

14.1 Alkanes

Name: _____ Class: _____ Date: _____

Total: 12 marks

Objective

Build the skills to answer exam questions on **alkanes** 烷烃—making them, **combustion** 燃烧, **free-radical substitution** 自由基取代, and their unreactivity.

You must be able to:

- recall how alkanes are made (hydrogenation, cracking) and describe combustion
- describe the free-radical substitution mechanism (initiation, propagation, termination)
- explain the unreactivity of alkanes and the environmental effects of combustion

1 Worked examples

■ Making alkanes and combustion

- **hydrogenation:** add H to an alkene (Pt/Ni catalyst, heat).
- **cracking:** break a long alkane into shorter ones (heat, Al₂O₃).
- **complete combustion** → CO + H₂O; **incomplete** (little O) → toxic CO + soot.

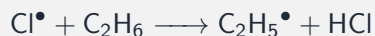
■ Free-radical substitution

1. initiation



UV light splits Cl–Cl into two radicals

2. propagation



each radical makes a new radical, so the chain continues

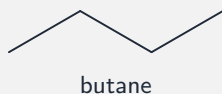
3. termination



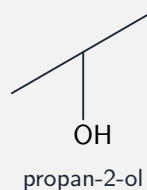
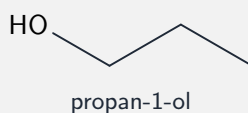
two radicals join, ending the chain

Free-radical substitution (needs UV light): initiation → propagation → termination

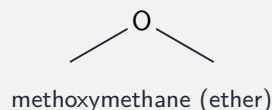
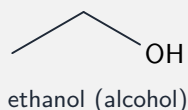
chain



positional



functional



Alkanes show chain and position isomerism

- **initiation:** $\text{Cl}_2 \xrightarrow{\text{UV}} 2\text{Cl}\cdot$
- **propagation:** $\text{Cl}\cdot + \text{C}_2\text{H}_6 \rightarrow \text{C}_2\text{H}_5\cdot + \text{HCl}$; $\text{C}_2\text{H}_5\cdot + \text{Cl}_2 \rightarrow \text{C}_2\text{H}_5\text{Cl} + \text{Cl}\cdot$
- **termination:** two radicals join, e.g. $\text{Cl}\cdot + \text{C}_2\text{H}_5\cdot \rightarrow \text{C}_2\text{H}_5\text{Cl}$

Alkanes are unreactive: the C–H and C–C bonds are strong and have little polarity, so nothing attracts a polar reagent.

2 Practice

2.1 State the reagent and condition for making an alkane from an alkene. [2]

2.2 Give the products of the **incomplete** combustion of an alkane. [2]

3 Exam-style questions

3.1 What condition is needed for the free-radical substitution of an alkane by chlorine?[1]

- **A** a nickel catalyst
- **B** ultraviolet light

- **C** concentrated sulfuric acid
 - **D** aqueous sodium hydroxide
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3.2 Why are alkanes generally unreactive towards polar reagents? [1]

- **A** they are ionic
 - **B** the C–H and C–C bonds are strong and non-polar
 - **C** they contain a double bond
 - **D** they are very volatile
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3.3 Ethane reacts with chlorine in UV light.

(a) Write equations for the initiation step and **one** propagation step. [3]

(b) Write an equation for a termination step that forms chloroethane. [1]

3.4 Explain why incomplete combustion of a fuel is dangerous. [2]

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **14.1 Alkanes** past-paper sheet in the Library, or try these in **Practice mode**:

- 9701/11 N25 —Q28 (alkanes)
- 9701/14 N25 —Q25 (free-radical substitution)
- 9701/22 N25 —Q3 (organic, structured)

Solutions

2.1 hydrogen (H₂) with a Pt or Ni catalyst; and heat.

2.2 carbon monoxide (and/or carbon/soot); water.

3.1 B. Free-radical substitution needs ultraviolet light.

3.2 B. Strong, non-polar C–H and C–C bonds offer no site for a polar reagent.

3.3 (a) initiation: $\text{Cl}_2 \rightarrow 2\text{Cl}\cdot$; propagation: $\text{Cl}\cdot + \text{C}_2\text{H}_6 \rightarrow \text{C}_2\text{H}_5\cdot + \text{HCl}$ and $\text{C}_2\text{H}_5\cdot + \text{Cl}_2 \rightarrow \text{C}_2\text{H}_5\text{Cl} + \text{Cl}\cdot$.

(b) $\text{C}_2\text{H}_5\cdot + \text{Cl}\cdot \rightarrow \text{C}_2\text{H}_5\text{Cl}$.

3.4 it produces carbon monoxide, a toxic gas that binds to haemoglobin and prevents oxygen transport.