Miscibility with water: The –OH group is similar to water (H–OH) and can form hydrogen bonds with water molecules. This "like dissolves like" interaction allows ethanol to mix with water in all proportions.

(ii) Dissolving organic substances: The non-polar hydrocarbon part of ethanol can interact with non-polar organic substances (which water cannot dissolve, as water is polar). Thus ethanol acts as a bridge solvent, dissolving both polar and non-polar substances.

Source: Chapter 4, Section 4.4.1 — Properties of Ethanol

Explanation

The examiner expects students to link **structure → property**. The key concept is the dual nature of ethanol's molecule: the –OH end makes it water-compatible (polar), and the –C_2H_5 end makes it organic-solvent-compatible (non-polar). The textbook directly states ethanol is soluble in water in all proportions and is a good solvent used in medicines. For full marks, both parts (i) and (ii) must be addressed separately. The phrase "like dissolves like" is a useful principle to mention, even if not explicitly in the textbook passage.

Q47. deep | thorough-understanding | § 4.4.1 Properties of Ethanol **[3]**

Ethanol reacts with ethanoic acid in the presence of a few drops of concentrated sulphuric acid on gentle heating. (i) Name the type of reaction and the product formed. (ii) What is the role of concentrated H_2SO_4 here, and how does it differ from its role when ethanol alone is heated with excess concentrated H_2SO_4 at 443 K? (iii) How would you identify the product formed, and what happens when this product is treated with NaOH solution?

◆ **Carbon and its Compounds**

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Model Answer

(i) The reaction is **esterification**. The product formed is **ethyl ethanoate** (an ester) and water.

$$CH_3COOH + C_2H_5OH \xrightarrow{\text{Conc. } H_2SO_4} CH_3COOC_2H_5 + H_2O$$

(ii) Here, conc. H_2SO_4 acts as an **acid catalyst**. When ethanol alone is heated with excess conc. H_2SO_4 at 443 K, H_2SO_4 acts as a **dehydrating agent**, removing water to form ethene.

(iii) The ester (ethyl ethanoate) is identified by its **sweet smell**. When treated with NaOH solution, it undergoes **saponification**, breaking back into ethanol and sodium ethanoate (sodium salt of ethanoic acid):

$$CH_3COOC_2H_5 + NaOH \rightarrow C_2H_5OH + CH_3COONa$$

Source: Chapter 4, Section 4.4.1 & 4.4.2

Explanation

- Examiners expect the **equation** for esterification and saponification — even in short answers, these earn marks.
- The key contrast for part (ii) is: **catalyst vs. dehydrating agent** — this distinction is frequently tested.
- For identification, "sweet smell" is the textbook answer; always link it to the ester's property.
- "Saponification" as the name of the NaOH reaction is a scoring keyword — include it.

Q48. medium | thorough-understanding | § 4.4.2 Properties of Ethanoic Acid **[2]**

When ethanoic acid is tested with both litmus paper and a universal indicator, litmus turns red but the universal indicator shows a colour corresponding to a weak acid — not as strong as hydrochloric acid of the same concentration. Why does ethanoic acid behave as a weaker acid than HCl even though both release H^+ ions in solution?

◆ **Carbon and its Compounds**

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Model Answer

Ethanoic acid is a **weak acid** because it is **partially (incompletely) ionised** in water — only a few H^+ ions are released. HCl, being a **mineral (strong) acid**, is **completely ionised**, releasing far more H^+ ions at the same concentration. Since the universal indicator responds to H^+ ion concentration (pH), it shows ethanoic acid at a higher pH than HCl, indicating weaker acidity. Litmus only detects whether a substance is acidic or basic, so both turn it red.

Source: Chapter 4, Section 4.4.2 — Properties of Ethanoic Acid

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Explanation

- The key concept is **degree of ionisation**: strong acids ionise completely; weak acids ionise partially.
- Litmus is a qualitative test (acid/base only); universal indicator is quantitative — it reflects actual H^+ concentration, so it distinguishes strong from weak acids.
- Examiners award 1 mark for "partial/incomplete ionisation of ethanoic acid" and 1 mark for the comparison with complete ionisation of HCl. Don't just say "weak acid" — explain *why* (partial ionisation = fewer H^+ ions).

Q49. medium | thorough-understanding | § 4.4.2 Properties of Ethanoic Acid **[3]**

[short_answer] Ethanol is warmed with ethanoic acid in the presence of a few drops of concentrated sulphuric acid. A sweet-smelling compound 'P' is formed. 'P' is then treated with sodium hydroxide solution to give compound 'Q' and ethanol. (i) Identify 'P' and 'Q', and name the type of reaction that forms each of them. (ii) Write balanced chemical equations for both reactions. (iii) State one industrial application of the reaction that produces 'Q'.

◆ Carbon and its Compounds

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Model Answer

(i)

- **P** = Ethyl ethanoate (an ester); formed by **esterification** reaction.
- **Q** = Sodium ethanoate (sodium acetate); formed by **saponification** reaction.

(ii)

Formation of P (Esterification):

$$CH_3COOH + C_2H_5OH \xrightarrow{\text{Conc. } H_2SO_4} CH_3COOC_2H_5 + H_2O$$

Formation of Q (Saponification):

$$CH_3COOC_2H_5 + NaOH \rightarrow CH_3COONa + C_2H_5OH$$

(iii) Saponification is used industrially in **soap making** — fats/oils are hydrolysed with sodium hydroxide to produce soap (sodium salts of fatty acids) and glycerol.

Explanation

- Examiners expect you to correctly name both compounds and both reaction types — these fetch separate marks.
- The balanced equations must show the catalyst (conc. H_2SO_4) for esterification; forgetting it costs marks.
- For the industrial application, "soap making / saponification of fats and oils" is the standard accepted answer. Do not confuse this with the saponification of the ester in part (ii) — the principle is the same but applied to triglycerides in industry.

Q50. deep thorough-understanding § 4.4.2 Properties of Ethanoic Acid **[3]**

[short_answer] Ethanoic acid reacts with both sodium carbonate solution and sodium hydroxide solution to form salts. (i) Write the name and formula of the salt produced in each reaction, and write balanced chemical equations for both. (ii) A student argues that because ethanoic acid reacts with sodium carbonate — a reaction that mineral acids also undergo — ethanoic acid must be equally strong as hydrochloric acid. Evaluate this claim and describe one experimental observation that would clearly demonstrate the difference in acid strength between ethanoic acid and hydrochloric acid.

◆ Carbon and its Compounds

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Model Answer

(i)

- **With NaOH:** Salt formed is **Sodium ethanoate (sodium acetate), CH_3COONa**

$$NaOH + CH_3COOH \rightarrow CH_3COONa + H_2O$$

- **With Na_2CO_3:** Salt formed is **Sodium ethanoate (sodium acetate), CH_3COONa**

$$2CH_3COOH + Na_2CO_3 \rightarrow 2CH_3COONa + H_2O + CO_2$$

(ii)

The student's claim is **incorrect**. The fact that ethanoic acid reacts with Na_2CO_3 only shows it is acidic enough to do so, not that it is equally strong as HCl. Unlike HCl, which is completely ionised, ethanoic acid is a **weak acid** and only partially ionises.

Experimental observation: On testing equal concentrations of both acids with universal indicator, HCl shows a much lower pH (strong acid colour) than ethanoic acid, proving ethanoic acid is weaker.

Source: Chapter 4, Section 4.4.2

Explanation

- Part (i) is worth ~2 marks: name the salt, give the formula, write both balanced equations — examiners award marks for each correct equation.
- Part (ii) is ~1 mark: clearly state the claim is wrong, give the reason (partial vs complete ionisation), and name a specific, observable experiment (universal indicator / pH comparison). Litmus alone won't distinguish them — universal indicator/pH is the key point from Activity 4.7.

Q51. medium | thorough-understanding | § 4.5 SOAPS AND DETERGENTS **[3]**

When soap is added to water containing dissolved calcium and magnesium salts, a white curdy precipitate forms instead of lather. Explain why this happens and how detergents overcome this problem.

◆ Carbon and its Compounds

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Model Answer

Soap molecules are sodium or potassium salts of long-chain carboxylic acids. When added to hard water (containing dissolved Ca^{2+} and Mg^{2+} salts), the soap reacts with these ions to form insoluble calcium and magnesium salts of the fatty acid. This insoluble substance appears as a white curdy precipitate (scum), and lather is not formed until all the Ca^{2+}/Mg^{2+} ions are used up.

Detergents are sodium salts of sulphonic acids or ammonium salts with chloride/bromide ions. The charged ends of detergent molecules **do not form insoluble precipitates** with calcium and magnesium ions in hard water. Therefore, detergents produce lather readily in hard water and remain effective as cleansing agents.

Source: Chapter 4, Section 4.5 – Soaps and Detergents

Explanation

- The key contrast examiners look for: **soap** → **insoluble precipitate with Ca^{2+}/Mg^{2+}** vs. **detergent** → **no such precipitate**.
- Mention the chemical nature of both (soap = salt of carboxylic acid; detergent = salt of sulphonic acid) for full marks.
- Avoid vague phrases like "detergent is better" without the chemical reason — that's where students lose marks.

Q52. straightforward | thorough-understanding | § 4.5 SOAPS AND DETERGENTS **[1]**

A student prepares soap solution in water and shines a beam of light through it. The path of the light beam becomes visible inside the solution. (i) What phenomenon is responsible for this observation? (ii) What does this tell you about the nature of the soap solution?

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Model Answer

(i) **Tyndall effect** — scattering of light by colloidal particles.
(ii) Soap solution is a **colloid** (not a true solution); soap micelles are large enough to scatter light.

Source: Chapter 4, Section 4.5 Soaps and Detergents

Explanation

The key phrase in the passage is: *"The soap micelles are large enough to scatter light. Hence a soap solution appears cloudy."* Examiners expect both parts answered: name the phenomenon (Tyndall effect) and state what it reveals (colloidal nature). Since this is 1 mark, keep it to one or two short lines — don't over-explain.

Q53. deep | thorough-understanding | § 4.5 SOAPS AND DETERGENTS **[3]**

If you dissolve soap in a hydrocarbon solvent instead of water, what orientation would the soap molecules adopt in a micelle, and what kind of substance could be cleaned using such a micelle?

◆ Carbon and its Compounds

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Model Answer

When soap is dissolved in a **hydrocarbon solvent**, the micelle orientation is **reversed** compared to water. The **ionic (hydrophilic) ends** of the soap molecules point **inward** (toward the centre of the micelle), while the **hydrophobic hydrocarbon tails** point **outward** (toward the hydrocarbon solvent).

Such a micelle, with its ionic interior, could be used to clean substances that are **water-soluble or ionic in nature** (e.g., water-based stains or salts), since the ionic core can trap and dissolve them, even in a non-polar/hydrocarbon medium.

Source: Carbon and its Compounds, Section 4.5 – Soaps and Detergents

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Explanation

- The key concept is the **reversal of micelle structure** in a non-polar solvent: tails go out, ionic heads go in — the opposite of the aqueous micelle.
- Examiners expect students to clearly state **which end faces inward/outward** and **why** (hydrophobic tails are compatible with the hydrocarbon solvent).
- For the cleaning part, students must logically deduce that since the **ionic/hydrophilic core** is now exposed to trapped material, such a micelle would clean **water-soluble or ionic dirt** — this is the direct application of the reversed structure.
- This question is based on the textbook Activity 4.10 discussion and the "More to Know" micelle box. Do not confuse the orientation with the standard aqueous micelle.

Q54. medium | thorough-understanding | § 4.5 SOAPS AND DETERGENTS **[1]**

Soap micelles remain permanently suspended in water without settling. What property of the outer surface of a micelle is responsible for this colloidal stability?

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Model Answer

The outer surface of a micelle is covered with **ionic (hydrophilic) ends** of soap molecules, which cause **ion-ion repulsion** between micelles, preventing them from coming together and precipitating.

Source: Chapter 4, Section 4.5 – Soaps and Detergents

Explanation

The key phrase from the passage is: *"The micelles stay in solution as a colloid and will not come together to precipitate because of ion-ion repulsion."* Examiners expect you to identify the ionic/hydrophilic outer surface and link it directly to ion-ion repulsion as the cause of colloidal stability. Mentioning only "hydrophilic" without the repulsion mechanism may lose the mark.

Q55. deep | thorough-understanding | § 4.5 SOAPS AND DETERGENTS **[5]**

When testing two samples of water — one distilled and one from a tubewell — with the same amount of soap solution and shaking equally, one produces abundant lather while the other forms a white precipitate with very little lather. (i) Identify which sample produces which result and explain why. (ii) If the tubewell water is instead tested with a detergent solution under identical conditions, predict and explain the result.

◆ **Carbon and its Compounds**

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Model Answer

(i) Distilled water is soft water. When soap solution is added and shaken, it produces **abundant lather**, because soap molecules form micelles freely in soft water.

Tubewell water is hard water — it contains dissolved calcium and magnesium salts. When soap is added to it, the soap reacts with these salts to form an **insoluble white curdy precipitate** (scum) with very little lather:

> Ca^{2+}/Mg^{2+} ions + soap → insoluble calcium/magnesium salt (scum)

This scum is the white precipitate observed. Soap is wasted in forming scum, so little lather is produced.

(ii) When detergent solution is used with tubewell (hard) water, it produces **good lather with no white precipitate**. This is because detergents are sodium salts of sulphonic acids whose charged ends do **not** form insoluble precipitates with calcium and magnesium ions. Hence detergents remain effective in hard water, unlike soaps.

Source: Chapter 4, Section 4.5 Soaps and Detergents (Activities 4.11 and 4.12)

Explanation

- The key distinction examiners want: distilled water = soft, tubewell = hard; soap forms scum with hard water, detergent does not.
- Name the precipitate as insoluble calcium/magnesium salt (scum) — just saying "white precipitate" alone may lose a mark.
- For part (ii), explicitly state **two things**: lather is formed AND no precipitate forms, then give the reason (charged ends of detergent don't react with Ca^{2+}/Mg^{2+}).
- Avoid over-explaining micelle mechanism here — it's not asked; focus on hard/soft water behaviour.

Q56. straightforward | thorough-understanding | § 4.5 SOAPS AND DETERGENTS **[1]**

A soap molecule has two structurally different ends. (i) Name each end and identify the part of the molecule responsible for its character. (ii) How does each end interact differently with water and oily substances?

◆ Carbon and its Compounds

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Model Answer

(i) **Hydrophilic end** (ionic/carboxylate end) and **Hydrophobic end** (long hydrocarbon chain tail).
(ii) The hydrophilic (ionic) end interacts with water; the hydrophobic (hydrocarbon) end interacts with oily substances.

Source: Chapter 4, Section 4.5 Soaps and Detergents

Explanation

Though this is a 1-mark question, it has two parts (i) and (ii), so keep each part to one short phrase. Examiners look for the two key terms — **hydrophilic** and **hydrophobic** — and the correct pairing: ionic end ↔ water, hydrocarbon tail ↔ oil. Don't write full paragraphs; two compact lines are enough.

Q57. medium | thorough-understanding | § 4.5 SOAPS AND DETERGENTS **[2]**

After adding soap to a mixture of oil and water, vigorous agitation is needed to clean effectively, whereas simply letting the soap sit in the mixture is not enough. Using your understanding of micelle formation, explain why mechanical agitation plays a crucial role in the cleaning process.

◆ Carbon and its Compounds

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Model Answer

Soap molecules form **micelles** around oily dirt — the hydrophobic tails surround the oil droplet while the hydrophilic ionic ends face water. However, micelles form only when there is sufficient contact between soap and dirt. **Mechanical agitation** (beating/scrubbing) breaks oil into smaller droplets, increases surface area, and helps soap molecules quickly surround each droplet, forming stable micelles that remain suspended as a colloid and are easily rinsed away.

Source: Chapter 4, Section 4.5 – Soaps and Detergents

Explanation

- Examiners expect you to mention: (1) micelle structure (hydrophobic tail inward, ionic end outward), and (2) how agitation aids micelle formation by increasing contact/surface area.
- The textbook Activity 4.10 and Question 2 at the end of the section directly address this — agitation breaks oil into droplets so soap can act effectively.
- Avoid writing vague statements like "soap cleans better" — link it explicitly to micelle formation for full marks.

Q58. deep | thorough-understanding | § (whole-chapter synthesis) **[3]**

Carbon forms millions of stable compounds, whereas silicon — also a tetravalent element — forms far fewer. Explain TWO reasons why carbon's covalent compounds are so much more numerous and stable than silicon's, drawing on both the nature of the carbon–carbon bond and carbon's atomic size.

◆ Carbon and its Compounds

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Model Answer

Carbon forms far more stable compounds than silicon due to two main reasons:

(i) Catenation: Carbon has a unique ability to form strong bonds with other carbon atoms, producing long chains, branched chains, and rings. The carbon–carbon bond is **very strong and stable**, allowing millions of compounds. Silicon also shows catenation, but silicon–silicon bonds are much weaker, so silicon chains are limited to only seven or eight atoms and are highly reactive.

(ii) Small atomic size: Carbon's nucleus is small, so it holds the shared pairs of electrons very strongly, forming exceptionally stable covalent bonds. Silicon has a larger atom, so its nucleus cannot hold shared electrons as firmly, making its bonds weaker and its compounds less stable.

Source: Chapter 4, Section 4.2 – Versatile Nature of Carbon

Explanation

- Examiners expect **two distinct, labelled points** — catenation and atomic size — directly from the textbook.
- For catenation, you must contrast carbon (stable, unlimited chains) with silicon (reactive, max ~7–8 atoms).
- For atomic size, the key phrase is: small nucleus → stronger hold on shared electrons → stronger, more stable bonds.
- Avoid vague statements like "carbon is special"; use precise textbook language.

Q59. deep thorough-understanding § (whole-chapter synthesis) **[5]**

Ethanol can be converted to ethene, or it can be converted to ethanoic acid. (i) State the reagent and condition used for each conversion. (ii) One conversion is a dehydration and the other is an oxidation — explain what each term means in the context of these specific reactions. (iii) Why is the product of oxidation classified as belonging to a different homologous series than ethanol?

◆ **Carbon and its Compounds**

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Model Answer

(i) Reagents and Conditions:

- **Ethanol → Ethene (dehydration):** Reagent — excess concentrated H_2SO_4; Condition — heated at 443 K.
- **Ethanol → Ethanoic acid (oxidation):** Reagent — alkaline $KMnO_4$ or acidified $K_2Cr_2O_7$ (oxidising agent); Condition — heated.

(ii) Meaning of each term:

- **Dehydration** means removal of water from a molecule. Here, conc. H_2SO_4 removes H and OH from ethanol to form ethene ($CH_2{=}CH_2$) and H_2O.
- **Oxidation** means addition of oxygen (or removal of hydrogen). Here, an oxidising agent adds oxygen to ethanol (–OH group) to form ethanoic acid (–COOH), increasing the oxygen content.

(iii) Different homologous series:

Ethanol belongs to the **alcohol** series (functional group: –OH), while ethanoic acid belongs to the **carboxylic acid** series (functional group: –COOH). A homologous series is defined by its functional group, and since the two compounds have different functional groups with different chemical properties, they belong to different homologous series.

Source: Chapter 4, Section 4.4.1 (Properties of Ethanol); Section 4.2.4 (Homologous Series)

Explanation

- For (i), the textbook explicitly states conc. H_2SO_4 at 443 K for dehydration. For oxidation, the textbook question asks *why* it is oxidation — oxidising agents like $KMnO_4$/$K_2Cr_2O_7$ are the standard expected reagents; mention either.
- For (ii), examiners want the general definition applied to *these* reactions specifically — don't just define in the abstract.
- For (iii), the key concept is from Section 4.2.4: a homologous series is identified by its functional group. Two compounds with *different* functional groups (–OH vs –COOH) cannot belong to the same series, regardless of carbon chain length. State both functional groups clearly for full marks.

Q60. medium | thorough-understanding | § (whole-chapter synthesis) **[3]**

A student burns two gases: one produces a clean blue flame and the other a yellow, sooty flame. She also finds that the second gas decolourises bromine water while the first does not. (i) Identify whether each gas is a saturated or an unsaturated hydrocarbon, giving one reason for each identification. (ii) Explain, in terms of the types of bonds present, why unsaturated hydrocarbons decolourise bromine water while saturated hydrocarbons do not.

◆ Carbon and its Compounds

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Model Answer

(i)

- **Gas 1 (clean blue flame):** Saturated hydrocarbon. Saturated hydrocarbons burn with a clean blue flame due to complete combustion.
- **Gas 2 (yellow, sooty flame):** Unsaturated hydrocarbon. Unsaturated hydrocarbons burn with a yellow, sooty flame due to their high carbon content and incomplete combustion.

(ii)

Unsaturated hydrocarbons contain **double or triple bonds** (C=C or C≡C). These bonds break easily and react with bromine water in an **addition reaction**, decolourising it. Saturated hydrocarbons have only **single bonds** and are fairly unreactive; they cannot undergo addition reactions, so bromine water remains orange-brown.

Source: Chapter 4, Sections 4.2.2 and 4.3.1

Explanation

- For (i), examiners want the correct label (saturated/unsaturated) **and** the reason linked to the type of flame — both parts needed for full credit.
- For (ii), the key terms examiners look for are **double/triple bonds**, **addition reaction**, and the contrast with single bonds in saturated hydrocarbons. Avoid just saying "they react" — name the reaction type.
- The bromine water test is the standard differentiation test between saturated and unsaturated hydrocarbons (Q14 in exercises).

Q61. deep | thorough-understanding | § (whole-chapter synthesis) **[3]**

Covalent compounds are generally poor conductors of electricity and have low melting points, yet graphite — a covalent form of carbon — conducts electricity well. Explain why most covalent carbon compounds have low melting points, and then account for why graphite is an exception despite being made entirely of covalent bonds.

◆ **Carbon and its Compounds**

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Model Answer

Low melting points of covalent compounds: In covalent compounds, electrons are shared between atoms, forming strong bonds *within* molecules. However, the inter-molecular forces between molecules are weak. Therefore, little energy is needed to separate the molecules, resulting in low melting and boiling points.

Why graphite is an exception: In graphite, each carbon atom is bonded to three other carbon atoms in the same plane, forming hexagonal layers. One bond is a double bond. These layers are stacked one above the other. The remaining electrons are free to move between the layers, allowing graphite to conduct electricity well, unlike typical covalent compounds.

Source: Chapter 4 – Bonding in Carbon (Covalent Bond); Allotropes of Carbon (More to Know)

Explanation

- **Key distinction:** Examiners want you to separate *intra*-molecular bonds (strong, within the molecule) from *inter*-molecular forces (weak, between molecules) — this is the textbook reason for low melting points.
- **Graphite exception:** The textbook only states graphite conducts electricity due to its layered hexagonal structure with a double bond. At Class 10 level, you are *not* required to explain "delocalised electrons" explicitly — but noting free/mobile electrons between layers earns the mark.
- **Stick to source passages:** Do not add extra detail (e.g., specific band theory) that goes beyond the textbook.
- Aim: ~2 marks for covalent low melting point explanation + ~1 mark for graphite exception.

Q62. medium | thorough-understanding | § (whole-chapter synthesis) **[1]**

Which of the following statements correctly explains why soap fails to clean effectively in hard water but a detergent does not?

(A) Soap molecules are too large to form micelles in hard water, whereas detergent molecules are smaller.

(B) Soap reacts with calcium and magnesium ions in hard water to form insoluble salts, while the charged ends of detergent molecules do not form such precipitates.

(C) Soap is hydrophobic in hard water, so it cannot interact with water, whereas detergent remains hydrophilic.

(D) Hard water destroys the hydrocarbon tail of soap molecules but not that of detergent molecules.

A Soap molecules are too large to form micelles in hard water, whereas detergent molecules are smaller.
B Soap reacts with calcium and magnesium ions in hard water to form insoluble salts, while the charged ends of detergent molecules do not form such precipitates.
C Soap is hydrophobic in hard water, so it cannot interact with water, whereas detergent remains hydrophilic.
D Hard water destroys the hydrocarbon tail of soap molecules but not that of detergent molecules.

◆ Carbon and its Compounds

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Model Answer

(B) Soap reacts with calcium and magnesium ions in hard water to form insoluble salts (scum), while the charged ends of detergent molecules do not form such precipitates, so detergents remain effective in hard water.

Explanation

The textbook explicitly states: "The charged ends of these (detergent) compounds do not form insoluble precipitates with the calcium and magnesium ions in hard water." Soap forms a curdy scum with Ca^{2+}/Mg^{2+} ions, wasting it and reducing cleaning. Options A, C, and D are not supported by the textbook and describe incorrect mechanisms.

Source: Chapter 4, Section 4.5 Soaps and Detergents

Q63. medium | thorough-understanding | § (whole-chapter synthesis) **[3]**

Ethanoic acid and ethanol both contain oxygen, yet their behaviours with sodium hydrogencarbonate and with sodium metal are very different. (i) State what you would observe when each compound is separately treated with sodium hydrogencarbonate. (ii) Explain, in terms of their functional groups, why the two compounds behave differently with sodium hydrogencarbonate even though both react with sodium metal to produce hydrogen.

◆ Carbon and its Compounds

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Model Answer

(i) Observations with $NaHCO_3$:

- **Ethanoic acid** reacts with sodium hydrogencarbonate to produce brisk effervescence (CO_2 gas), which turns lime water milky.

$CH_3COOH + NaHCO_3 \rightarrow CH_3COONa + H_2O + CO_2$

- **Ethanol** shows **no reaction** with sodium hydrogencarbonate; no effervescence is observed.

(ii) Explanation in terms of functional groups:

Ethanoic acid contains the **carboxyl group (–COOH)**, which is acidic enough to react with weak bases like $NaHCO_3$, releasing CO_2. Ethanol contains the **hydroxyl group (–OH)**, which is only weakly acidic — too weak to react with $NaHCO_3$. However, both –COOH and –OH can donate H^+ to sodium metal (a strong reducing agent), so both produce hydrogen gas with Na.

Source: Chapter 4, Section 4.4.2 – Properties of Ethanoic Acid

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Explanation

- Examiners award marks for: (a) correct observation for each compound (1 mark), (b) functional group explanation linking –COOH to acidity and $NaHCO_3$ reaction, and –OH to insufficient acidity (2 marks).
- Always write the chemical equation for ethanoic acid + $NaHCO_3$ — it shows understanding and secures full credit.
- The key contrast: carboxylic acids are acidic enough to displace CO_2 from hydrogencarbonates; alcohols are not. Both react with Na because Na is a far stronger base/reducing agent.

Q64. deep | thorough-understanding | § (whole-chapter synthesis) **[3]**

Natural fats and oils are esters formed from long-chain carboxylic acids and glycerol. (i) Name the type of reaction used to convert a fat or oil into soap, and state the reagent required. (ii) Identify the other organic product formed alongside soap in this reaction. (iii) The reverse reaction — forming an ester from an acid and an alcohol — is called esterification. State the reagent and condition used and explain why this reaction is described as reversible.

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Model Answer

(i) The reaction is called **saponification**. The reagent required is **sodium hydroxide (NaOH)** — a strong alkali (or potassium hydroxide, KOH).

(ii) The other organic product formed alongside soap is **glycerol** (propane-1,2,3-triol).

(iii) Reagent: **concentrated sulphuric acid (H_2SO_4)** as catalyst; Condition: **heating**. The reaction is reversible because the ester and water formed can react with each other to regenerate the original acid and alcohol, so neither reaction goes to completion — both forward and backward reactions occur simultaneously.

Source: Chapter 4, Section 4.5 Soaps and Detergents

Explanation

- **Saponification** is the key term examiners expect for (i); simply writing "hydrolysis" may lose the mark.
- For (ii), glycerol is the specific organic by-product — do not write water (it is inorganic).
- For (iii), the two marks cover: naming the reagent/condition **and** explaining reversibility. The reversibility point must mention that the backward reaction (hydrolysis of ester) also occurs, making it an equilibrium — this is what earns the mark.

Q65. deep | thorough-understanding | § (whole-chapter synthesis) **[3]**

Consider the homologous series of alkanes and the homologous series of alcohols. (i) Boiling points increase steadily as you move from methane to butane, and from methanol to butanol. Explain why this gradation in boiling points occurs, and why the chemical properties within each series remain similar despite this physical change. (ii) A student claims that ethane and ethanol belong to the same homologous series because they differ by only one atom. Identify the error in the student's reasoning and explain what conditions must be satisfied for two compounds to belong to the same homologous series.

◆ Carbon and its Compounds

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Model Answer

(i) As we move from methane to butane (or methanol to butanol), each successive compound has one extra $-CH_2-$ unit, increasing molecular mass. Greater molecular mass means stronger intermolecular forces, so more energy (higher boiling point) is needed to separate molecules. Chemical properties remain similar because they are determined solely by the functional group (e.g., –OH in alcohols), which stays the same throughout the series.

(ii) The student's error is that ethane (C_2H_6) and ethanol (C_2H_5OH) do **not** differ merely by one atom — they belong to *different* homologous series (alkanes and alcohols respectively) with different functional groups. For two compounds to belong to the same homologous series, they must: (a) have the same functional group, (b) differ by a $-CH_2-$ unit, and (c) follow the same general formula.

Source: Carbon and its Compounds, Section 4.2.4 Homologous Series

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Explanation

- Examiners look for: molecular mass → intermolecular forces → boiling point (for part i), and functional group → same chemical properties.
- For part (ii), clearly name the error (different functional groups / different series) and then state the three conditions of a homologous series. Don't just say "they differ by one atom is wrong" — explain *why* and state the correct conditions.
- Key phrase to use: "chemical properties are determined solely by the functional group."

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