

1.3 Elemental Composition of Pure Substances

Name: _____ Class: _____ Date: _____

Total: 14 marks

KEY WORDS empirical formula 实验式 • molecular formula 分子式 • percent composition 百分组成
• molar mass 摩尔质量 • moles 摩尔

Objective

Build the skills to answer exam questions on **the elemental composition of pure substances**.

You must be able to:

- calculate the **percent composition** 百分组成 by mass of each element
- find an **empirical formula** 实验式 from mass percentages
- find a **molecular formula** 分子式 from the empirical formula and molar mass
- convert masses to moles and divide by the smallest

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Percent composition

$$\% \text{ element} = \frac{\text{mass of that element}}{\text{total mass}} \times 100\%.$$

In water ($M = 18$), oxygen is $16/18 \times 100 \approx 89\%$.

■ Empirical formula

Convert each element's mass to moles, then divide by the smallest. For 40% C, 6.7% H, 53.3% O (per 100 g): C = 3.33, H = 6.7, O = 3.33 mol; dividing by 3.33 gives CH₂O.

■ Molecular formula

Divide the true molar mass by the empirical mass for the multiple n . Glucose: empirical CH₂O (30), molar mass 180, so $n = 6$, giving C₆H₁₂O₆.

2 Practice

Now apply the methods above.

2.1 In water (H_2O , $M = 18$), what percent of the mass is oxygen (16)? [2]

2.2 State what an empirical formula gives. [1]

2.3 A compound has empirical mass 30 and molar mass 90. Find the multiple n . [2]

2.4 After dividing by the smallest you get a ratio 1 : 1.5. State the whole-number ratio. [1]

3 Exam-style questions

3.1 The empirical formula of a compound gives [1]

- **A** the exact number of atoms in a molecule
- **B** the simplest whole-number ratio of atoms
- **C** the molar mass
- **D** the percent composition

3.2 A compound is 75% carbon and 25% hydrogen by mass ($\text{C} = 12$, $\text{H} = 1$). Its empirical formula is [1]

- **A** CH
- **B** CH_2
- **C** CH_4
- **D** C_2H

3.3 A compound is 40% sulfur and 60% oxygen by mass ($\text{S} = 32$, $\text{O} = 16$).

(a) Find the empirical formula. [3]

(b) State the method you used.

[1]

3.4 A compound has empirical formula CH_2 (empirical mass 14) and a molar mass of 56 g/mol.

(a) Find the multiple n .

[1]

(b) Write the molecular formula.

[1]

Solutions

2.1 $16/18 \times 100 \approx 89\%$.

2.2 The simplest whole-number ratio of atoms.

2.3 $n = 90/30 = 3$.

2.4 2 : 3 (multiply both by 2).

3.1 B — the simplest whole-number ratio of atoms.

3.2 C — C: $75/12 = 6.25$, H: $25/1 = 25$; ratio 1 : 4, so CH_4 .

3.3 (a) Per 100 g: S = $40/32 = 1.25$, O = $60/16 = 3.75$ mol; divide by 1.25: S 1, O 3; empirical formula SO_3 . (b) Convert mass percents to moles and divide by the smallest.

3.4 (a) $n = 56/14 = 4$. (b) C_4H_8 .