AP CHEMISTRY • EXERCISE SHEET

# 1.3 Elemental Composition of Pure Substances

Name: _____ Class: _____ Date: _____ **Total: 14 marks**

## 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 $CH_2O$.

■ **Molecular formula**

Divide the true molar mass by the empirical mass for the multiple $n$. Glucose: empirical $CH_2O$ (30), molar mass 180, so $n = 6$, giving $C_6H_{12}O_6$.

## 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 (C = 12, 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 (S = 32, 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]

## 4 Go further

You are ready for more on this subtopic:

- work through the interactive **1.3 Elemental Composition of Pure Substances** lesson on the **Learn** page;
- read the **Atomic Structure and Properties** section of the AP Chemistry handout on the **Know** page for the full explanation and worked diagrams.

## 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) $C_4H_8$.