11.5 Alkenes

Name: _____ Class: _____ Date: _____ **Total: 28 marks**

KEY WORDS bromine • saturated • unsaturated • nickel • catalyst

Objective

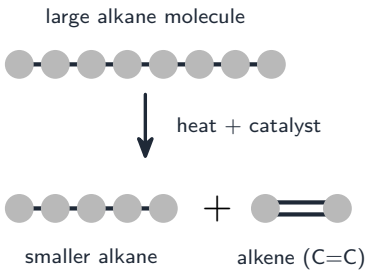
Build the skills to answer exam questions on **alkenes** – unsaturated hydrocarbons, **cracking**, **addition reactions**, and the **bromine water test**.

You must be able to:

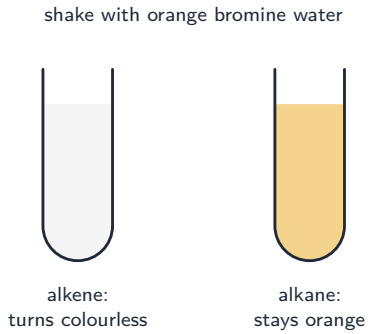
- describe alkenes as unsaturated (C=C) and reactive
- describe cracking and its products
- describe addition reactions and the test for unsaturation

1 Key knowledge and worked examples

Cracking & the bromine water test



Cracking breaks large alkanes into smaller alkanes + alkenes (heat + catalyst)



Test for unsaturation: an alkene turns orange bromine water colourless; an alkane does not

- – H_2 (Ni) → alkane; + steam (acid catalyst) → alcohol.

Cracking, addition, and the test that tells them apart

Cracking breaks a long-chain alkane into a shorter alkane plus an **alkene**, using heat (about 600–700 °C) and a catalyst. It is done because the long fractions from crude oil are in surplus while the short ones – petrol, and the alkenes needed to make polymers – are in demand. Every cracking equation must balance:

$$C_{10}H_{22} \rightarrow C_8H_{18} + C_2H_4$$

Count the carbons and hydrogens on each side: $10 = 8 + 2$ and $22 = 18 + 4$. An unbalanced equation loses the mark even when the products are right.

Why alkenes react and alkanes do not. An alkane is **saturated** – all single bonds – so it can only substitute. An alkene is **unsaturated**: its C = C double bond can open, and a molecule **adds across** it without anything being lost.

Reagent	Conditions	Product
bromine, Br_2	room temperature	1,2-dibromoethane – orange bromine water is **decolourised**
hydrogen, H_2	nickel catalyst, ~150 °C	the alkane, ethane
steam, H_2O	phosphoric acid catalyst, high pressure	the alcohol, ethanol

The test for unsaturation is the bromine-water one: shake the sample with orange aqueous bromine. An **alkene decolourises it**; an alkane leaves it orange. State the colour BOTH before and after – "it goes colourless" without the starting colour is only half the mark.

Worked example. Explain why $C_{12}H_{26}$ is cracked, and write one possible equation. It is cracked because a 12-carbon molecule is a poor fuel and is in surplus, while shorter molecules and alkenes are in demand. One possibility: $C_{12}H_{26} \rightarrow C_{10}H_{22} + C_2H_4$, which balances at 12 carbons and 26 hydrogens.

2 Practice

2.1 State the functional group in an alkene. [1]

2.2 State what cracking does. [1]

2.3 Write a balanced equation for cracking $C_{14}H_{30}$ to give octane, C_8H_{18}, and one alkene. [2]

2.4 State the reagent and the catalyst used to convert ethene into ethanol. [2]

2.5 Explain, in terms of bonding, why ethene decolourises bromine water but ethane does not. [2]

3 Exam-style questions

3.1 When ethene is shaken with bromine water, the bromine water: [1]

- ☐ **A** stays orange
- **B** turns colourless
- **C** turns blue
- **D** turns purple

3.2 Cracking breaks decane ($C_{10}H_{22}$) into octane (C_8H_{18}) and one other product.

(a) Name the type of compound formed as the other product. [1]

(b) Give the molecular formula of the other product. [1]

3.3 Describe how you could use bromine water to tell an alkene from an alkane. [2]

3.4 A refinery cracks decane, $C_{10}H_{22}$.

(a) State two conditions used for cracking. [2]

(b) Explain why a refinery cracks long-chain alkanes. [2]

(c) Decane is cracked to give one molecule of octane and one other product. Write the balanced equation and name the second product. [3]

(d) Describe a test that would distinguish the second product from octane, giving the result for each. [3]

(e) The alkene product is reacted with steam. Name the product, state the catalyst, and give the type of reaction. [3]

(f) Explain why the alkene can take part in addition reactions but octane cannot. [2]

Solutions

Each answer shows the steps, then the **result**.

2.1

- the alkene functional group is the **C=C** double bond

2.2

- cracking **breaks large alkanes into smaller, more useful molecules** (alkanes and alkenes)

2.3

- remaining fragment: $14 - 8 = 6$ carbons, $30 - 18 = 12$ hydrogens
- $\mathbf{C_{14}H_{30} \rightarrow C_8H_{18} + C_6H_{12}}$

2.4

- reagent: **steam**
- catalyst: **phosphoric acid**, at high pressure

2.5

- ethene has a C=C that can **open** so bromine **adds**
- ethane is **saturated**, so bromine cannot add

3.1 B

- the alkene **turns bromine water colourless**
- A is an alkane; C and D are other tests

3.2

(a)

- the other product is an **alkene**

(b)

- $10 - 8 = 2$ carbons, $22 - 18 = 4$ hydrogens
- $\mathbf{C_2H_4}$

3.3

- add **bromine water** and shake
- alkene: **colourless**; alkane: stays **orange**

3.4

(a)

- high temperature, about 600–700 **°C**
- a catalyst, e.g. **aluminium oxide** or silica

(b)

- long-chain fractions are in surplus and make **poor fuels**
- cracking makes **petrol** and **alkenes** for polymers

(c)

- $\mathbf{C_{10}H_{22} \rightarrow C_8H_{18} + C_2H_4}$
- the second product is **ethene**

(d)

- shake with **orange bromine water**
- ethene **decolourises** it; octane leaves it **orange**

(e)

- product: **ethanol**
- catalyst: **phosphoric acid**
- type: **addition / hydration**

(f)

- the alkene has a C=C that can **open**, so atoms add with nothing lost
- octane is **saturated**, so it can only react by **substitution**