

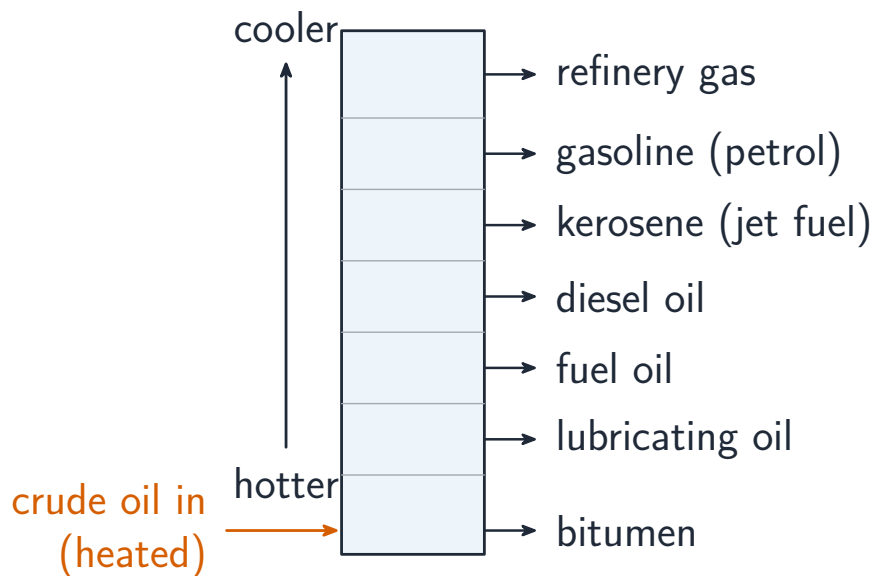
Exercise walk-through

11.1

Formulae, functional groups and terminology

IGCSE Chemistry

Fuels: fractional distillation



up the column: smaller molecules,
lower boiling points, more volatile

Petroleum fractions is split into by boiling point in a tall column.

Top (cool): short chains, more **volatile**, low **viscosity**. Bottom (hot): long chains, **bitumen**.

Separating crude oil

The fractionating column

Crude oil is heated and fed into a **fractionating column** that is hot at the bottom and cool at the top.

Why it works

Longer molecules have stronger forces between them, so a longer **chain length** means a higher boiling point – and it condenses lower down.

Top to bottom

Refinery gases, petrol, naphtha, kerosene, diesel, fuel oil, bitumen.

Cracking

Long fractions in surplus are cracked into short ones in demand, giving alkenes for plastics as well as petrol.

One property – chain length – explains the order, the boiling points, the viscosity and how easily each fraction burns.

The fractions, top to bottom

Fraction	What it is used for
refinery gas	gas for heating and cooking
gasoline (petrol)	fuel for cars
naphtha	raw material for making chemicals
kerosene (paraffin)	fuel for aircraft
diesel oil	fuel for lorries and some cars
fuel oil	fuel for ships and home heating
bitumen	surfacing roads and roofs

Going **up** the column the chains get shorter: lower boiling point, higher **volatility** , lower **viscosity** , and they burn more easily.

Alkanes

combustion

burn in $\text{O}_2 \rightarrow \text{CO}_2 + \text{water}$

substitution

+ Cl_2 in **UV light**

Alkanes are **saturated** & generally unreactive. $\text{CH}_4 + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{HCl}$ (a photochemical reaction).

Cracking

large alkane molecule



heat + catalyst



smaller alkane + alkene (C=C)

Cracking breaks a big alkane into a smaller alkane + an **alkene**, using heat & a catalyst. It makes useful small molecules & alkenes for plastics.

Exercises 2.1-2.3

2.1 State the general formula of the alkanes.

[1]

2.2 Define a structural isomer.

[1]

2.3 State the general formula of the alkenes and give the molecular formula of the alkene with four carbon atoms.

[2]

Exercises 2.1-2.3

2.1 State the general formula of the alkanes. [1]

2.1

- alkanes: C_nH_{2n+2}

2.2 Define a structural isomer. [1]

2.2

- structural isomers have the **same molecular formula** but **different structural formulae**

2.3 State the general formula of the alkenes and give the molecular formula of the alkene with four carbon atoms. [2]

2.3

- alkenes: C_nH_{2n}
- four carbons: C_4H_8

Exercises 2.4·2.5

2.4 State two features shared by all members of a homologous series. [2]

2.5 Explain why the boiling points rise as you go along a homologous series. [2]

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2.4

- any **two** of: same functional group / same general formula / neighbours differ by CH_2 / similar chemistry / gradual change in physical properties
-

2.5 Explain why the boiling points rise as you go along a homologous series. [2]

2.5

- the molecules get **longer**
- intermolecular forces are **stronger**, so more energy is needed to separate them

Exercise 3.1

3.1 A saturated hydrocarbon contains:

[1]

☐

A a C=C double bond

B only single C–C bonds

C an –OH group

D a –COOH group

Exercise 3.1

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☐

A a C=C double bond

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3.1 B

- a saturated hydrocarbon has **only single C–C bonds**
- A is an alkene; C is an alcohol; D is a carboxylic acid

Exercise 3.2 (a)

3.2 Members of a homologous series have similar chemical properties.

(a) State why they have similar chemical properties.

[1]

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(a)

- they have the **same functional group**

Exercise 3.2 (b)

3.2 Members of a homologous series have similar chemical properties.

(b) State how consecutive members differ.

[1]

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(b) State how consecutive members differ.

[1]

(b)

- consecutive members differ by a **CH₂** unit

Exercise 3.3

3.3 Draw the two structural isomers of C_4H_{10} and name each.

[3]

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3.3

- straight chain: **butane** $CH_3CH_2CH_2CH_3$
- branched: **2-methylpropane**
- both named correctly

Exercise 3.4 (a)

3.4 A hydrocarbon X has the molecular formula C_5H_{12} .

(a) Identify the homologous series X belongs to, and give its general formula. [2]

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(a)

- the **alkanes**; general formula $\text{C}_n\text{H}_{2n+2}$

Exercise 3.4 (b)

3.4 A hydrocarbon X has the molecular formula C_5H_{12} .

(b) Draw the displayed formula of the straight-chain isomer of X.

[2]

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3.4 A hydrocarbon X has the molecular formula C_5H_{12} .

(b) Draw the displayed formula of the straight-chain isomer of X.

[2]

(b)

- a chain of **five carbons**, all single-bonded
- every carbon has four bonds, 12 hydrogens in total

Exercise 3.4 (c)

3.4 A hydrocarbon X has the molecular formula C_5H_{12} .

(c) Draw the displayed formula of one branched isomer of X, and explain why it is described as a structural isomer of your answer to (b). [3]

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3.4 A hydrocarbon X has the molecular formula C_5H_{12} .

(c) Draw the displayed formula of one branched isomer of X, and explain why it is described as a structural isomer of your answer to (b). [3]

(c)

- e.g. **2-methylbutane**: a four-carbon chain with CH_3 on carbon 2
- same formula C_5H_{12} , atoms joined in a **different order**

Exercise 3.4 (d)

3.4 A hydrocarbon X has the molecular formula C_5H_{12} .

(d) The straight-chain isomer boils at $36\text{ }^{\circ}\text{C}$ and the branched one at $28\text{ }^{\circ}\text{C}$. Explain this difference. [2]

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(d)

- straight-chain molecules **pack more closely**, so intermolecular forces are stronger
- more energy is needed to separate them, so the **boiling point is higher**

Exercise 3.4 (e)

3.4 A hydrocarbon X has the molecular formula C_5H_{12} .

(e) A different compound, Y, has the molecular formula C_5H_{10} and decolourises bromine water. Identify the homologous series of Y and explain how the test shows this. [3]

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(e)

- **alkenes**; they contain a **C=C**
- bromine **adds** across the double bond, so orange bromine water is **decolourised**