

14.1 Alkanes

Name: _____ Class: _____ Date: _____

Total: 25 marks

KEY WORDS propagation • initiation • termination • carbon monoxide
• free-radical substitution

Objective

Build the skills to answer exam questions on **alkanes** – making them, **combustion**, **free-radical substitution**, 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 Key knowledge and 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.

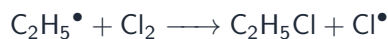
■ Free-radical substitution

1. initiation



UV light splits Cl–Cl into two radicals

2. propagation



each radical makes a new radical, so the chain continues

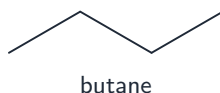
3. termination



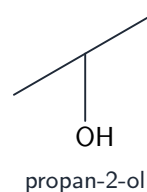
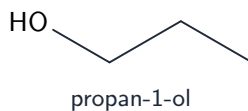
two radicals join, ending the chain

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

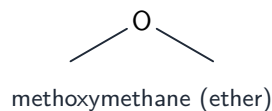
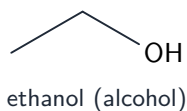
chain



positional



functional



Alkanes show chain and position isomerism

- **initiation:** $\text{Cl}_2 \xrightarrow{\text{UV}} 2\text{Cl}^\bullet$
- **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** 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** 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]
