

Exercise walk-through

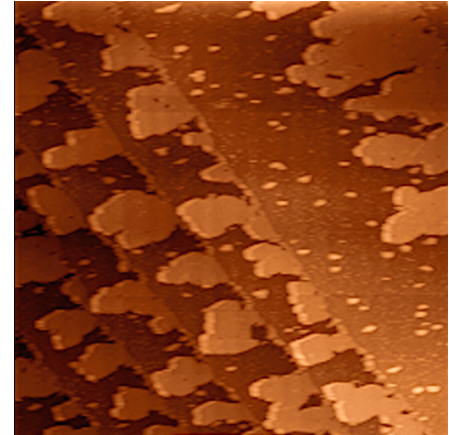
1.2

Isotopes

A-Level Chemistry

What we will cover

- 1 Inside the atom
- 2 Counting particles & radius
- 3 Isotopes
- 4 Sub-shells & orbitals
- 5 Electronic configuration
- 6 Ionisation energy



real atoms, imaged

What isotopes change, and what they do not

the atomic number

the proton count – identical between isotopes, so the element is the same

the mass number

protons plus neutrons – this is what differs

chemical properties

identical, because they depend on the electron arrangement, which is unchanged

physical properties

some **depend on mass**, so they differ: a heavier isotope diffuses more slowly and has a higher density and boiling point

neutral atoms

protons equal electrons; an ion has gained or lost electrons, never protons

the atomic radius

unchanged between isotopes, since it is set by the electron shells

Chemistry is electrons; mass effects are physics. That single split answers every isotope question on the paper.

Exam tips

- Define **isotopes** in full: atoms of the same element with the same number of protons but a different number of neutrons – the mark scheme wants both halves.
- 4s fills **before** 3d, but electrons are **removed from 4s first** when forming ions, so Fe^{3+} is $[\text{Ar}]\text{3d}^5$ (not $[\text{Ar}]\text{3d}^3\text{4s}^2$).
- In successive ionisation energies, a **big jump** marks the start of a new (inner) shell – use the jumps to place the element in its group.
- Explain every ionisation-energy trend with the same three factors: **nuclear charge, distance and shielding**, plus sub-shell effects for the small dips.
- Learn the exact reason first ionisation energy of oxygen is **below** nitrogen: oxygen's **paired 2p electrons repel**, so one is easier to remove.

Exercises 2.1·2.2

2.1 Define the term **isotope**.

[2]

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

[3]

Exercises 2.1·2.2

2.1 Define the term **isotope**.

[2]

2.1

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

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

[3]

2.2

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

Exercises 3.1·3.2

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]

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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

Exercises 3.1·3.2

3.1 Two isotopes of the same element always have the same:

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3.1 B

- Isotopes have the same number of protons

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

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D they have different densities

3.2 B

- The same electron arrangement gives the same chemistry

Exercise 3.3 (a)

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

(a) Calculate the relative atomic mass of boron.

[2]

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(a)

- $$A_r = \frac{(10 \times 20) + (11 \times 80)}{100} = \frac{1080}{100} = 10.8$$

Exercise 3.3 (b)

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

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

[1]

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

[1]

(b)

- ^{11}B has one more neutron, so more mass in the same volume

Exercise 3.4

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

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3.4

- $$A_r = \frac{(63 \times 69) + (65 \times 31)}{100} = \frac{6362}{100} = 63.6$$

Exercise 3.5 (a)

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]

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(a)

$$\bullet A_r = \frac{(64 \times 48.6) + (66 \times 27.9) + (67 \times 4.1) + (68 \times 18.8) + (70 \times 0.6)}{100} = \frac{6546.9}{100} = 65.469 = 65.5; \text{ this is } \mathbf{zinc}$$

Exercise 3.5 (b)

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

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(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.

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(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

Exercise 3.5 (c)

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m/z	64	66	67	68	70
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(c) Explain why the peak at $m/z = 67$ is so much shorter than the others.

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(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

Exercise 3.5 (d)

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

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

[2]

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(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