IGCSE CHEMISTRY • EXERCISE SHEET

11.5 Alkenes

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

KEY WORDS bromine 溴 • nickel 镍 • saturated 饱和的 • unsaturated 不饱和的 • steam 蒸汽

Objective

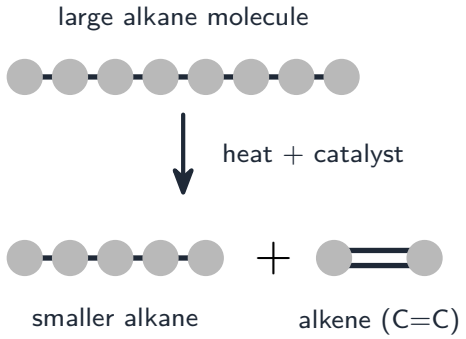
Build the skills to answer exam questions on **alkenes** 烯烃 — unsaturated hydrocarbons, **cracking** 裂化, **addition reactions** 加成反应, and the **bromine water test** 溴水检验.

You must be able to:

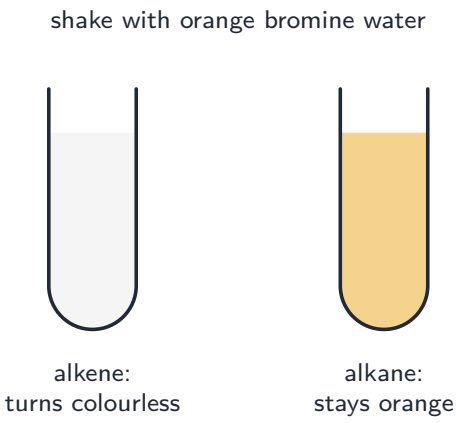
- describe alkenes as unsaturated (C=C) and reactive
- describe cracking and its products
- describe addition reactions and the test for unsaturation

1 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 裂化 breaks a long-chain alkane into a shorter alkane plus an **alkene** 烯烃, 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** 饱和的 — all single bonds — so it can only substitute. An alkene is **unsaturated** 不饱和的: 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]

3.3 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

2.1 the C=C carbon–carbon double bond.

2.2 it breaks large alkane molecules into smaller, more useful molecules (alkanes and alkenes).

3.1 B. The alkene decolourises the bromine water.

3.2 (a) an alkene.
(b) C_2H_4.

3.3 add bromine water to each and shake; the alkene turns it colourless while the alkane leaves it orange.

2.3 $C_{14}H_{30} \rightarrow C_8H_{18} + C_6H_{12}$.

2.4 Steam; a phosphoric acid catalyst, at high pressure.

2.5 Ethene contains a carbon–carbon double bond, which can open so that bromine adds across it; ethane has only single bonds and is saturated, so it has no double bond for the bromine to add to.

3.3 (a) A high temperature, about 600–700 °C; a catalyst, for example aluminium oxide or silica.
(b) The long-chain fractions are produced in surplus and make poor fuels; cracking converts them into shorter molecules such as petrol, and into alkenes needed for making polymers, which are in high demand.
(c) $C_{10}H_{22} \rightarrow C_8H_{18} + C_2H_4$; the second product is ethene.
(d) Shake each with aqueous bromine, which is orange; ethene decolourises it; octane leaves it orange.
(e) Ethanol; a phosphoric acid catalyst; addition, or hydration.
(f) The alkene has a carbon–carbon double bond that can open, so atoms add across it with nothing lost; octane is saturated, with only single bonds, so it can only react by substitution.