IGCSE CHEMISTRY • EXERCISE SHEET

11.5 Alkenes

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

KEY WORDS bromine 溴 • saturated 饱和的 • unsaturated 不饱和的 • nickel 镍 • catalyst 催化剂

Objective

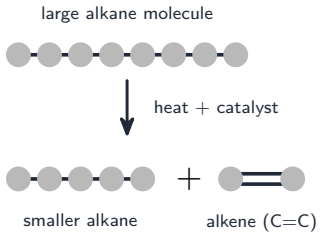
Build the skills to answer exam questions on **alkenes** 烯烃 — unsaturated hydrocarbons, **cracking** 裂化, **addition reactions** 加成反应, and the **bromine water test** 溴水检验.

You must be able to:

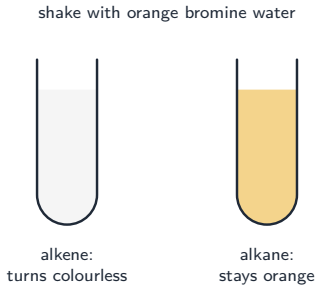
- describe alkenes as unsaturated (C=C) and reactive
- describe cracking and its products
- describe addition reactions and the test for unsaturation

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]

3.4 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

2.1 the C=C carbon–carbon double bond.

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

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.

3.1 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.

3.4 (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.