Ionisation Energies Map

Cambridge International AS & A Level Chemistry · Topic 1 Ionisation energy and 9.1 Period 3

1 Ionisation energies

1.4.1–1.4.2

- **First IE**: one electron from each atom in 1 mol of **gaseous** atoms
- $Na(g) \rightarrow Na^+(g) + e^-$
- Second: $Na^+(g) \rightarrow Na^{2+}(g) + e^-$
- Always **endothermic**
- Each successive IE is larger



2 The four factors

1.4.5–1.4.6

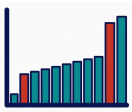
- **Nuclear charge**: more protons, stronger pull
- **Atomic radius**: further, weaker pull
- **Shielding** by inner shells and sub-shells
- **Spin-pair repulsion**: a paired electron is easier to remove
- Attraction: nucleus and outer electron

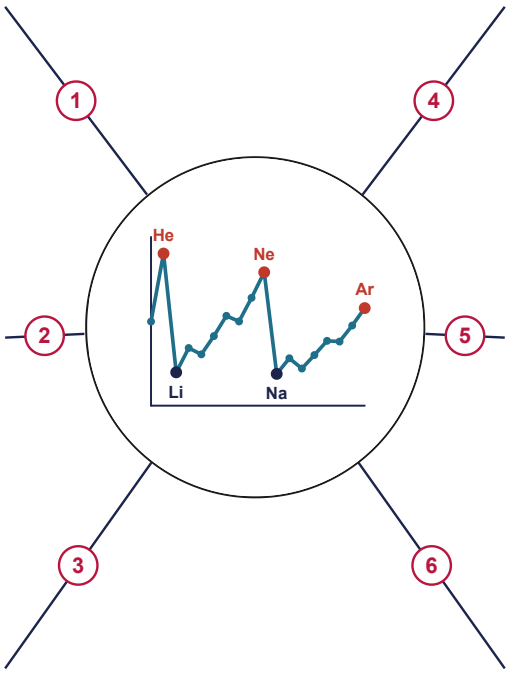


3 Successive IEs

1.4.4, 1.4.7–1.4.8

- **Big jump**: next electron from an inner shell
- Na: jumps after 1 and 9 → 2,8,1
- Counts between jumps = electrons per shell
- Group: count before the first jump (s)
- p block: count + 10 (Groups 13–18)

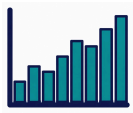




4 Across a period

1.4.3(a)

- General **rise**: more protons, same shell
- Shielding roughly constant
- **Dip at B, Al**: electron from p
- **Dip at O, S**: spin-pair repulsion
- Peak at the noble gas



5 Down a group

1.4.3(b)

- First IE **falls**
- One more shell: **larger radius**
- **More shielding**
- These outweigh the extra protons
- Metals more reactive down the group



6 Period 3 properties

9.1

- **Na → Al**: metallic, melting point rises; conductors
- **Si**: giant covalent, highest; semiconductor
- **P_4, S_8, Cl_2**: weak intermolecular forces
- **Ar**: single atoms, lowest
- P to Ar: non-conductors



Period 3 at a glance

first IE in kJ mol^{-1}; melting point in K

Element	First IE	Electron removed	Structure	Melting point	Conducts?
Na	496	3s (unpaired)	giant metallic	371	yes
Mg	738	3s (paired)	giant metallic	923	yes
Al	578	3p (unpaired)	giant metallic	933	yes (best)
Si	789	3p (unpaired)	giant covalent	1683	semiconductor
P	1012	3p (unpaired)	simple molecular, P_4	317	no
S	1000	3p (paired)	simple molecular, S_8	392	no
Cl	1251	3p (paired)	simple molecular, Cl_2	172	no
Ar	1521	3p (paired)	monatomic	84	no

Reading the evidence

Evidence for shells

- Big jumps in successive IEs
- Counts between jumps = electrons per shell
- Na: 1, 8, 2

Evidence for sub-shells

- Dips at B and Al: p above s
- Dips at O and S: spin-pair repulsion
- A single-shell model cannot explain them

Structure decides properties

- metallic: delocalised electrons
- giant covalent: strong bonds
- simple molecular: weak forces

Ionisation energies explain why metals form positive ions and why reactivity changes down a group (Topics 3 and 10).

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