

13.1 Formulas, functional groups and naming of organic compounds

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

KEY WORDS alkane 烷烃 • functional group 官能团 • hydrocarbon 碳氢化合物
• nomenclature 命名法 • molecular formula 分子式

Objective

Build the skills to answer exam questions on **formulas, functional groups and naming** — **hydrocarbons** 碳氢化合物, **functional groups** 官能团, the types of formula, and systematic **nomenclature** 命名法.

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

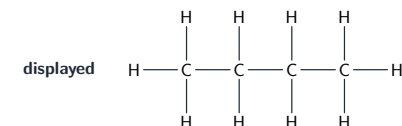
1 Worked examples

■ 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).

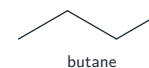
molecular C_4H_{10}

structural $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$

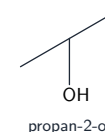
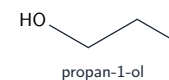


The same molecule shown as molecular, structural, displayed and skeletal formulas

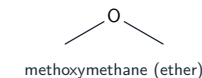
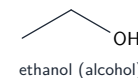
chain



positional



functional



Naming distinguishes structural isomers

- **general** (family pattern, e.g. alkanes $\text{C}_n\text{H}_{2n+2}$); **molecular** (C_4H_{10}); **structural** ($\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$); **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. $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$ = 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

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

3.3 (a) a four-carbon zigzag with a methyl branch on the second carbon.

(b) $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CH}_3$.

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

3.5 (a) $n(\text{CO}_2) = \frac{17.6}{44.0} = 0.400$ mol, so 4 C per molecule; $n(\text{H}_2\text{O}) = \frac{7.20}{18.0} = 0.400$ 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 $\text{C}_4\text{H}_8\text{O}_2$.

(b) $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$; **butanoic acid**.

(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 $\text{CH}_3\text{COOCH}_2\text{CH}_3$.

(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, $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$.