Exercise walk-through

Alkanes ▪ 14.1

eXercise

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

Method — Making alkanes and combustion

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

Method — Free-radical substitution

- **initiation:** $Cl_2 \xrightarrow{UV} 2Cl\cdot$
- **propagation:** $Cl\cdot + C_2H_6 \rightarrow C_2H_5\cdot + HCl$; $C_2H_5\cdot + Cl_2 \rightarrow C_2H_5Cl + Cl\cdot$
- **termination:** two radicals join, e.g. $Cl\cdot + C_2H_5\cdot \rightarrow C_2H_5Cl$

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

Method — Free-radical substitution

1. initiation

$$Cl_2 \xrightarrow{UV} 2\,Cl^{\bullet}$$

UV light splits Cl–Cl into two radicals

2. propagation

$$Cl^{\bullet} + C_2H_6 \longrightarrow C_2H_5{}^{\bullet} + HCl$$

$$C_2H_5{}^{\bullet} + Cl_2 \longrightarrow C_2H_5Cl + Cl^{\bullet}$$

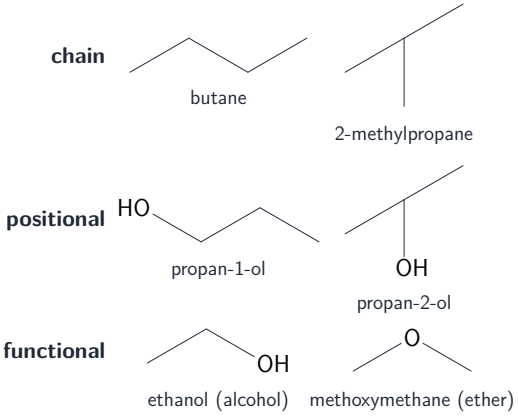
each radical makes a new radical, so the chain continues

3. termination

$$Cl^{\bullet} + C_2H_5{}^{\bullet} \longrightarrow C_2H_5Cl$$

two radicals join, ending the chain

Method — Free-radical substitution



Alkanes show chain and position isomerism

Practice 2.1 ▪ 2 marks

State the reagent and condition for making an alkane from an alkene.

Solution 2.1

Method: Making alkanes and combustion

Worked steps

hydrogen (H) with a Pt or Ni catalyst B1; and heat B1.

Practice 2.2 ▪ 2 marks

Give the products of the **incomplete** combustion of an alkane.

Solution 2.2

Method: Making alkanes and combustion

Worked steps

carbon monoxide (and/or carbon/soot) B1; water B1.

Exam-style 3.1 ▪ 1 mark

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

A a nickel catalyst

B ultraviolet light

C concentrated sulfuric acid

D aqueous sodium hydroxide

Solution 3.1

Method: Free-radical substitution

A a nickel catalyst

B ultraviolet light ✓

C concentrated sulfuric acid

D aqueous sodium hydroxide

Worked steps

B. Free-radical substitution needs ultraviolet light.

Exam-style 3.2 ▪ 1 mark

Why are alkanes generally unreactive towards polar reagents?

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

Solution 3.2

Method: Free-radical substitution

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

Worked steps

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

Exam-style 3.3 ▪ 3 marks

Ethane reacts with chlorine in UV light.
(a) Write equations for the initiation step and **one** propagation step.
(b) Write an equation for a termination step that forms chloroethane.

Solution 3.3

Method: Free-radical substitution

Worked steps

(a) initiation: $Cl_2 \rightarrow 2Cl\cdot$ B1; propagation: $Cl\cdot + C_2H_6 \rightarrow C_2H_5\cdot + HCl$ B1 and $C_2H_5\cdot + Cl_2 \rightarrow C_2H_5Cl + Cl\cdot$ B1.
(b) $C_2H_5\cdot + Cl\cdot \rightarrow C_2H_5Cl$ B1.

Exam-style 3.4 ▪ 2 marks

Explain why incomplete combustion of a fuel is dangerous.

Solution 3.4

Method: Making alkanes and combustion

Worked steps

it produces carbon monoxide **M1**, a toxic gas that binds to haemoglobin and prevents oxygen transport **A1**.