Ionization Energy

12.1.1 Explain how evidence from first ionization energies across periods accounts for the existence of main energy levels and sub-levels in atoms

12.1.2 Explain how successive ionization energy data is

related to the electron configuration of an atom

Ionization Energy

- The amount of energy required to completely remove an electron from a gaseous atom.
- An atom's 'desire' to grab another atom's electrons.
- Removing one electron makes a +1 ion.
- The energy required is called the first ionization energy.

$$X_{(g)} + \text{energy} \rightarrow X^{+} + e^{-}$$

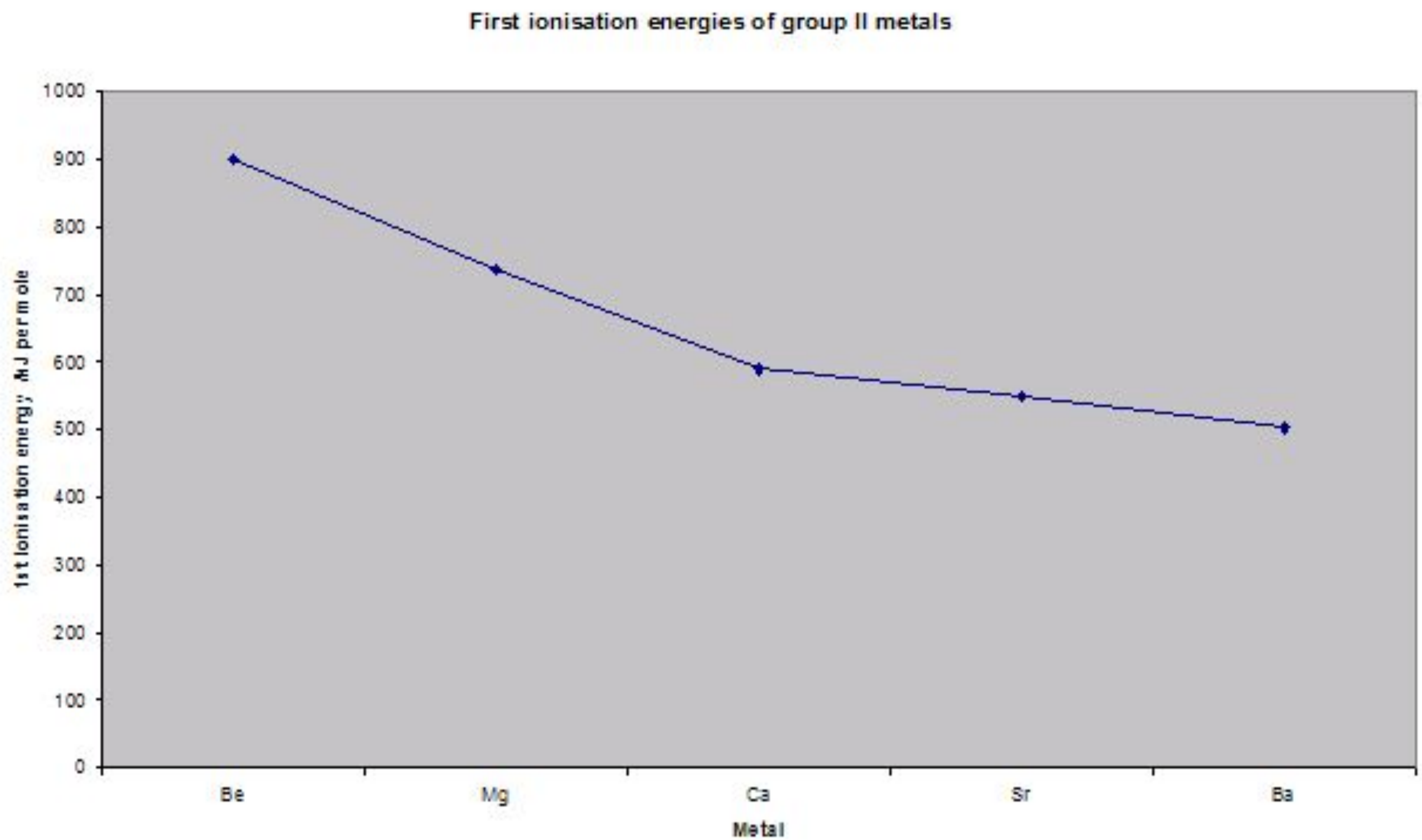
Ionization Energy

The second and third ionization energies can be represented as follows:

- $X^{+}_{(g)}$ + energy $\rightarrow$ $X^{2+}_{(g)}$ + e-
- $X^{2+}_{(g)}$ + energy $\rightarrow$ $X^{3+}_{(g)}$ + e-
- More energy required to remove 2nd electron, and still more energy required to remove 3rd electron

Group trends

- Ionization energy decreases down the group.

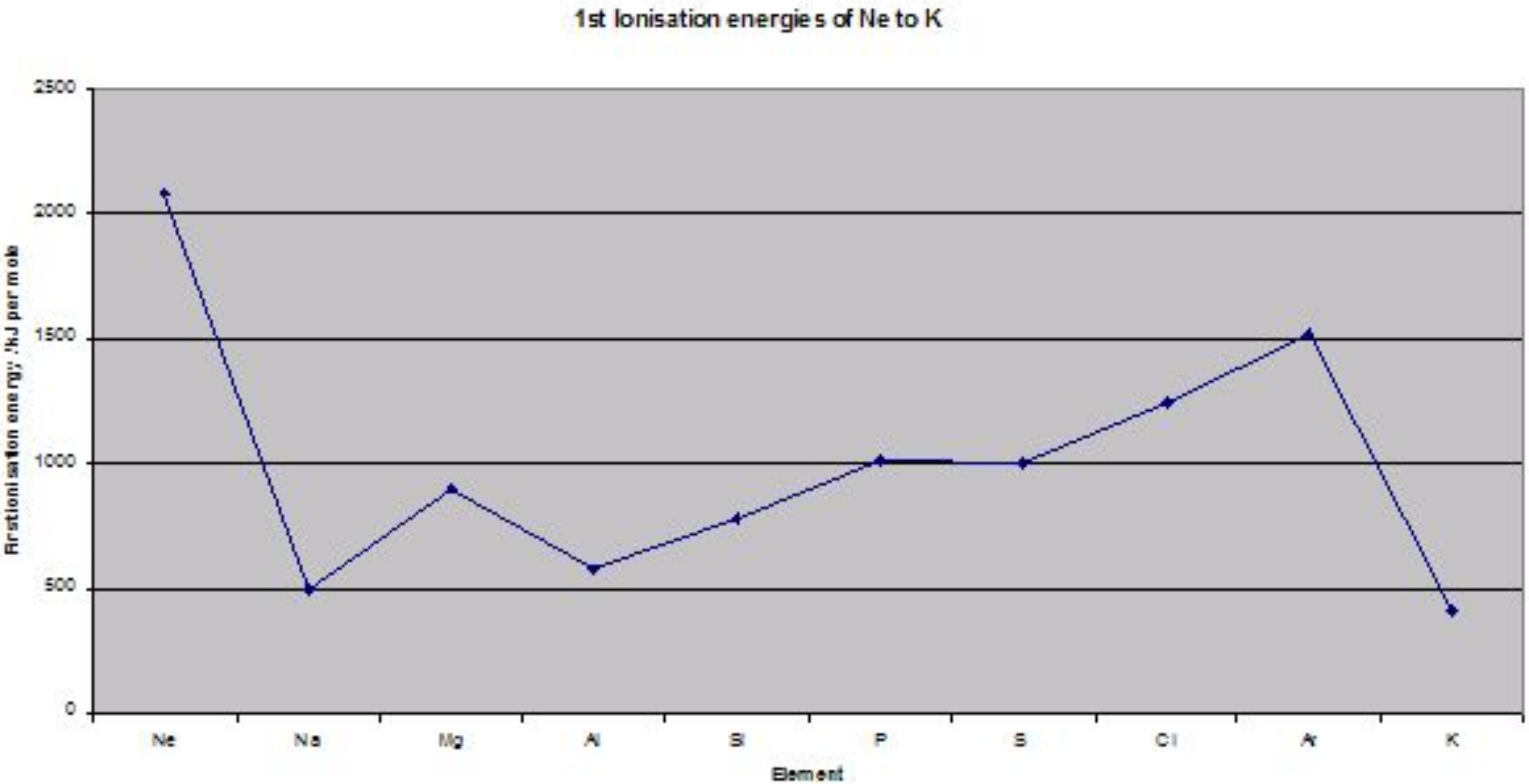


Going from Be to Mg, IE decreases because:

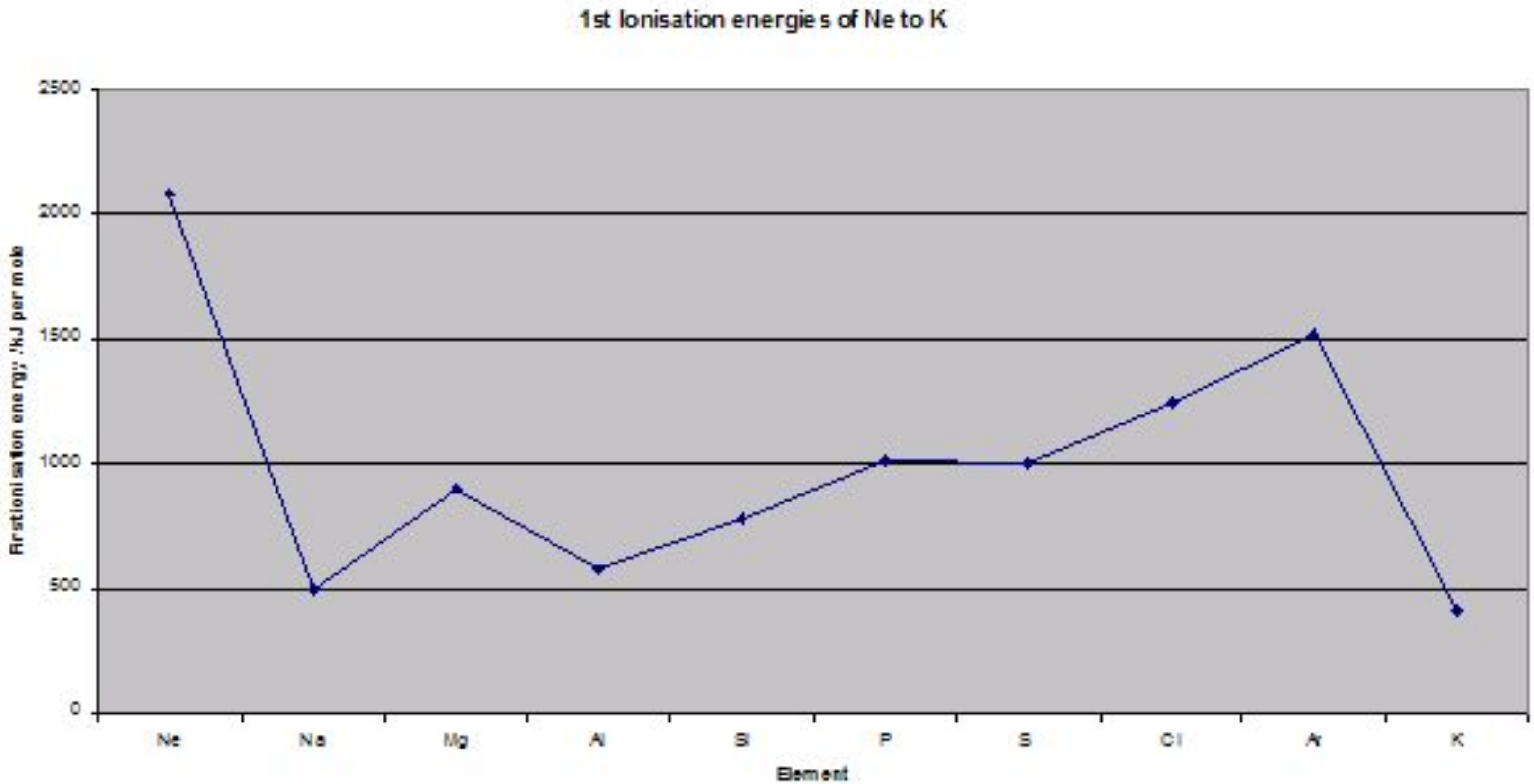
- Mg outer electron is in the 3s sub-shell rather than the 2s. This is higher in energy
- The 3s electron is further from the nucleus and shielded by the inner electrons
- So the 3s electron is more easily removed

- A similar decrease occurs in every group in the periodic table.

Notice any trends? Any surprises?



- **General trend**: Increasing I.E. as we go across a period
- Look at the peak at Mg and the plateau between P and S. Can you explain why?



Why is there a fall from Mg to Al?

- Al has configuration $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$, its outer electron is in a p sublevel
- Mg has electronic configuration $1s^2 2s^2 2p^6 3s^2$.
- The p level is higher in energy and with Mg the s sub level is full – *this gives it a slight stability advantage*

Why is there a fall from P to S?

- This can be explained in terms of electron pairing.
- As the p sublevel fills up, electrons fill up the vacant sub levels and are unpaired.
- This configuration is more energetically stable than S as *all the electrons are unpaired.* It requires more energy to pair up the electrons in S so it has a lower Ionisation energy.
- There is some repulsion between the paired electrons which lessens their attraction to the nucleus.
- It becomes easier to remove!

Driving Force

- Full Energy Levels are very low energy.
- Noble Gases have full energy levels.
- Atoms behave in ways to achieve noble gas configuration.

2^{nd} Ionization Energy

- For elements that reach a filled or half filled sublevel by removing 2 electrons 2^{nd} IE is lower than expected.
- Makes it easier to achieve a full outer shell
- True for s^2
- Alkaline earth metals form +2 ions.

3rd IE

- Using the same logic s^2p^1 atoms have an low 3rd IE.
- Atoms in the aluminum family form +3 ions.
- 2nd IE and 3rd IE are always higher than 1st IE!!!