

Exercise walk-through

13.1

Formulas, functional groups and the naming of organic compounds

A-Level Chemistry

Types of formula

empirical

CH_2 – simplest ratio

molecular

C_2H_4 – actual numbers

structural

$\text{CH}_2=\text{CH}_2$ – how they join

displayed

every bond drawn

Types of formula, in detail

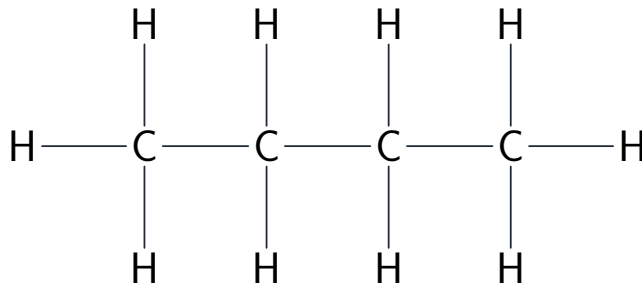
molecular



structural



displayed



skeletal



The same molecule (butane) shown four ways: each formula reveals different structural detail.

The formula types, and the reaction types

empirical formula

the simplest whole-number ratio of atoms

molecular formula

the actual number of each atom in one molecule

displayed formula

every atom and every bond drawn out

hydrolysis

a molecule is **split apart by water**

condensation

two molecules join and a **small molecule such as water is lost**

organic redox

[O] stands for one oxygen atom from an oxidising agent, and
[H] for one hydrogen from a reducing agent

[O] and [H] are a shorthand that keeps organic equations balanced without writing out the whole oxidising agent. Use them – the mark scheme does.

Five ways to write the same compound

General formula

The pattern for a whole family: alkanes are C_nH_{2n+2} .

Molecular formula

The actual number of each atom: C_4H_{10} .

Structural formula

The groups in order: $CH_3CH_2CH_2CH_3$.

Displayed formula

Every atom and every bond drawn out – what a mechanism question needs.

Skeletal formula

Lines for bonds, carbons at the corners, hydrogens on carbon not shown.

A **homologous series** is a family sharing one functional group and one general formula, successive members differing by CH_2 .

Naming

Use systematic **nomenclature** : a stem for the number of carbons (meth-, eth-, prop-, but-, pent-, hex- for 1 to 6), an ending for the functional group.

Exercises 2.1·3.1

2.1 Define the term **hydrocarbon**.

[1]

2.2 Give the molecular formula of the alkane with 5 carbons (using C_nH_{2n+2}).

[1]

3.1 Which formula shows the simplest whole-number ratio of atoms?

[1]

☐

A molecular

B empirical

C displayed

D skeletal

Exercises 2.1·3.1

2.1 Define the term **hydrocarbon**.

[1]

2.1

- a compound made up of only carbon and hydrogen atoms

2.2 Give the molecular formula of the alkane with 5 carbons (using C_nH_{2n+2}).

[1]

2.2

- C_5H_{12}

3.1 Which formula shows the simplest whole-number ratio of atoms?

[1]

☐

- A molecular
B empirical
C displayed
D skeletal

3.1 B

- The empirical formula is the simplest whole-number ratio

Exercise 3.2

3.2 What is the name of $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$?

[1]

☐

A propan-1-ol

B propan-2-ol

C propanal

D propanoic acid

Exercise 3.2

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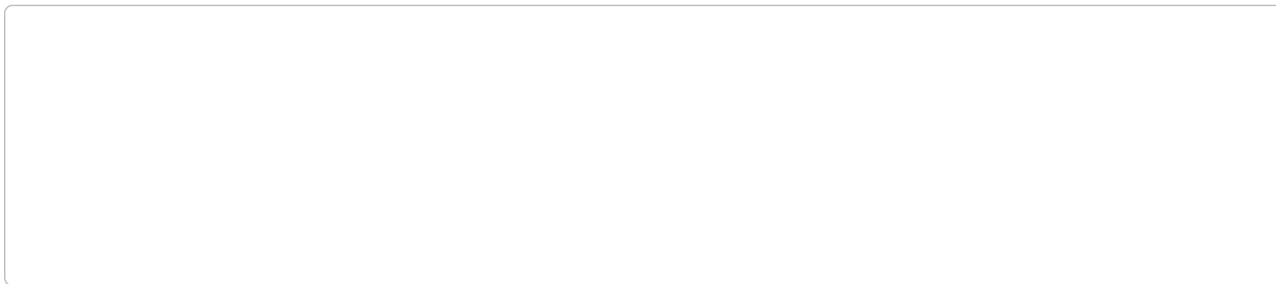
3.2 A

- $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ is propan-1-ol

Exercise 3.3

3.3 (a) Draw the skeletal formula of 2-methylbutane.

[2]



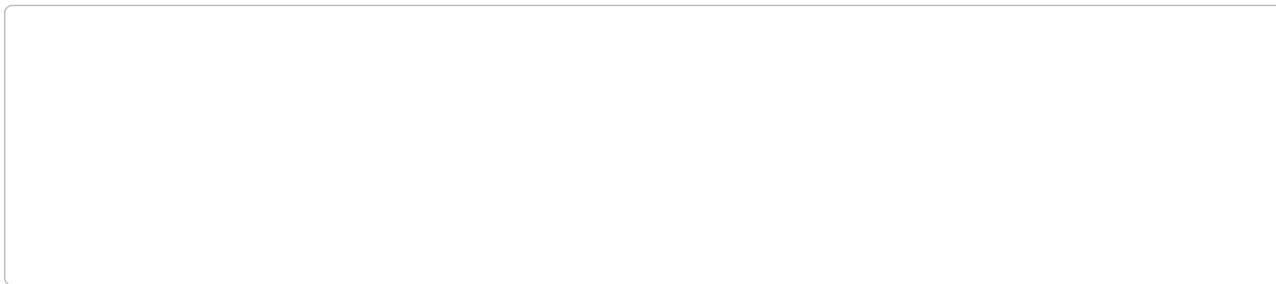
(b) Give the structural formula of butan-2-ol.

[1]

Exercise 3.3

3.3 (a) Draw the skeletal formula of 2-methylbutane.

[2]



(b) Give the structural formula of butan-2-ol.

[1]

3.3

(a)

- a four-carbon zigzag with a methyl branch on the second carbon

(b)

- $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CH}_3$

Exercise 3.4

3.4 Explain why all members of a homologous series have similar chemical properties.[2]

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3.4

- they all have the same functional group, which determines their chemical reactions

Exercise 3.5 (a)

3.5 A compound **Z** contains carbon, hydrogen and oxygen only. Burning 0.100 mol of **Z** completely gives 17.6 g of carbon dioxide and 7.20 g of water. The relative molecular mass of **Z** is 88.0.

(a) Determine the molecular formula of **Z**.

[4]

Exercise 3.5 (a)

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[4]

(a)

- $n(\text{CO}_2) = \frac{17.6}{44.0} = 0.400 \text{ mol}$, so 4 C per molecule; $n(\text{H}_2\text{O}) = \frac{7.20}{18.0} = 0.400 \text{ mol}$, giving 0.800 mol H, so 8 H per molecule; C_4H_8 has a mass of 56.0, leaving $88.0 - 56.0 = 32.0$, i.e. **2** oxygens; molecular formula $\text{C}_4\text{H}_8\text{O}_2$

Exercise 3.5 (b)

3.5 A compound **Z** contains carbon, hydrogen and oxygen only. Burning 0.100 mol of **Z** completely gives 17.6 g of carbon dioxide and 7.20 g of water. The relative molecular mass of **Z** is 88.0.

(b) **Z** is an unbranched carboxylic acid. Give its structural formula and its systematic name.

[2]

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(b)

- $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$; butanoic acid

Exercise 3.5 (c)

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(c) Draw the displayed formula of a structural isomer of **Z** that is an ester, and name it. [3]

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(c)

- Any ester of formula $\text{C}_4\text{H}_8\text{O}_2$ drawn with every bond shown – e.g. methyl propanoate $\text{CH}_3\text{CH}_2\text{COOCH}_3$, or ethyl ethanoate $\text{CH}_3\text{COOCH}_2\text{CH}_3$

Exercise 3.5 (d)

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(d) Using **Z**, explain the difference between an empirical, a molecular and a structural formula. [3]

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(d)

- Empirical = simplest whole-number ratio, $\text{C}_2\text{H}_4\text{O}$; molecular = the actual number of each atom, $\text{C}_4\text{H}_8\text{O}_2$; structural = shows how the atoms are joined, $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$