Periodicity

Ionisation Energies

First ionisation energy is the energy needed to remove one electron form each atom, in a mole of atoms, in the gas phase.

$$X_{(g)} \longrightarrow X^{+}_{(g)} + e^{-}_{(g)}$$

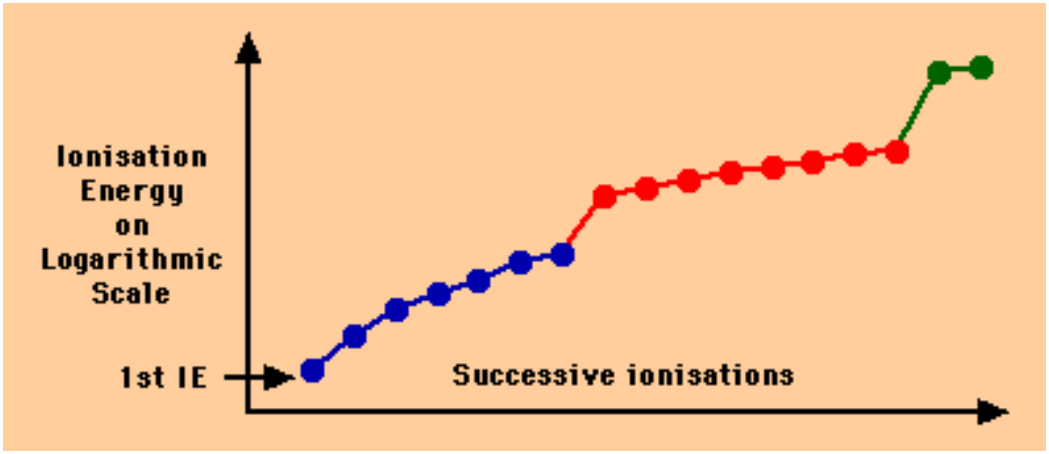
Second ionisation energy is the energy needed to remove one electron from each ion, in one mole of +1 ions, in the gas phase.

$$X^{+}_{(g)} \longrightarrow X^{2+}_{(g)} + e^{-}_{(g)}$$

Successive ionisation energies for an element are the first, second, third, etc… ionisation energies.

A high ionisation energy means that the electron is difficult to remove because the attraction between it and the nucleus is strong

A plot showing the successive ionisation energies of chlorine



The plot shows:-

- the first 7 electrons are easily removed because they are far from the nucleus so the attraction is weak
- the next 8 electrons in the second shell - closer to nucleus - less shielding - stronger attraction
- the two 1s electrons being very difficult to remove as they are close to the nucleus with no shielding and strong attraction

From this plot, you can tell the number of electrons in each shell and that Chlorine is in group 7 of the Periodic Table as it has 7 electrons in the outermost shell.

The Structure of the Periodic Table

Arrangement of elements is in order of increasing atomic (proton) number.

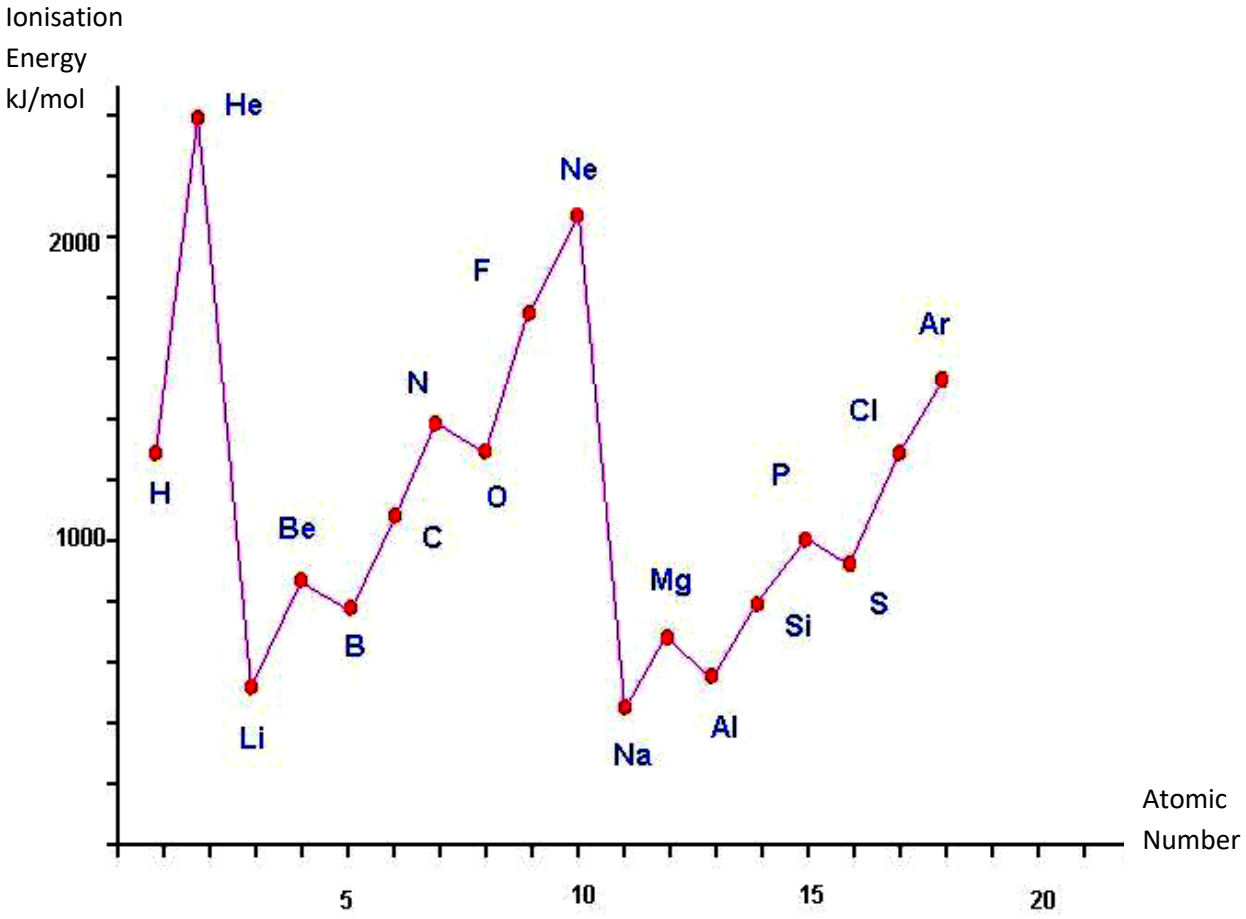
The horizontal periods show repeating trends in physical and chemical properties.

The vertical groups have similar physical and chemical properties because atoms of elements in a group have similar outer shell electron configurations.

Periodicity is a repeating pattern across different periods.

Periodicity of physical properties of elements

A plot showing the 1st ionisation energies of the elements H to Ca



The plot shows:-

Down a group a decrease making it easier to remove the outer electron. The increase in nuclear charge is cancelled out by the increase in shielding, while the outermost electron becomes further from the nucleus reducing the attraction.

Across a period an increase - it is harder to remove an electron. The nuclear charge increases but the shielding does not, so the attraction increases.

When a new period begins there is a large fall in ionisation energy because:-

a new shell is further from the nucleus

there is a large increase in the number of inner electrons (and therefore in shielding)

Both reduce the attraction of the nucleus making it easier to remove the outermost electron.

Ionisation energy depends on:-

a) The charge of the nucleus
b) The atomic radius (how far the outermost electron is from the nucleus)
c) The amount of **shielding** - this is related to the number of inner electrons which repel the outer electrons and make them easier to remove

As the attraction between the outer electron and the nucleus increases, the ionisation energy increases.

Periodicity across Period 2 (Li → Ne) and Period 3 (Na → Ar)

Electronic configurations The group number equals the number of outer shell electrons which increases by one for each element.

Atomic radii decrease because nuclear charge increases but number of shielding electrons is constant as electrons are added to the same shell. Attraction between outer electrons and nucleus increases.

Melting points and boiling points also depend on structure and bonding. The stronger the bonds, the higher the values.

Li → Be and Na → Al Values are high and increase due to increasing strong electrostatic attraction between the positive ions and delocalised electrons, so stronger metallic bonding in the giant metallic lattice. Across the period, the number of delocalised electrons in the sea and charge on the positive ion increases, so the attraction increases and melting point increases.

B, C and Si have very high melting and boiling points due to their giant covalent network lattice with strong bonds between all atoms.

N → Ne and P → Ar have low values due to weak van der Waals' forces between simple molecules or single atoms.