13.1 Formulas, functional groups and naming of organic compounds

Name: _____ Class: _____ Date: _____ **Total: 21 marks**

KEY WORDS alkane • functional group • hydrocarbon • nomenclature • molecular formula

Objective

Build the skills to answer exam questions on **formulas, functional groups and naming** – **hydrocarbons**, **functional groups**, the types of formula, and systematic **nomenclature**.

You must be able to:

- define hydrocarbon and explain what a functional group is
- interpret and use general, molecular, structural, displayed and skeletal formulas
- name simple organic molecules systematically

1 Key knowledge and worked examples

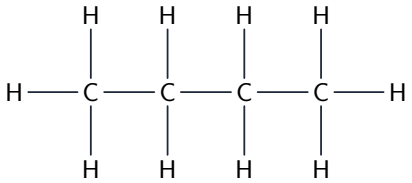
■ Functional groups and formulas

A **hydrocarbon** contains only C and H. A **functional group** is the reactive part that dictates a compound's properties (e.g. –OH in alcohols).

molecular C_4H_{10}

structural $CH_3CH_2CH_2CH_3$

displayed



skeletal

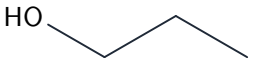
The same molecule shown as molecular, structural, displayed and skeletal formulas

chain

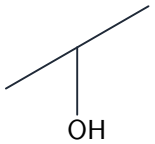
butane

2-methylpropane

positional

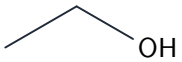


propan-1-ol

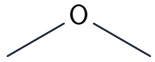


propan-2-ol

functional



ethanol (alcohol)



methoxymethane (ether)

Naming distinguishes structural isomers

- **general** (family pattern, e.g. alkanes C_nH_{2n+2}); **molecular** (C_4H_{10}); **structural** ($CH_3CH_2CH_2CH_3$); **displayed** (every bond drawn); **skeletal** (lines; C at corners).

Naming

Stem for carbons (meth/eth/prop/but/pent/hex = 1–6); ending for the functional group; numbers for positions. E.g. $CH_3CH(OH)CH_3$ = propan-2-ol.

2 Practice

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 Exam-style questions

3.1 Which formula shows the simplest whole-number ratio of atoms? [1]

- **A** molecular
- **B** empirical
- **C** displayed
- **D** skeletal

3.2 What is the name of $CH_3CH_2CH_2OH$? [1]

- **A** propan-1-ol
- **B** propan-2-ol
- **C** propanal
- **D** propanoic acid

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

(b) Give the structural formula of butan-2-ol. [1]

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

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]

(b) **Z** is an unbranched carboxylic acid. Give its structural formula and its systematic name. [2]

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

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

Solutions

Each answer shows the steps, then the **result**.

2.1

- a compound made up of only carbon and hydrogen atoms

2.2

- C_5H_{12}

3.1 B

- The empirical formula is the simplest whole-number ratio

3.2 A

- $CH_3CH_2CH_2OH$ is propan-1-ol

3.3

(a)

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

(b)

- $CH_3CH(OH)CH_2CH_3$

3.4

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

3.5

(a)

- $n(CO_2) = \frac{17.6}{44.0} = 0.400$ mol, so 4 C per molecule; $n(H_2O) = \frac{7.20}{18.0} = 0.400$ 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 $C_4H_8O_2$

(b)

- $CH_3CH_2CH_2COOH$; **butanoic acid**

(c)

- Any ester of formula $C_4H_8O_2$ drawn with every bond shown – e.g. methyl propanoate $CH_3CH_2COOCH_3$, or ethyl ethanoate $CH_3COOCH_2CH_3$

(d)

- Empirical = simplest whole-number ratio, C_2H_4O; molecular = the actual number of each atom, $C_4H_8O_2$; structural = shows how the atoms are joined, $CH_3CH_2CH_2COOH$