

Exercise walk-through

1.4

Ionisation energy

A-Level Chemistry

First ionisation energy

First ionisation energy : $X(g) \rightarrow X^+(g) + e^-$.

- rises across a period (more nuclear charge)
- dips at Al ($3p < 3s$) and S (**spin-pair repulsion**)

The dips are evidence for **sub-shells**.

Defining first ionisation energy exactly

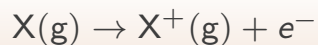
the definition

the energy to remove one electron from each atom in **one mole of gaseous atoms**

why gaseous

so there are **no forces between the particles** to include in the measurement

the equation



the unit

kJ mol^{-1}

what it depends on

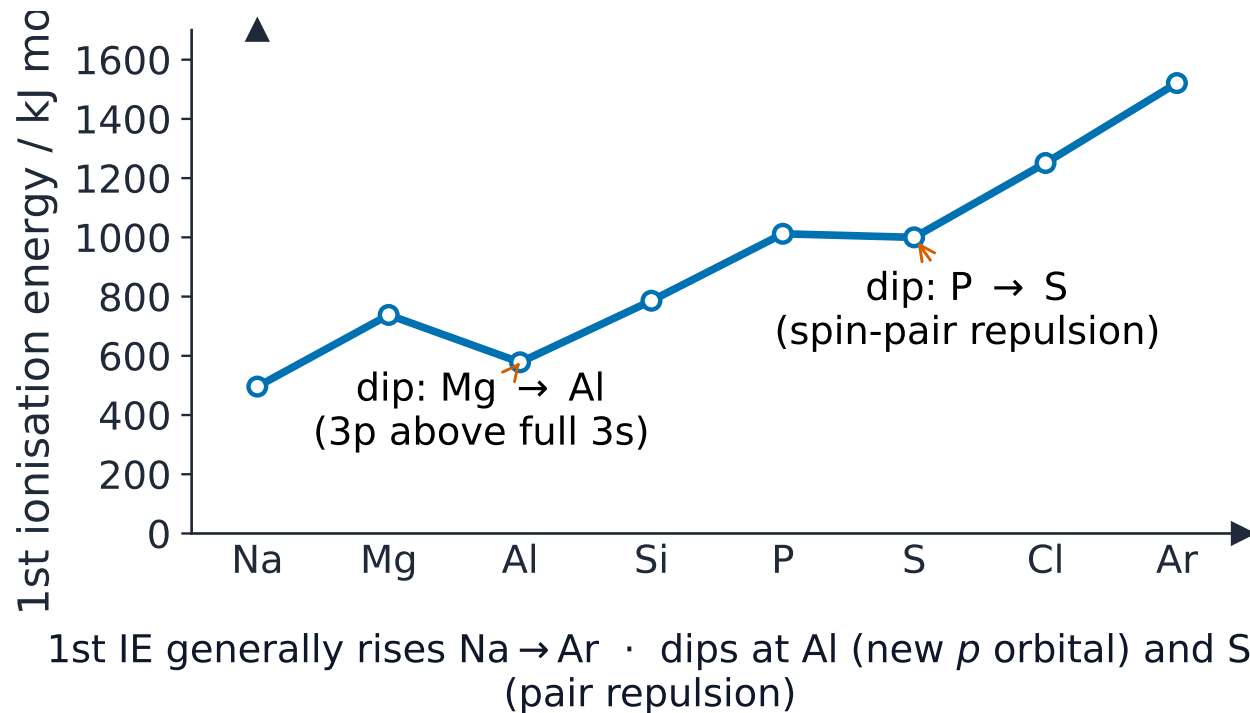
nuclear charge, **atomic radius**, and shielding by inner shells

the trend

increases across a period, decreases down a group – with the small drops that reveal sub-shell structure

The state symbols (**g**) are part of the definition, not decoration. Omitting them loses the mark even when the words are right.

First ionisation energy, in detail



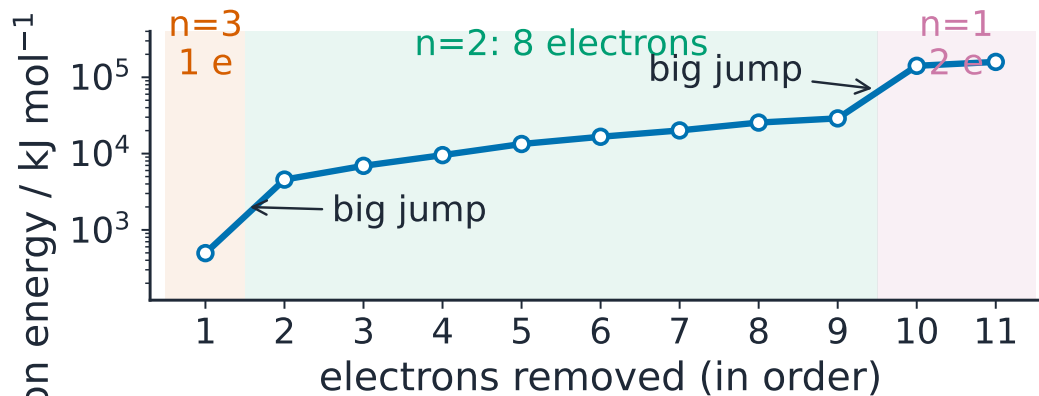
First ionisation energy rises across Period 3 but dips at Al and at S – evidence that sub-shells exist

Successive ionisation energies

Each **successive ionisation energy** is larger (a more positive ion).

Big jumps reveal the shells: sodium's 2, 8, 1 pattern. Electrons removed before the first jump = the group number.

Successive ionisation energies, in detail



big jump = next electron from a shell closer to the nucleus (shell structure)

Each **successive ionisation energy**

is larger (a more positive ion).

Exercises 2.1·3.1

2.1 Write an equation, with state symbols, for the first ionisation energy of magnesium.[2]

2.2 State **two** factors that affect the size of an ionisation energy. [2]

3.1 Why is the second ionisation energy of an element always larger than the first? [1]

☐

A the atom is now a gas

B the electron is removed from a more positive ion

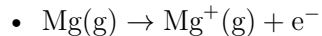
C there are more neutrons

D shielding increases

Exercises 2.1·3.1

2.1 Write an equation, with state symbols, for the first ionisation energy of magnesium.[2]

2.1



2.2 State **two** factors that affect the size of an ionisation energy. [2]

2.2

- any two: nuclear charge; atomic radius; shielding; (spin-pair repulsion)

3.1 Why is the second ionisation energy of an element always larger than the first? [1]

☐

A the atom is now a gas

B the electron is removed from a more positive ion

C there are more neutrons

D shielding increases

3.1 B

- The electron is pulled from a more positive ion, needing more energy

Exercises 3.2-3.3

3.2 The first ionisation energy of sulfur is lower than that of phosphorus because: [1]

☐

A sulfur has fewer protons

B sulfur's removed electron is one of a pair in a 3p orbital (spin-pair repulsion)

C sulfur is in a different period

D sulfur has more shielding

3.3 Explain why the first ionisation energy decreases down Group 2. [3]

Exercises 3.2-3.3

3.2 The first ionisation energy of sulfur is lower than that of phosphorus because: [1]

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A sulfur has fewer protons

B sulfur's removed electron is one of a pair in a 3p orbital (spin-pair repulsion)

C sulfur is in a different period

D sulfur has more shielding

3.2 B

- The paired 3p electron in sulfur is easier to remove (spin-pair repulsion)

3.3 Explain why the first ionisation energy decreases down Group 2. [3]

3.3

- down the group each element has more shells, so more shielding and a larger atomic radius; the outer electron is held less tightly, so it is easier to remove

Exercise 3.4

3.4 The first six ionisation energies of an element (kJ mol^{-1}) are: 590, 1150, 4940, 6480, 8120, 10500. Deduce which group the element is in, and explain your answer. [2]

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3.4

- Group 2; there is a large jump between the 2nd and 3rd ionisation energies, showing 2 easily-removed outer electrons before reaching a full inner shell