IGCSE CHEMISTRY • EXERCISE SHEET

11.1 Formulae, functional groups and terminology

Name: _____ Class: _____ Date: _____ **Total: 26 marks**

KEY WORDS molecular formula 分子式 • homologous series 同系物 • displayed formula 结构式 • structural formula 结构简式 • alcohols 醇

Objective

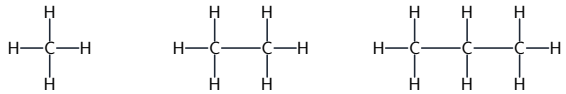
Build the skills to answer exam questions on **formulae, functional groups and terminology** 有机化学术语 — types of formula, the **homologous series** 同系物, saturated/unsaturated, and **structural isomers** 同分异构体.

You must be able to:

- use molecular, displayed, structural and general formulae
- describe a homologous series and its general formula
- recognise saturated/unsaturated and structural isomers

1 Worked examples

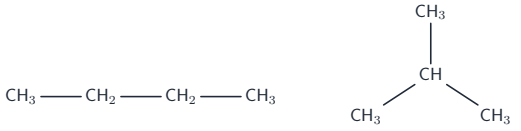
■ Homologous series & isomers



methane CH_4 | ethane C_2H_6 | propane C_3H_8

each step adds a CH_2 unit general formula C_nH_{2n+2}

A homologous series: same functional group, differ by CH_2, general formula C_nH_{2n+2} for alkanes



butane (straight chain) 2-methylpropane (branched)

both have the formula C_4H_{10}: same formula, different structure (structural isomers)

Structural isomers: same molecular formula, different structures

■ Naming, drawing and telling isomers apart

A **homologous series** 同系列 is a family with the same **functional group** 官能团, the same general formula, and neighbours differing by CH_2. Along a series the boiling point rises as the molecules get longer, because the intermolecular forces between the larger molecules are stronger.

Series	Functional group	General formula	First four
alkanes	none (all single bonds)	C_nH_{2n+2}	methane, ethane, propane, butane
alkenes	C = C	C_nH_{2n}	ethene, propene, butene
alcohols	−OH	$C_nH_{2n+1}OH$	methanol, ethanol, propanol
carboxylic acids	−COOH	$C_nH_{2n+1}COOH$	methanoic, ethanoic, propanoic

Three formulas, three jobs. The **molecular formula** counts the atoms (C_4H_{10}). The **structural formula** shows the order of the groups without drawing every bond ($CH_3CH_2CH_2CH_3$). The **displayed formula** 结构式 draws every atom and every bond, so each carbon must show four bonds and each hydrogen one.

Structural isomers 结构异构体 have the same molecular formula but different structures, so they have different physical properties (for example different boiling points) while sharing the same chemical family.

Worked example. Draw and name the two isomers of C_4H_{10}, and explain why they have different boiling points. Butane is a straight chain of four carbons; 2-methylpropane is a chain of three with a CH_3 branch on the middle carbon. Both must show every carbon with four bonds. Butane boils higher, because its unbranched molecules pack closer together, so the forces between them are stronger and more energy is needed to separate them.

2 Practice

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]

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]

3 Exam-style questions

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

3.2 Members of a homologous series have similar chemical properties.

(a) State why they have similar chemical properties. [1]

(b) State how consecutive members differ. [1]

3.3 Draw the two structural isomers of C_4H_{10} and name each. [3]

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]

(b) Draw the displayed formula of the straight-chain isomer of X. [2]

(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]

(d) The straight-chain isomer boils at 36 °C and the branched one at 28 °C. Explain this difference. [2]

(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]

Solutions

2.1 C_nH_{2n+2}.

2.2 compounds with the same molecular formula but different structural formulae.

2.3 C_nH_{2n}; C_4H_8.

2.4 Any two of: the same functional group; the same general formula; neighbouring members differ by CH_2; similar chemical properties; a gradual change in physical properties.

2.5 The molecules get longer as the series is climbed, so the intermolecular forces between them are stronger and more energy is needed to separate them.

3.1 B. A saturated hydrocarbon has only single C–C bonds.

3.2 (a) they have the same functional group.
(b) by a CH_2 unit each step.

3.3 straight chain butane $CH_3CH_2CH_2CH_3$; branched 2-methylpropane; both named correctly.

3.4 (a) The alkanes; C_nH_{2n+2}.
(b) A chain of five carbon atoms, each single-bonded, with every carbon showing four bonds and every hydrogen one, giving 12 hydrogens in total.
(c) A correct branched structure, for example 2-methylbutane: a four-carbon chain with a CH_3 group on the second carbon, drawn with all bonds shown; it is a structural isomer because it has the same molecular formula, C_5H_{12}, but the atoms are joined in a different order.
(d) The straight-chain molecules pack more closely together, so the intermolecular forces between them are stronger; more energy is needed to separate them, so its boiling point is higher.
(e) The alkenes; an alkene contains a carbon-carbon double bond, and bromine adds across that double bond, so the orange bromine water is decolourised, which an alkane would not do.