A-LEVEL CHEMISTRY • EXERCISE SHEET

1.2 Isotopes

Name: _____ Class: _____ Date: _____ **Total: 22 marks**

KEY WORDS isotope 同位素 • relative atomic mass 相对原子质量 • chemical properties 化学性质 • physical properties 物理性质 • density 密度

Objective

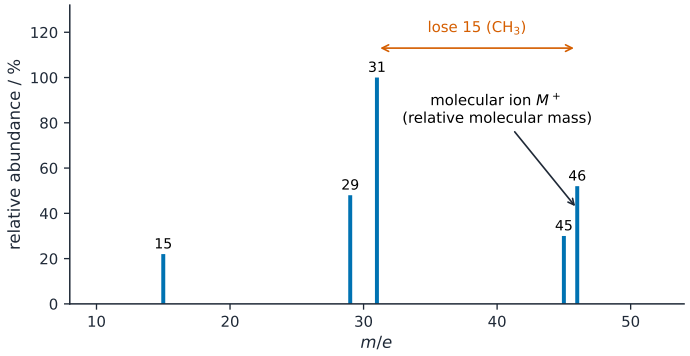
Build the skills to answer exam questions on **isotopes** 同位素 — what they are, the ${}^{A}_{Z}\mathrm{X}$ notation, their properties, and calculating **relative atomic mass** 相对原子质量 from isotopic abundances.

You must be able to:

- define isotope and use the ${}^{A}_{Z}\mathrm{X}$ notation
- explain why isotopes have the same chemical but different physical properties
- calculate relative atomic mass from isotopic abundances

1 Worked examples

What isotopes are



M^+ peak $\approx M_r$ · gaps between peaks = mass of fragments lost

A mass spectrum reveals isotopes and their abundance

Isotopes are atoms of the same element with the same number of **protons** but a different number of **neutrons** — same proton number Z, different nucleon number A. E.g. chlorine has ${}^{35}_{17}\mathrm{Cl}$ and ${}^{37}_{17}\mathrm{Cl}$.

Same chemical, different physical properties

Chemical properties depend on the **electrons** (especially the outer ones). Isotopes have the same electron arrangement, so they react the same way — **same chemical properties**. Some physical properties depend on **mass**, so they differ: a heavier isotope has a higher **density** 密度.

Relative atomic mass from abundances

$$A_r = \frac{\sum(\text{isotope mass} \times \%\ \text{abundance})}{100}$$

Example. Chlorine is 75% ${}^{35}\mathrm{Cl}$ and 25% ${}^{37}\mathrm{Cl}$:

$$A_r = \frac{(35 \times 75) + (37 \times 25)}{100} = \frac{3550}{100} = 35.5.$$

2 Practice

2.1 Define the term **isotope**. [2]

2.2 State the number of protons, neutrons and electrons in an atom of ${}^{37}_{17}\mathrm{Cl}$. [3]

3 Exam-style questions

3.1 Two isotopes of the same element always have the same: [1]

- **A** number of neutrons
- **B** number of protons
- **C** nucleon number
- **D** density

3.2 Why do isotopes of an element have identical chemical properties? [1]

- **A** they have the same mass
- **B** they have the same number and arrangement of electrons
- **C** they have the same number of neutrons
- **D** they have different densities

3.3 Boron has two isotopes: ^{10}B (20%) and ^{11}B (80%).

(a) Calculate the relative atomic mass of boron. [2]

(b) Explain why ^{11}B is denser than ^{10}B. [1]

3.4 A sample of copper contains 69% ^{63}Cu and 31% ^{65}Cu. Calculate its relative atomic mass to 1 decimal place. [2]

3.5 The mass spectrum of a sample of element **X** gives the following peaks.

m/z	**64**	**66**	**67**	**68**	**70**
Relative abundance / %	48.6	27.9	4.1	18.8	0.6

(a) Calculate the relative atomic mass of **X** to three significant figures and identify the element. [4]

(b) A second sample of **X**, taken from a meteorite, gives the same five peaks at different heights. State, with a reason, whether the two samples have the same chemical properties. [2]

(c) Explain why the peak at $m/z = 67$ is so much shorter than the others. [2]

(d) A student writes "the relative atomic mass of **X** is 65.5 g". Give **two** things wrong with that statement. [2]

Solutions

2.1 atoms of the same element (same number of protons) with different numbers of neutrons.

2.2 protons 17; neutrons $37 - 17 = 20$; electrons 17.

3.1 B. Isotopes have the same number of protons.

3.2 B. The same electron arrangement gives the same chemistry.

3.3 (a) $A_r = \dfrac{(10 \times 20) + (11 \times 80)}{100} = \dfrac{1080}{100} = 10.8$.
(b) ^{11}B has one more neutron, so more mass in the same volume.

3.4 $A_r = \dfrac{(63 \times 69) + (65 \times 31)}{100} = \dfrac{6362}{100} = 63.6$.

3.5 (a) $A_r = \dfrac{(64 \times 48.6) + (66 \times 27.9) + (67 \times 4.1) + (68 \times 18.8) + (70 \times 0.6)}{100} = \dfrac{6546.9}{100} = 65.469 = 65.5$; this is **zinc**.
(b) Yes. Chemical properties depend on the electron arrangement, which is fixed by the proton number and is the same for every isotope — the extra neutrons take no part in bonding.
(c) The height of a peak is proportional to the relative abundance of that isotope; only 4.1% of the atoms are ^{67}X, so few ions of that mass reach the detector.
(d) Relative atomic mass is a **ratio** of masses, so it has no units; and it is a weighted mean over all the isotopes, not the mass of any single atom.