

14.1 Alkanes

Name: _____ Class: _____ Date: _____

Total: 25 marks

KEY WORDS propagation 增长 • initiation 引发 • termination 终止 • carbon monoxide 一氧化碳
• free-radical substitution 自由基取代

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

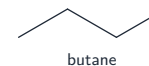
- hydrogenation:** add H_2 to an alkene (Pt/Ni catalyst, heat).
- cracking:** break a long alkane into shorter ones (heat, Al_2O_3).
- complete combustion** $\rightarrow \text{CO}_2 + \text{H}_2\text{O}$; **incomplete** (little O_2) $\rightarrow$ toxic **CO** + soot.

■ Free-radical substitution

- | | |
|-----------------------|---|
| 1. initiation | $\text{Cl}_2 \xrightarrow{\text{UV}} 2\text{Cl}^\bullet$ <p>UV light splits $\text{Cl}-\text{Cl}$ into two radicals</p> |
| 2. propagation | $\text{Cl}^\bullet + \text{C}_2\text{H}_6 \longrightarrow \text{C}_2\text{H}_5^\bullet + \text{HCl}$ $\text{C}_2\text{H}_5^\bullet + \text{Cl}_2 \longrightarrow \text{C}_2\text{H}_5\text{Cl} + \text{Cl}^\bullet$ <p>each radical makes a new radical, so the chain continues</p> |
| 3. termination | $\text{Cl}^\bullet + \text{C}_2\text{H}_5^\bullet \longrightarrow \text{C}_2\text{H}_5\text{Cl}$ <p>two radicals join, ending the chain</p> |

Free-radical substitution (needs UV light): initiation $\rightarrow$ propagation $\rightarrow$ termination

chain

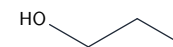


butane

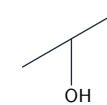


2-methylpropane

positional

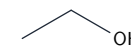


propan-1-ol



propan-2-ol

functional



ethanol (alcohol)



methoxymethane (ether)

Alkanes show chain and position isomerism

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

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 | B |
| C | D |
- A a nickel catalyst
B ultraviolet light
C concentrated sulfuric acid
D aqueous sodium hydroxide

3.2 Why are alkanes generally unreactive towards polar reagents? [1]

- | | |
|---|---|
| A | B |
| C | D |
- 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

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]

3.5 Methane reacts with chlorine in the presence of ultraviolet light.

(a) Write equations for the initiation step, **two** propagation steps and one termination step, labelling each. [5]

(b) Explain why no reaction occurs in the dark, and state what the ultraviolet light does. [2]

(c) Explain why a mixture of organic products is obtained, and name **two** organic products other than chloromethane. [3]

(d) Alkanes are described as unreactive. Explain this in terms of bond enthalpy and bond polarity. [3]
