Ionisation Energies Map

Edexcel International A Level Chemistry · Unit 1 · Topic 2C Ionisation Energies and Periodicity

1 Ionisation energies 2.8

- **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



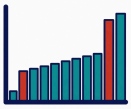
2 What decides the size 2.10

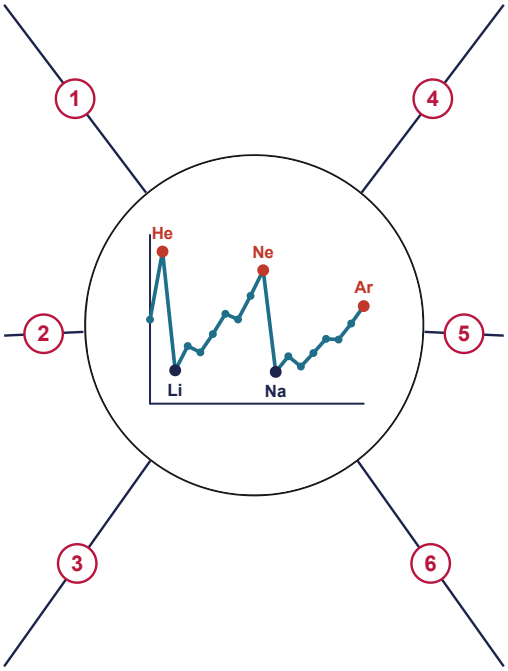
- **Nuclear charge**: more protons, stronger pull
- **Distance**: higher shell, weaker pull
- **Shielding**: inner electrons repel
- **Sub-shell**: p higher in energy than s
- Pairing: a paired electron is easier to remove



3 Successive IEs 2.11 i

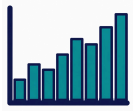
- Plot **$\log_{10}$(IE)**: the values span a huge range
- **Big jump**: next electron from an inner shell
- Na: jumps after 1 and 9 → 2,8,1
- Electrons before the first jump = **group**
- Small steps inside a shell: sub-shells





4 Across a period 2.11 ii, 2.18 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



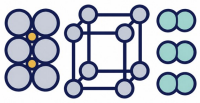
5 Down a group 2.18 iii

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



6 Melting temperatures 2.18 i

- **Na → Al**: metallic bonding strengthens
- **Si** (B, C): giant covalent, highest
- **P_4, S_8, Cl_2**: London forces only
- **Ar**, Ne: single atoms, lowest
- More electrons: stronger London forces



Period 3 at a glance

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

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

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: 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 3 and 4).

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