Ionisation Energies and Periodicity Map

Edexcel A Level Chemistry · Topic 1 Atomic Structure · Ionisation Energies and Periodicity

1 Ionisation energies 1.11

- **First IE**: remove 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



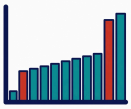
2 What decides the size 1.12

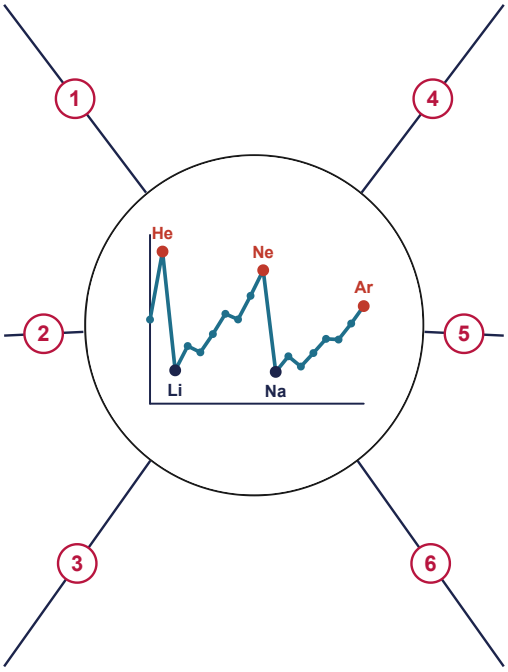
- **Nuclear charge**: more protons, stronger pull
- **Distance**: higher shell, weaker pull
- **Shielding**: inner electrons repel
- **Sub-shell**: p higher in energy than s
- Pairing: a paired electron is easier to remove



3 Successive IEs 1.15

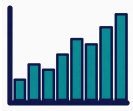
- Plot **$\log_{10}$(IE)**: the values span a huge range
- **Big jump**: next electron from an inner shell
- Na: jumps after 1 and 9 → 2,8,1
- Electrons before the first jump = **group**
- Small steps inside a shell: sub-shells





4 Across a period 1.13, 1.25 ii

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



5 Down a group 1.14

- First IE **falls**
- One more shell each time: **further** away
- **More shielding**
- These outweigh the extra protons
- Metals more reactive down the group



6 Radius and melting temperature 1.24–1.26

- **Atomic radius** falls across a period: more protons, same shell
- **Na → Al**: metallic bonding strengthens
- **Si** (B, C): giant covalent, highest
- **P_4, S_8, Cl_2, Ar**: London forces only
- Boiling temperatures follow the same pattern



Period 3 at a glance

metallic or covalent radius in pm; first IE in kJ mol^{-1}; melting temperature in K

Element	Radius / pm	First IE	Electron removed	Structure	Melting T
Na	186	496	3s (unpaired)	giant metallic	371
Mg	160	738	3s (paired)	giant metallic	923
Al	143	578	3p (unpaired)	giant metallic	933
Si	118	789	3p (unpaired)	giant covalent	1683
P	110	1012	3p (unpaired)	simple molecular, P_4	317
S	104	1000	3p (paired)	simple molecular, S_8	392
Cl	99	1251	3p (paired)	simple molecular, Cl_2	172
Ar	—	1521	3p (paired)	monatomic	84

Reading the evidence

Evidence for shells

- Emission spectra: lines, not a continuous band
- Big jumps in successive IEs
- Na: 1, 8, 2 between the jumps

Evidence for sub-shells

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

Periodic property

- Repeats regularly with Z
- Peaks: noble gases
- Minima: Group 1 metals

Ionisation energies explain why metals form positive ions and why reactivity changes down a group (Topics 2 and 4).

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