

1 Atomic structure – Part 2

Name: _____ Class: _____ Date: _____

Vocabulary

Write each word three times.

English	Write it 3 times (English)		
shells	_____	_____	_____
sub-shells	_____	_____	_____
orbitals	_____	_____	_____
first ionisation energy	_____	_____	_____
nuclear charge	_____	_____	_____
atomic radius	_____	_____	_____
shielding	_____	_____	_____

Recall

From Part 1 you know electrons sit in **shells** _____. Here we look more closely at how they are arranged, and at the energy needed to remove one.

- At IGCSE you wrote electron arrangements like 2,8,1.
- Now we split shells into **sub-shells** _____ (s, p, d).

New ideas

Read these first, then do the Practice.

■ 1 Shells, sub-shells and orbitals

Each shell ($n = 1, 2, 3, \dots$) is split into **sub-shells** (s, p, d). Each sub-shell is made of **orbitals**, and each orbital holds up to **two** electrons.

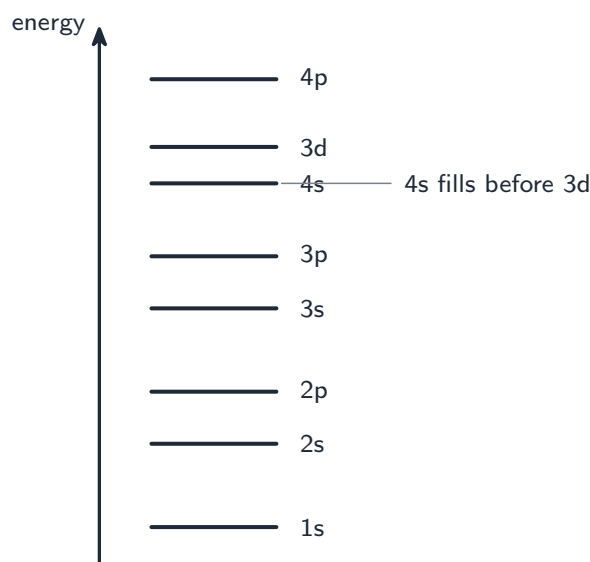
Sub-shell	Orbitals	Max electrons
s	1	2
p	3	6
d	5	10

■ 2 Filling order

Electrons fill the lowest-energy sub-shell first:

$$1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p$$

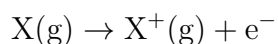
The surprise: **4s fills before 3d** (it is slightly lower in energy).



Worked example. Iron (Fe, $Z = 26$): $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$, or in short $[\text{Ar}] 3d^6 4s^2$.

■ 3 First ionisation energy

The **first ionisation energy** is the energy to remove one electron from each atom in one mole of gaseous atoms:

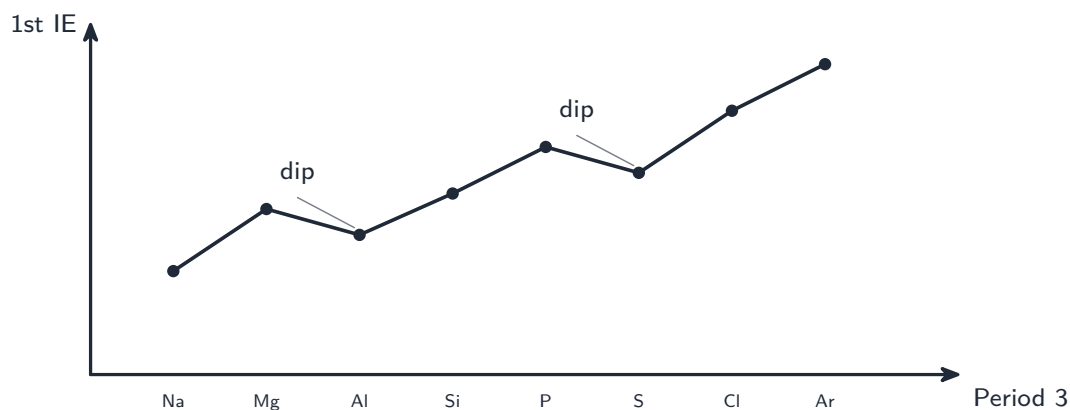


It depends on three factors:

- **nuclear charge** — more protons → stronger pull → higher.
- **atomic radius** — further out → weaker pull → lower.
- **shielding** — more inner shells → weaker pull → lower.

■ 4 The trend across Period 3

Across a period the first ionisation energy generally **rises** (more nuclear charge, similar shielding). But there are two small **dips** – at Al and at S – which are evidence that sub-shells exist.



Watch out: although 4s fills *before* 3d, the 4s electrons leave *first* when the atom ionises – so Fe^{2+} is $[\text{Ar}] 3d^6$, not $[\text{Ar}] 3d^4 4s^2$.

Practice

Try these in order.

1.1 How many electrons fill (a) an s sub-shell, (b) a p sub-shell, (c) a d sub-shell? [3]

1.2 Which fills first, 4s or 3d? [1]

1.3 Write the full electronic configuration of an atom with $Z = 20$ (calcium). [2]

1.4 Define the *first ionisation energy*, including a balanced equation for element X. [2]

1.5 Explain why the first ionisation energy generally rises across a period. [2]

1.6 Down a group, the first ionisation energy falls. Give two reasons why. [2]

1.7 Challenge. Across Period 3 the first ionisation energy dips at aluminium. Explain why aluminium's first ionisation energy is lower than magnesium's. [2]