



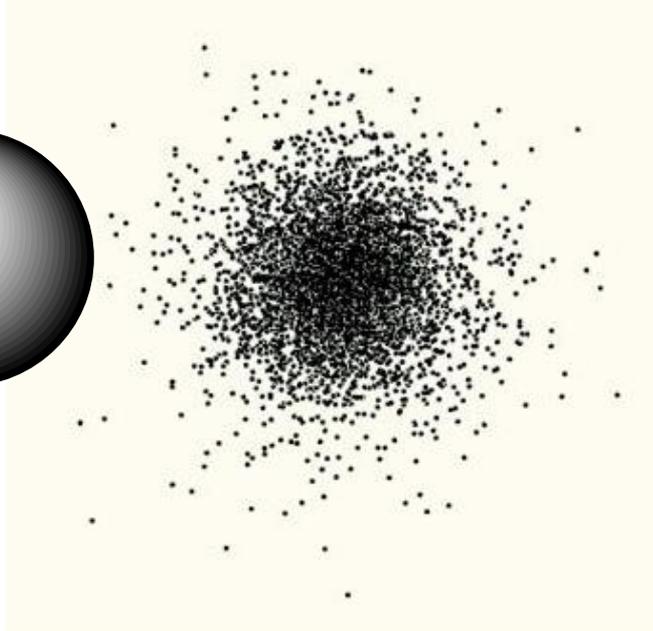
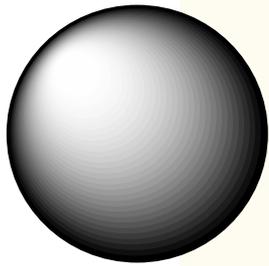
[WWW.CHEMSHEETS.CO.UK](http://www.chemsheets.co.uk)

ELECTRON ARRANGEMENT

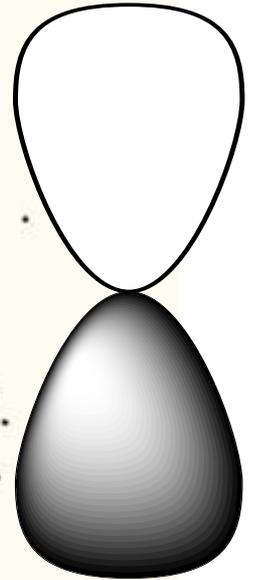
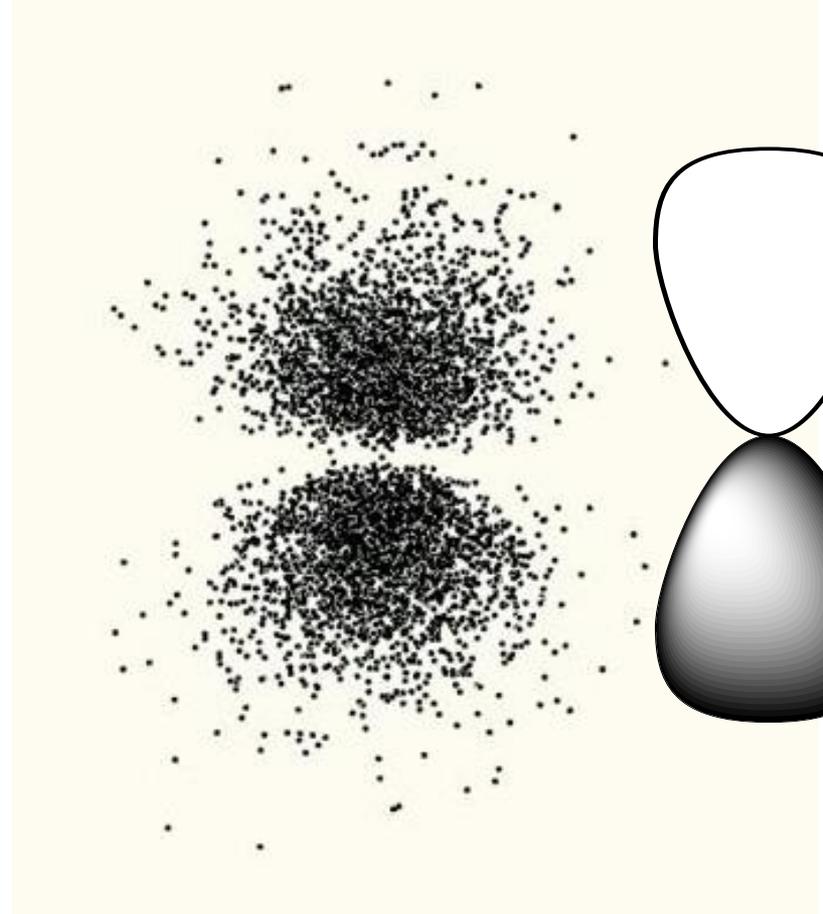
Shells, sub-shells & orbitals

- Electrons are arranged in electrons shells (energy levels).
- The shells have sub-shells (sub-levels).
- Each shell/sub-shell is made up of electron orbitals which can each hold 2 electrons.
- The two electrons in each orbital spin in opposite directions

Orbitals are regions of space that electrons are most likely to be in.



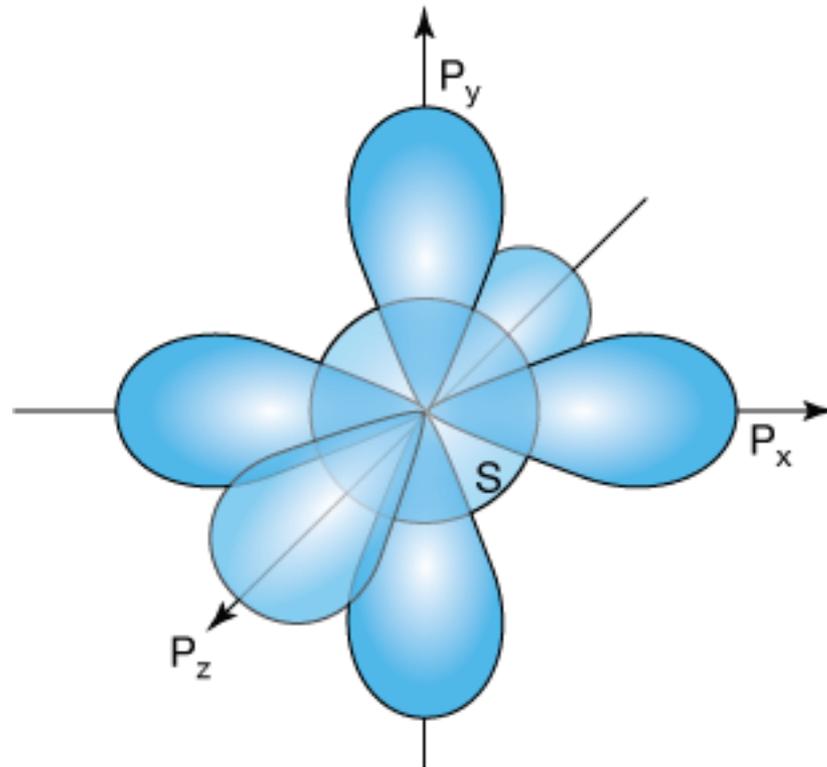
s orbital



p orbital

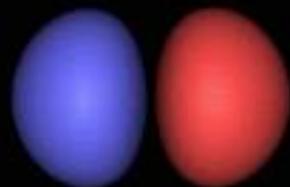
e.g. Shell 2

- shell 2 is made up of
 - one x s orbital
 - three x p orbitals

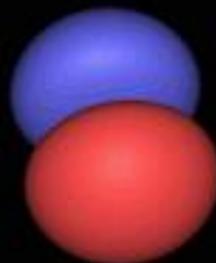




s



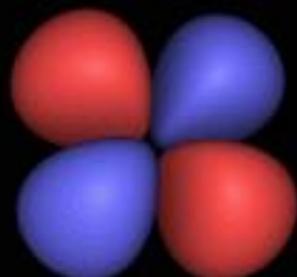
p_x



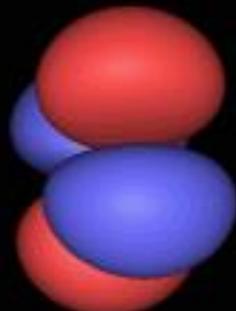
p_y



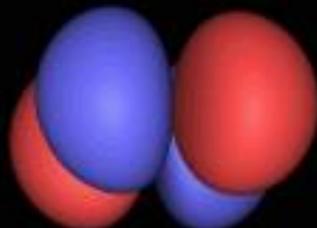
p_z



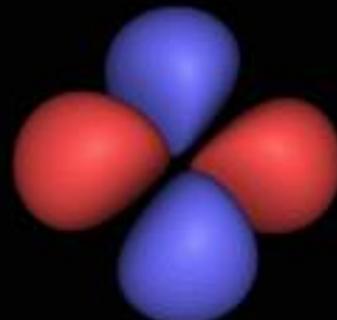
d_{xy}



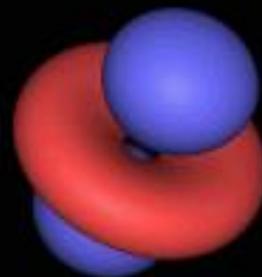
d_{xz}



d_{yz}



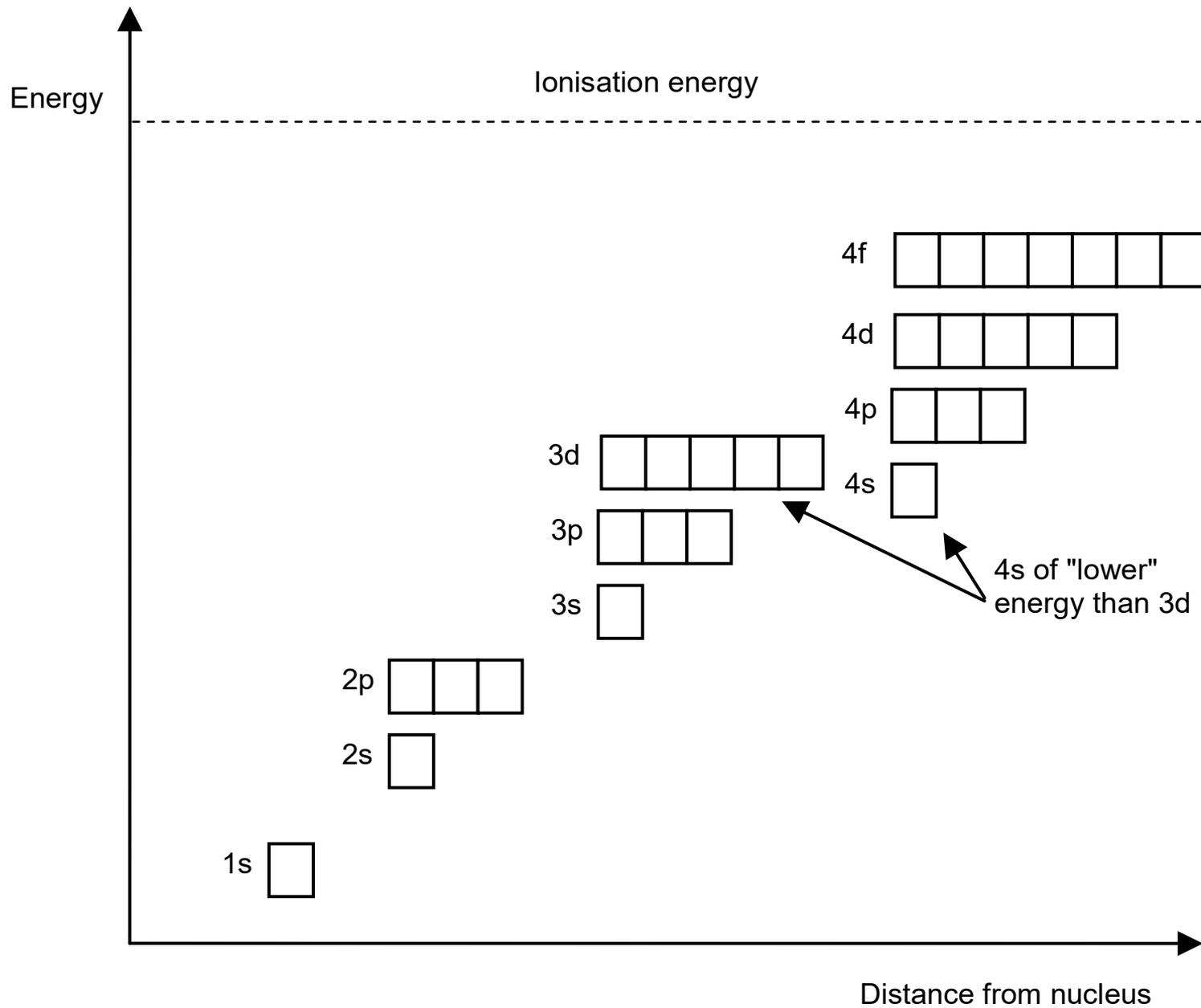
$d_{x^2 - y^2}$

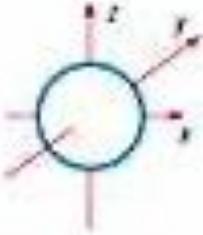
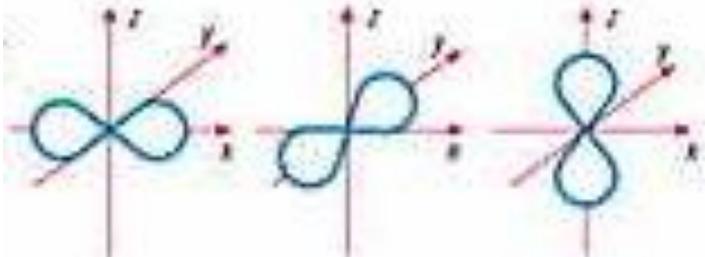
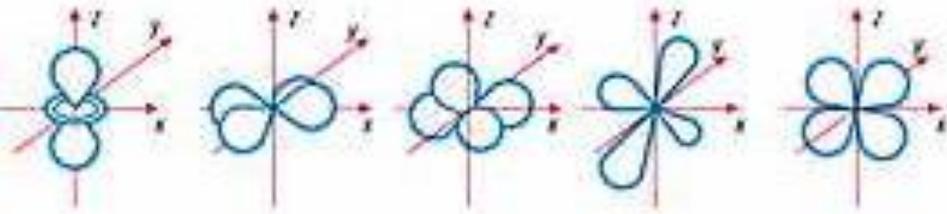


d_{z^2}

The Orbitron

<http://winter.group.shef.ac.uk/orbitron/AOs/1s/index.html>



Sub-level	Number of orbitals in sub-level	Shape (no need to learn)	Maximum number of electrons in sub-level
s	1		2
p	3		6
d	5		10
f	7	Even more complicated!	14

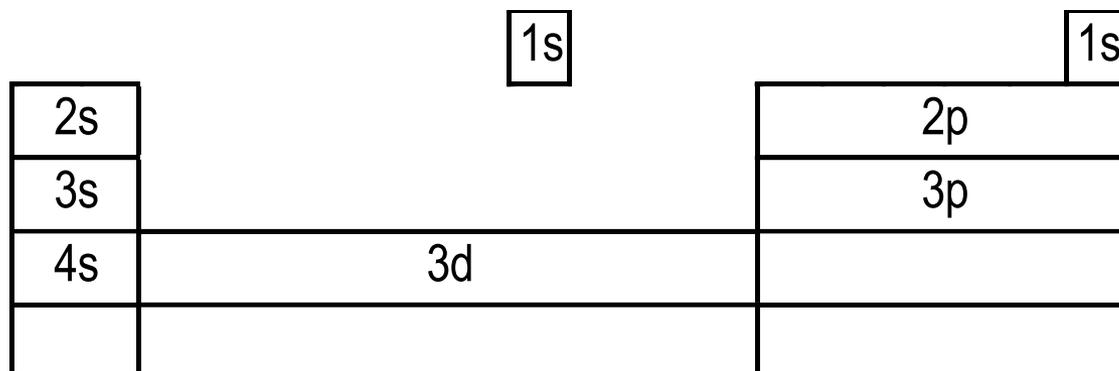
A black t-shirt with white text. The text is centered on the chest and reads "You're in my 1s friendship orbital." in a clean, sans-serif font. The t-shirt is shown from the chest up, with the person's arms visible on the sides.

You're in my 1s
friendship orbital.

other T-shirts
are available!!

Aufbau Principle

Electrons enter the lowest energy orbital available.

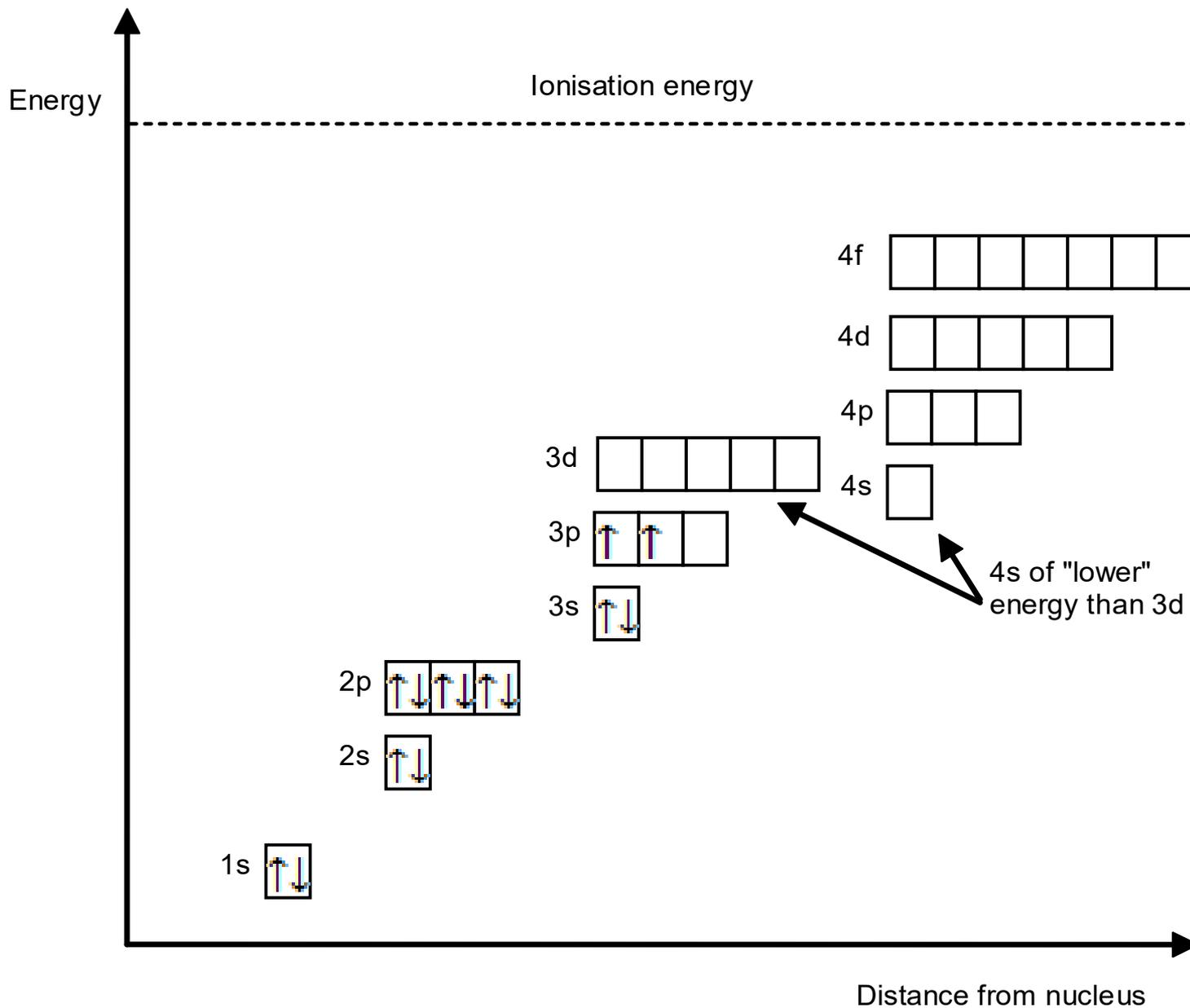


1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p

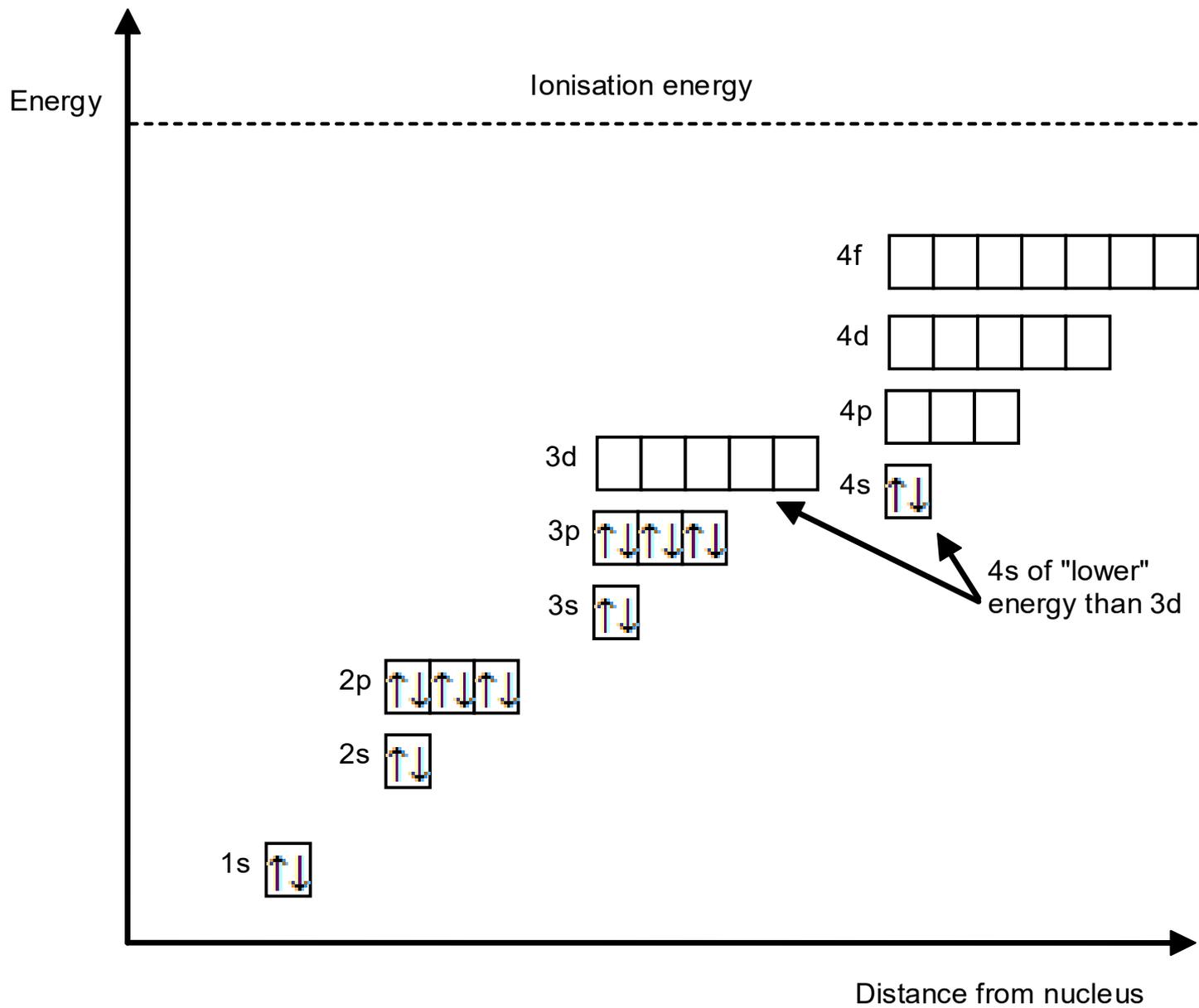
Hund's rule

Electrons prefer to occupy orbitals on their own, and only pair up when no empty orbitals of the same energy are available .

e.g. silicon 14 e⁻ 1s² 2s² 2p⁶ 3s² 3p²



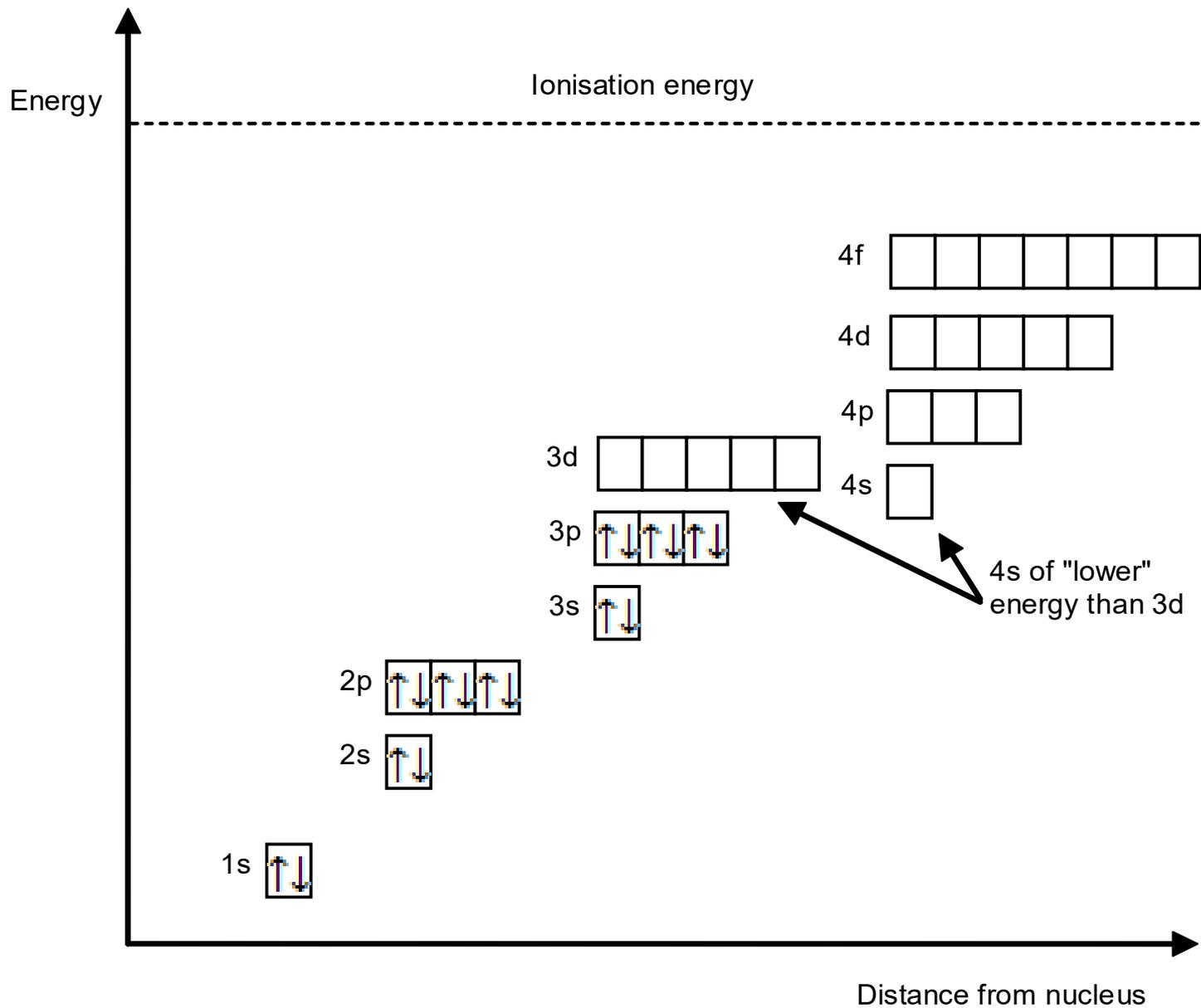
e.g. calcium 20 e⁻ 1s² 2s² 2p⁶ 3s² 3p⁶ 4s²



Ions

- The highest energy electrons are lost when an ion is formed.
- Note that 4s electrons are lost before 3d (as once 4s and 3d are occupied, 4s moves above 3d).

e.g. Ca^{2+} 18 e^- $1s^2 2s^2 2p^6 3s^2 3p^6$



Exceptions: Cr & Cu

- Cu and Cr do not have the expected electron structure.

Cr $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$

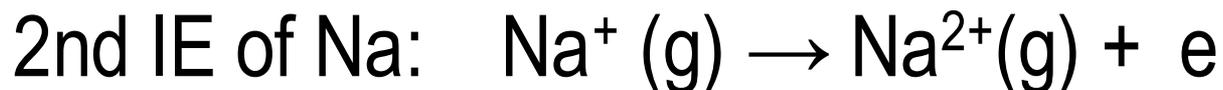
NOT $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^4$

Cu $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$

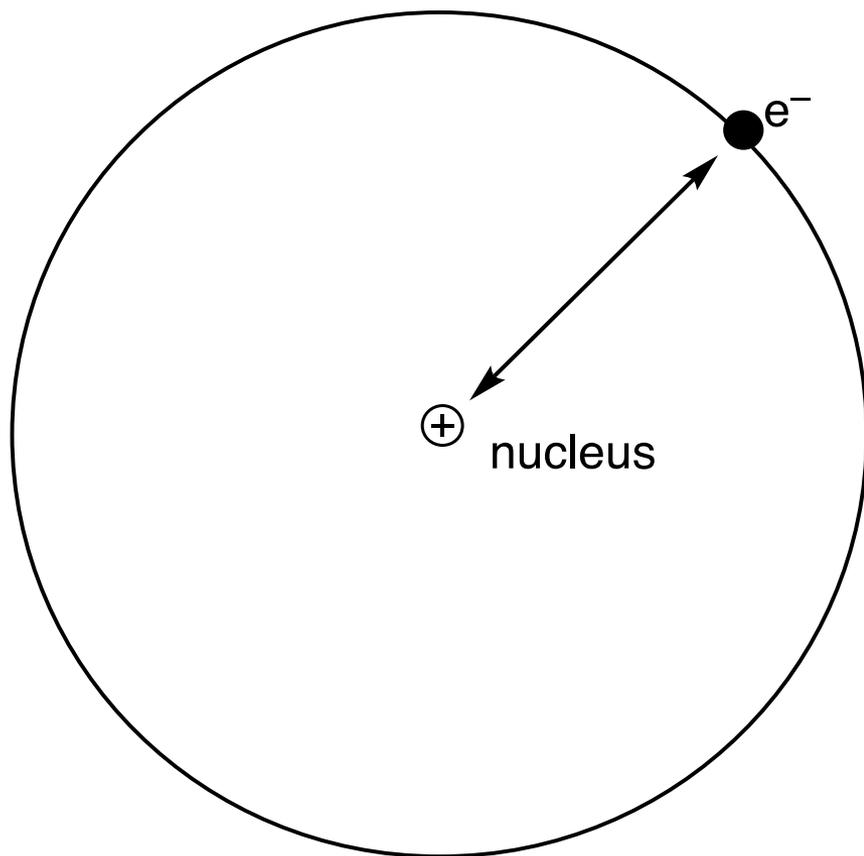
NOT $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^9$

Ionisation energy

- Evidence for how the electrons are arranged in atoms comes from ionisation energies.
- 1st ionisation energy = to remove 1st electron
- 2nd ionisation energy = to remove 2nd electron



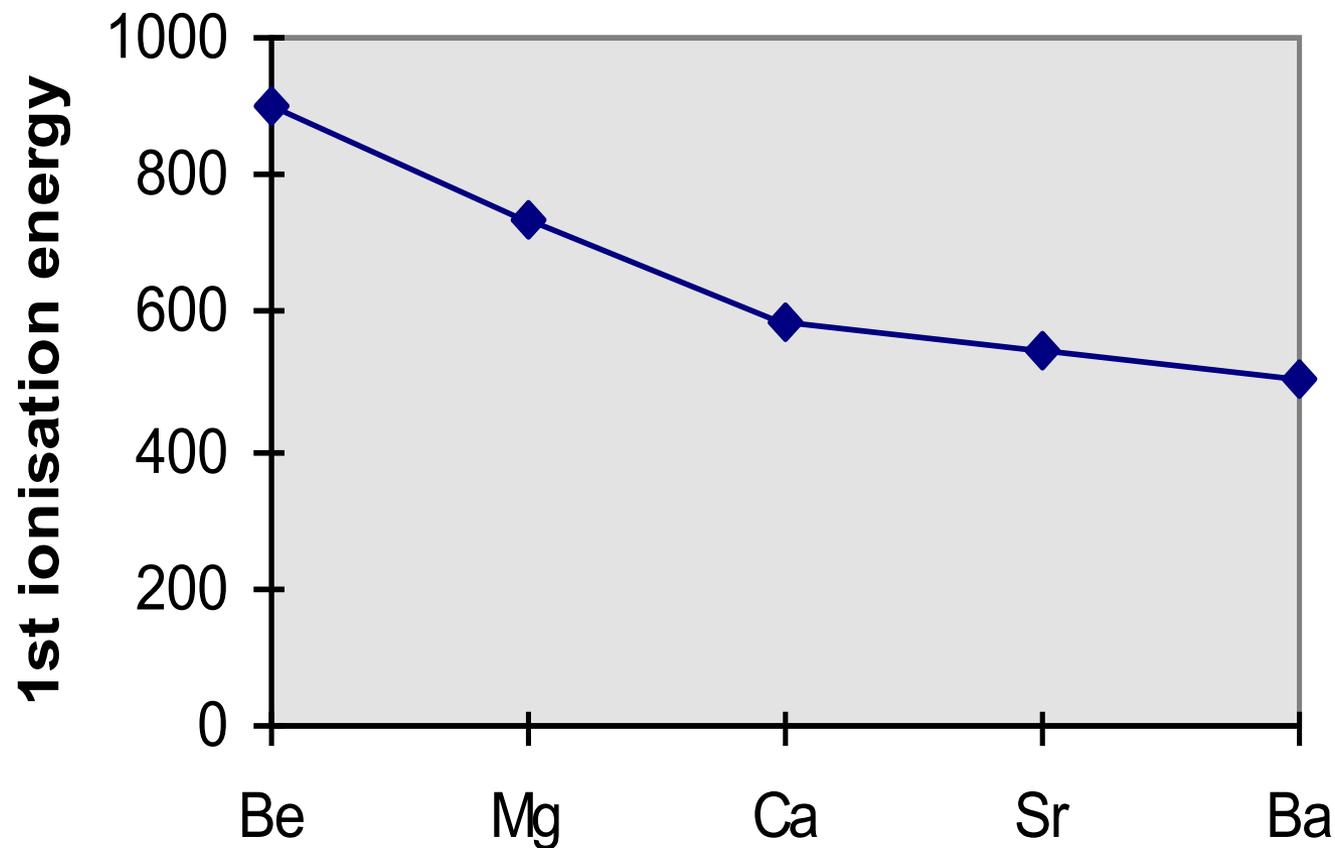
Ionisation energy



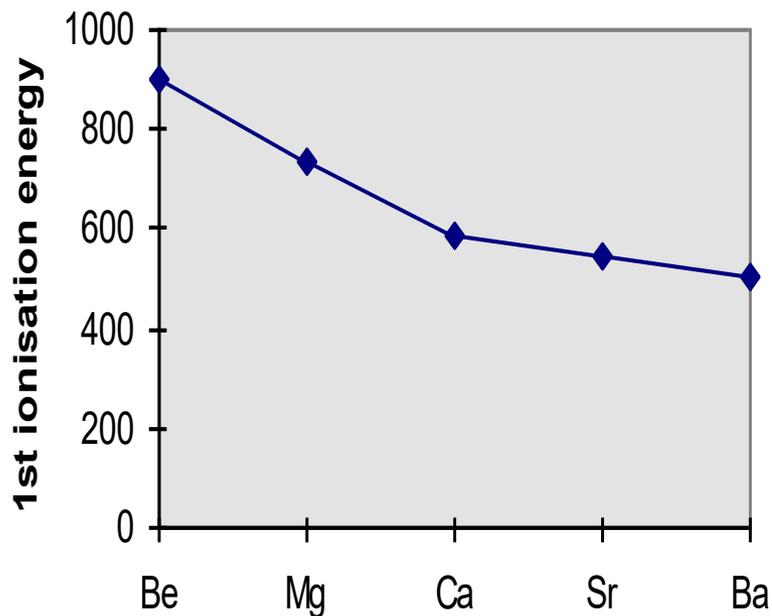
- 1 – Atomic radius
- 2 – Number of protons
- 3 – Shielding

Shielding = repulsion by inner shells of electrons

Down a group (e.g. Group 2)



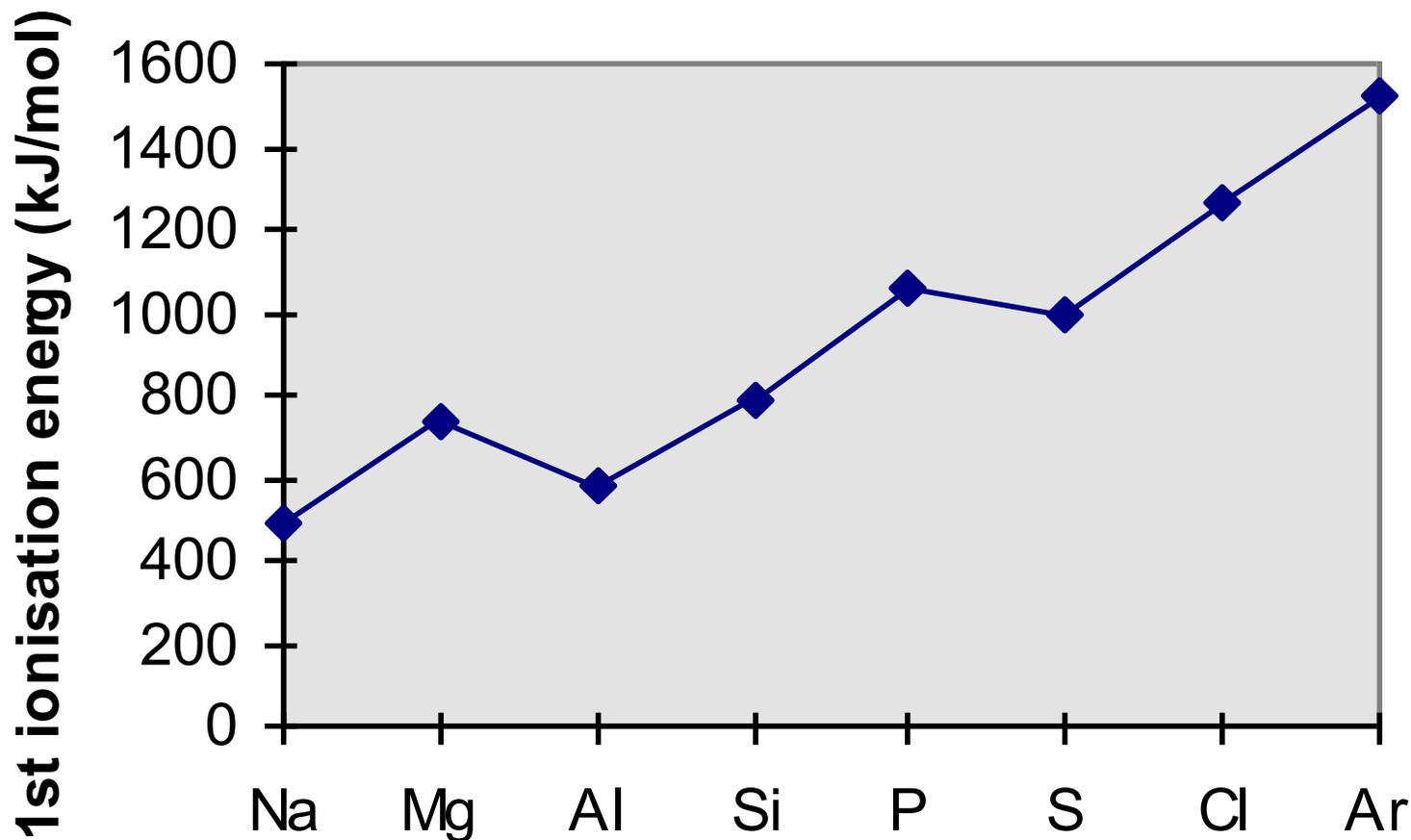
Down a group (e.g. Group 2)



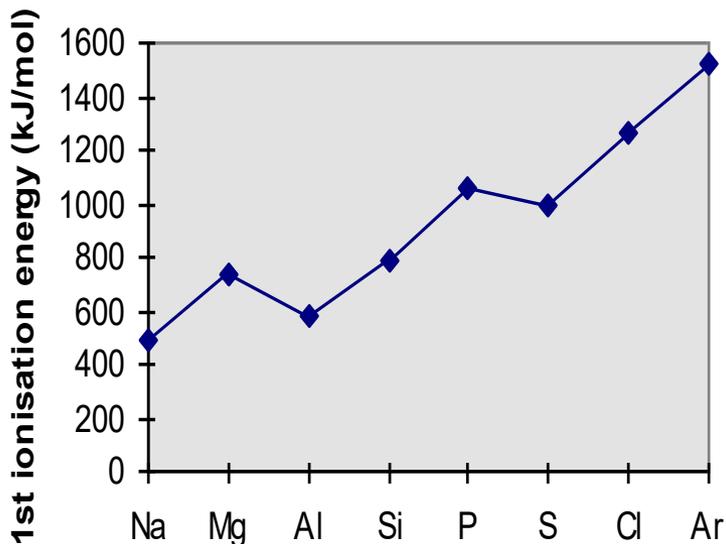
Decrease down group

- bigger atomic radius
- more shielding
- weaker attraction between nucleus and electron

Across a period (e.g. Period 3)



Across a period (e.g. Period 3)

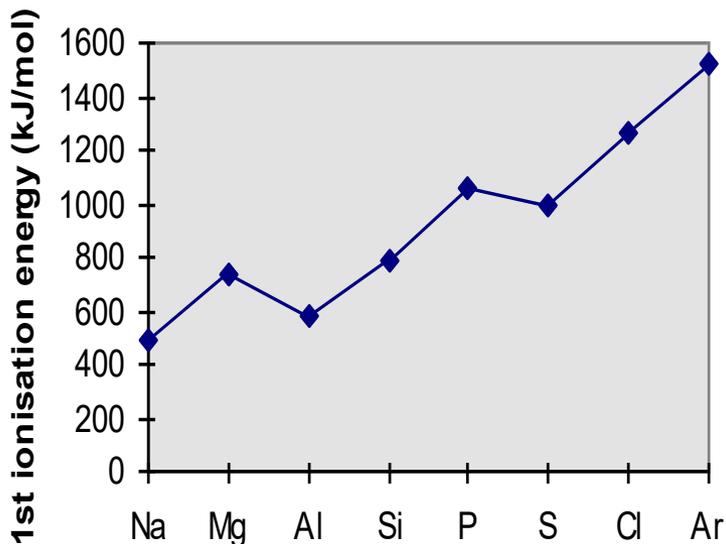


GENERAL trend

Increase across period

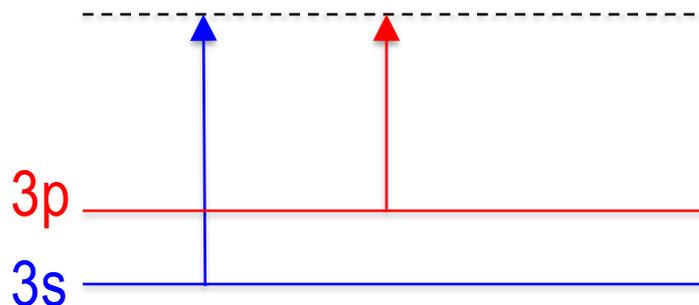
- smaller atomic radius
- more protons
- stronger attraction between nucleus and electron

Across a period (e.g. Period 3)

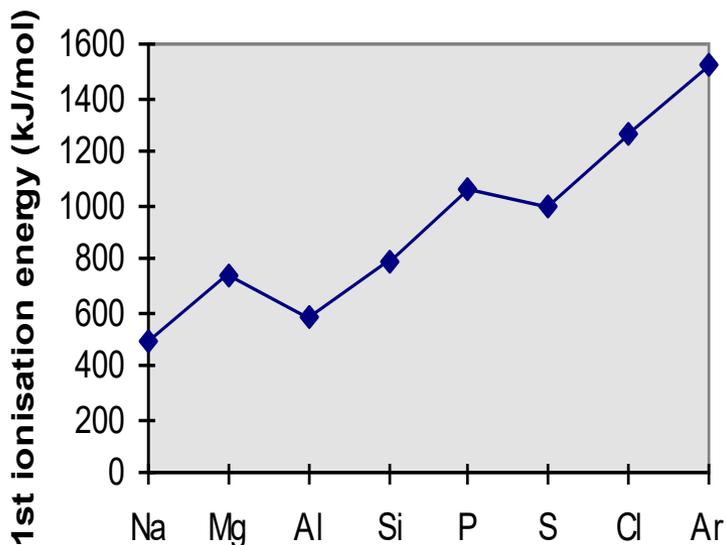


Group 2 to 3 dip

- Mg electron from s orbital
- Al electron from p orbital
- p orbital higher energy than s



Across a period (e.g. Period 3)

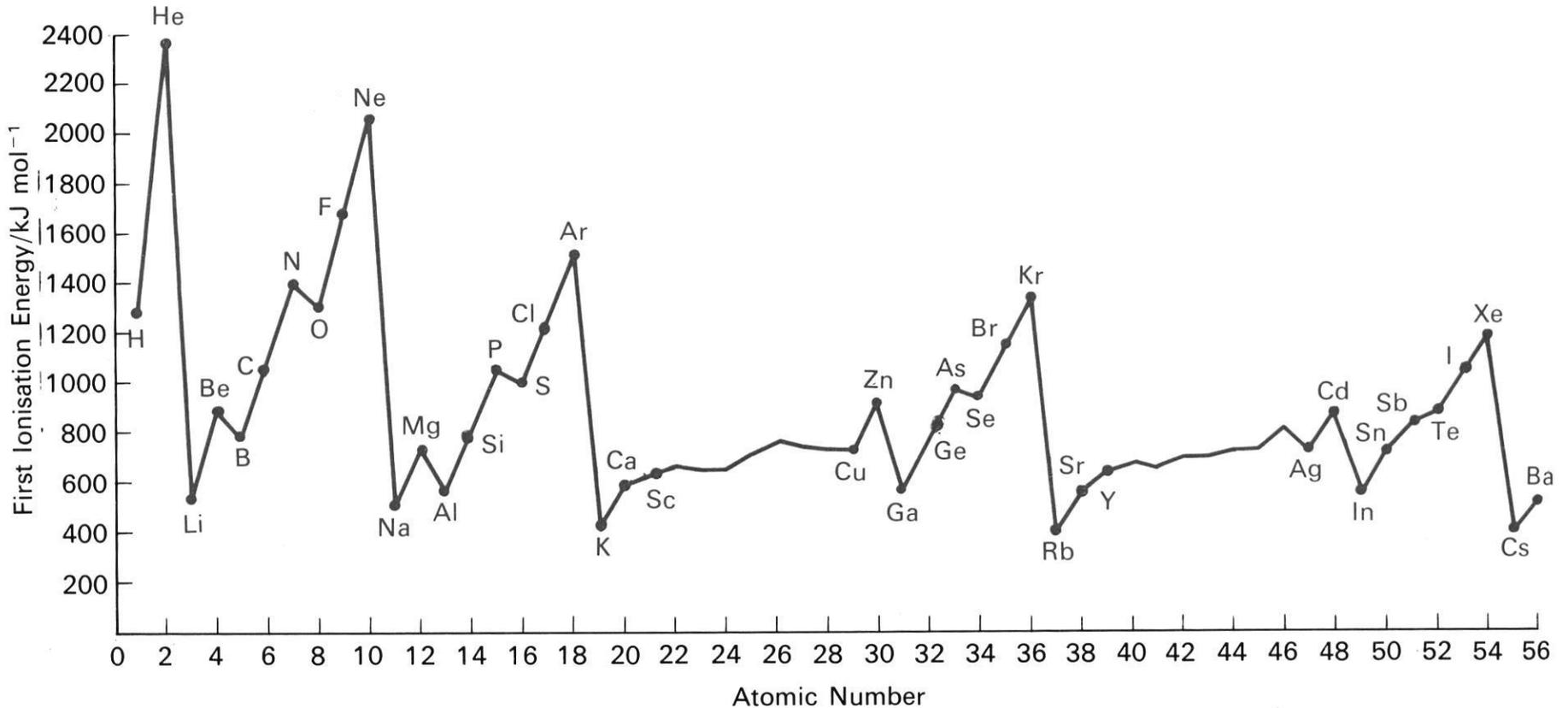


Group 5 to 6 dip

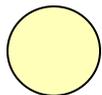
- P e^- from orbital with one e^-
- S e^- from orbital with two e^-
- More e^-e^- repulsion in S



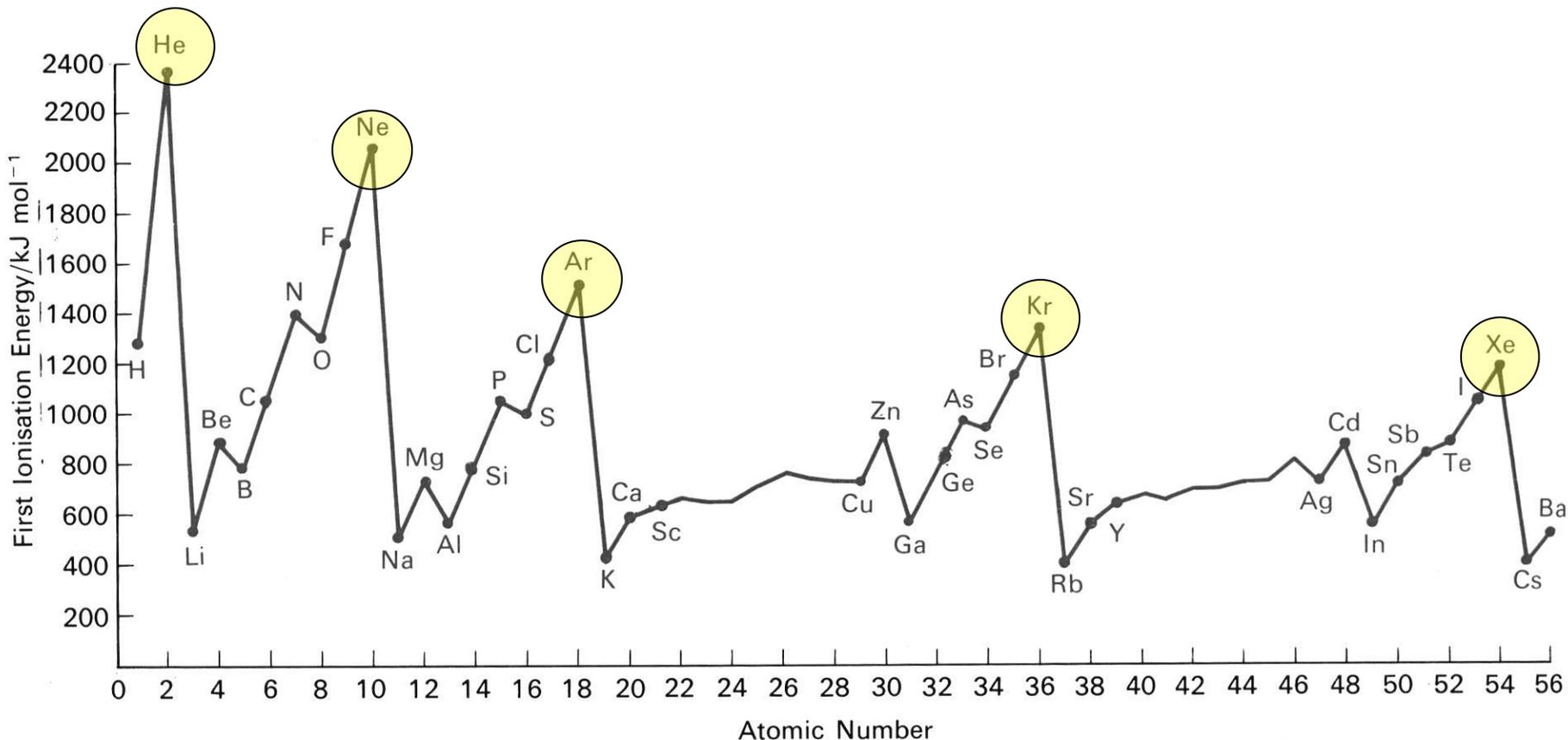
1st ionisation energy



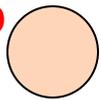
down a group
(group 0)



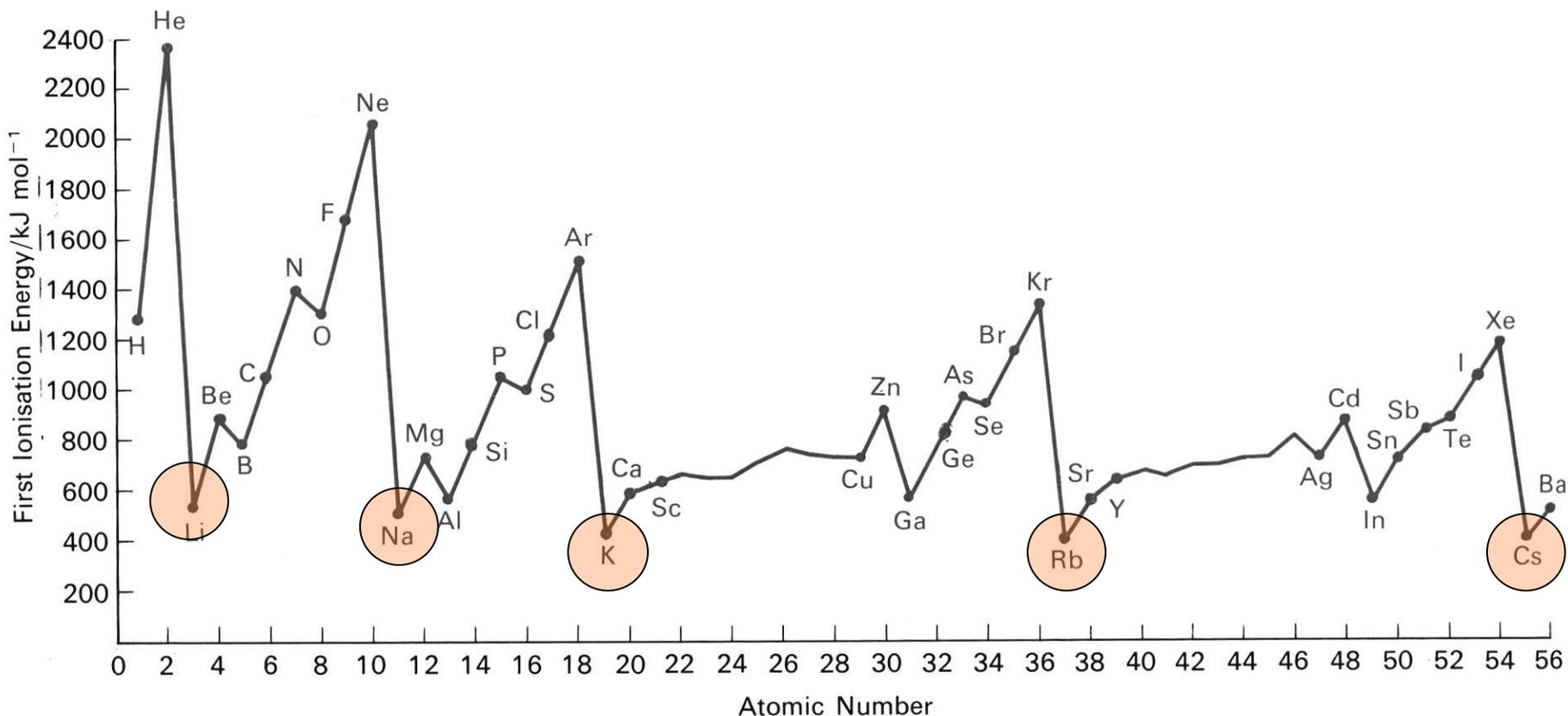
1st ionisation energy



down a group
(group 1)

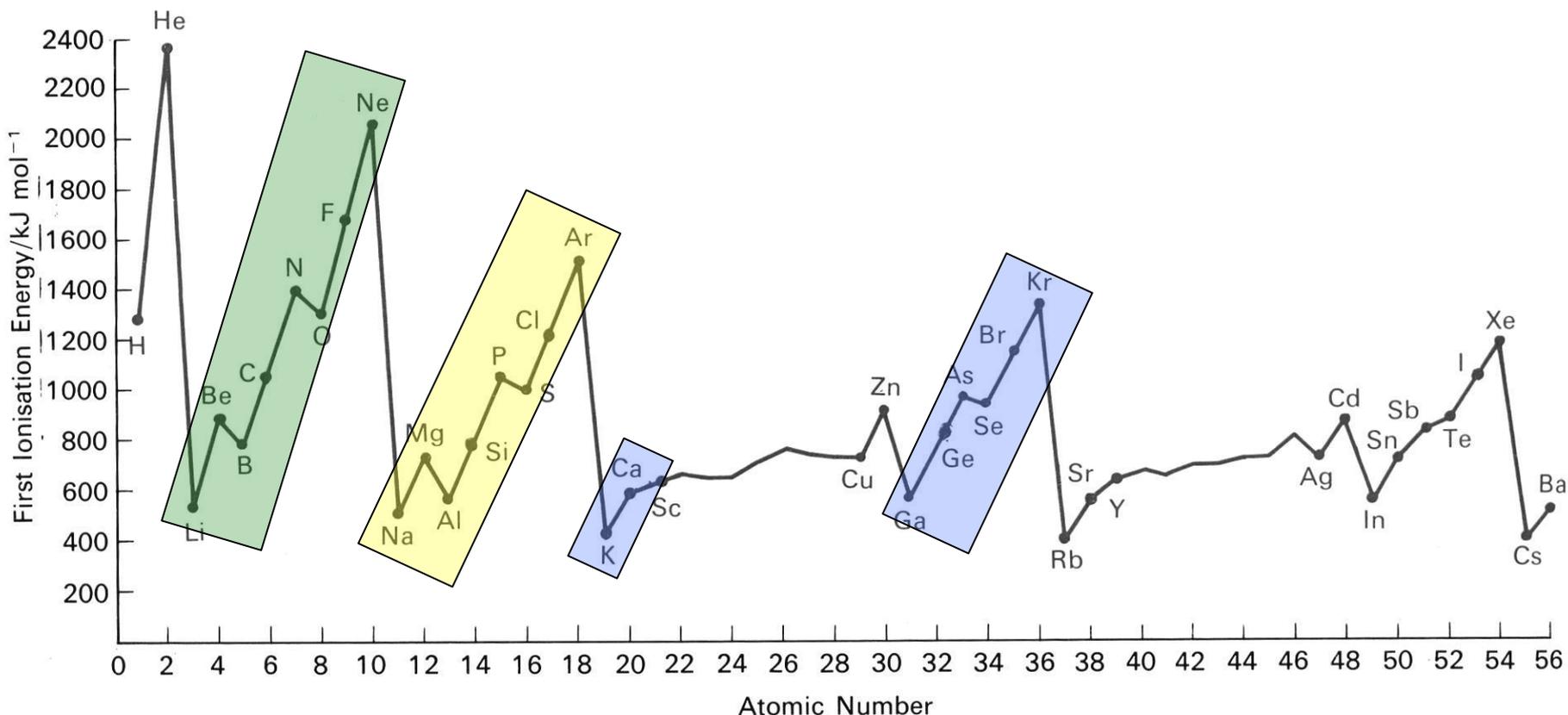
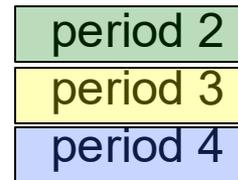


1st ionisation energy



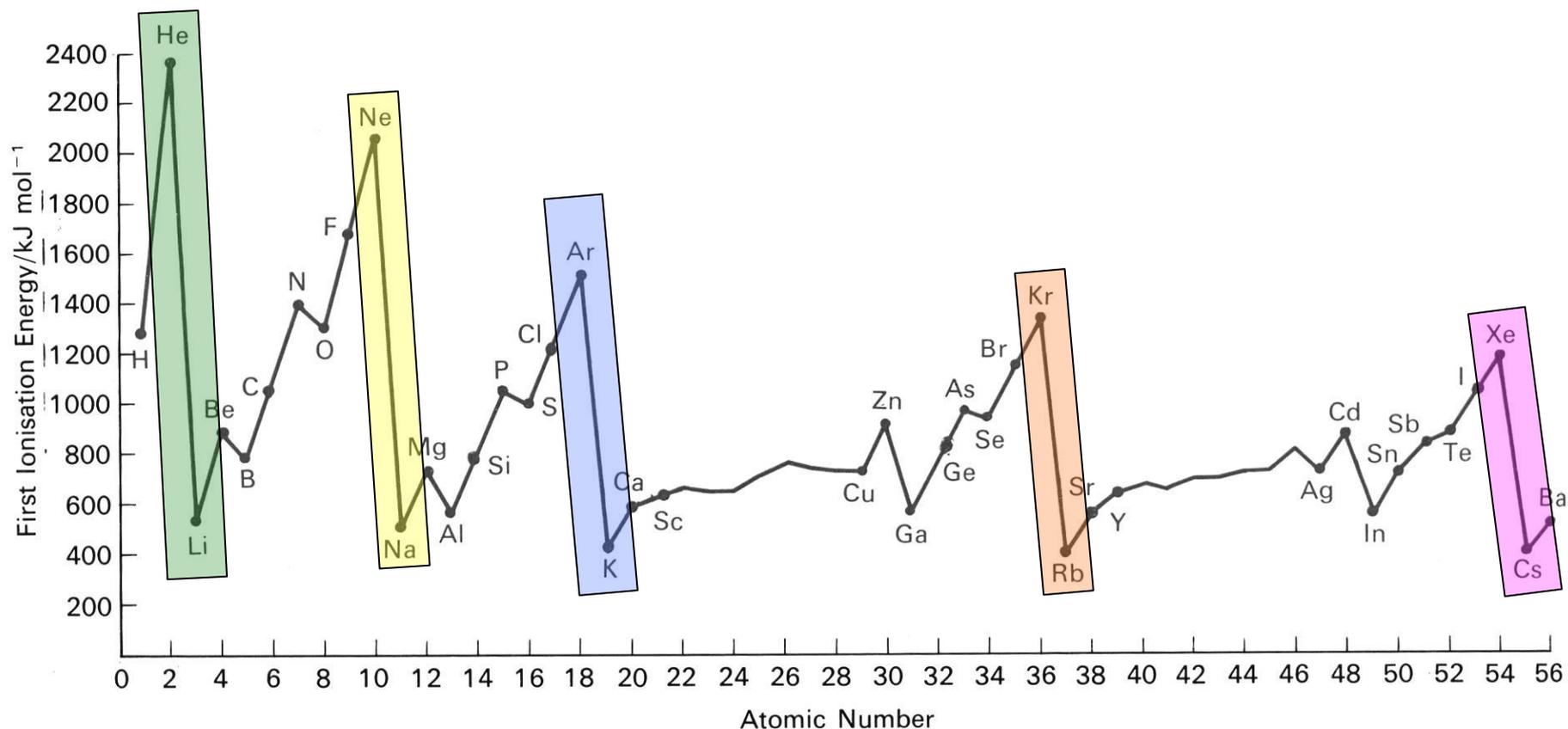
Across a period

1st ionisation energy



End of period

1st ionisation energy



Successive ionisation energies (K)

