Lesson 7: The Periodic Table

*Read through the lesson notes. You can write them out, print them or save them.

*Once you have tried to understand the lesson answer the questions that follow at the end.

*The answers to the question sheet(s) will be posted later and this will allow you to self-evaluate your learning.

Learning Intentions

-Learn about the four blocks s, p, d and f of The Periodic Table.

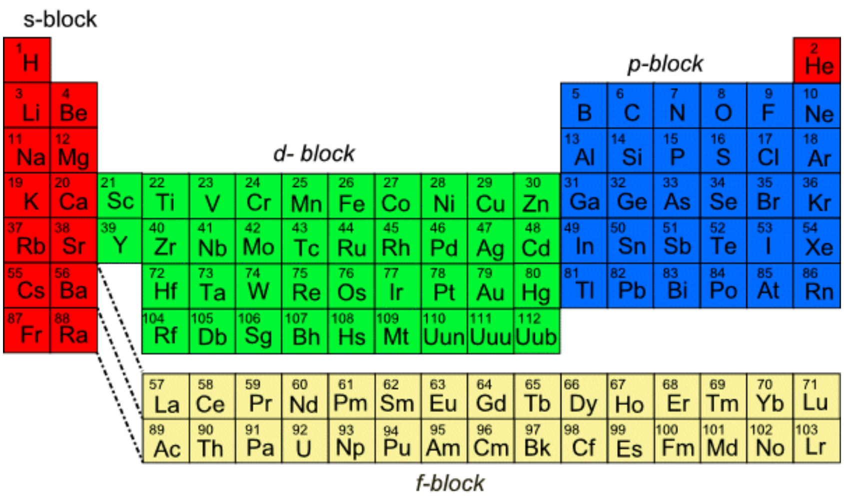
-Learn about anomalous ionisation energy values and how this can be explained using electronic configurations.

Background

-If you look at The Periodic Table from your data booklet you will observe that it is divided into blocks. This lesson explores the names and origin of these blocks. Moreover, we look back over ionisation energy from Higher Chemistry and consider some of the anomalous values that occur within a period.

(i) Blocks of The Periodic Table

The Periodic Table is subdivided into four blocks (s, p, d and f) corresponding to the outer electronic configurations of the elements within these blocks.



Example

-All elements in the s-block (groups 1 and 2) have their outer electron in an s-orbital.

→ Na: $1s^2\ 2s^2\ 2p^6\ \underline{3s^1}$

→ Ca: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ \underline{4s^2}$

-All elements in the p-block (groups 3 to 8) have their outer electron in a p-orbital.

→ O: $1s^2\ 2s^2\ 2p^4$

→ S: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$

-All elements in the d-block (transition metals) have their outer electron in a d-orbital.

→Ti: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^2$

→Mn: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^5$

*For Advanced higher Chemistry we do not regularly deal with the f-block (lanthanides actinides). However, you are expected to know its location on The Periodic Table.

(ii) Anomalies in the ionisation energy

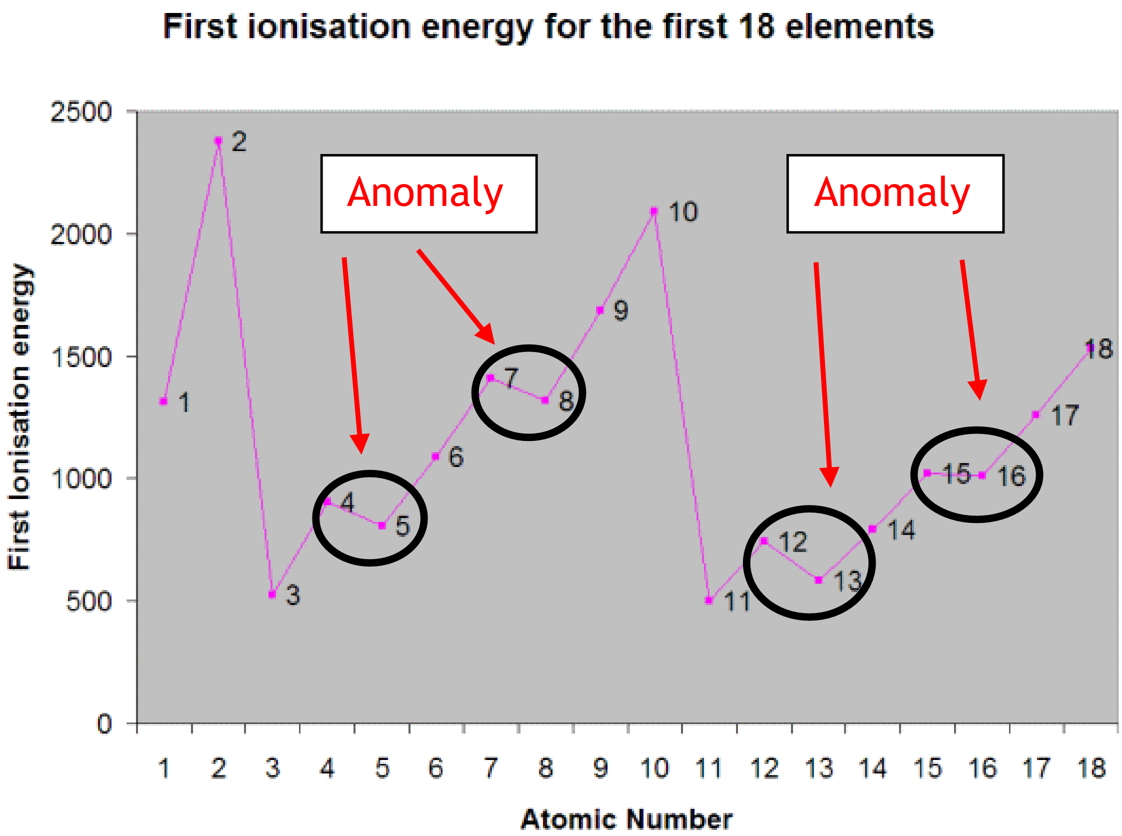
From Higher, the ionisation energy is defined as the energy required to remove 1 mole of electrons from an atom in the gaseous state:

$$E_{(g)} \rightarrow E^{+}_{(g)} + e$$

In general the ionisation energy:

A. Increases across a period
B. Decreases down a group

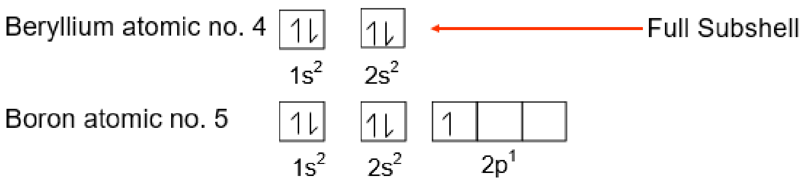
However, these trends are not smooth and there are some anomalies. By looking at four different cases from the following graph, these anomalies can be explained.

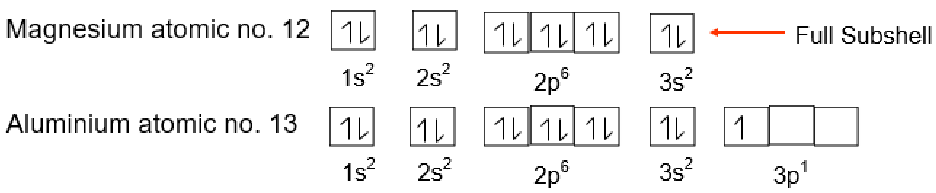


The anomalies can be explained by considering them in two different sets.

<u>A-Full Shell Stability</u>

Between the elements beryllium and boron (atomic numbers 4 and 5) and magnesium and aluminium (atomic numbers 12 and 13) there is a decrease in the ionisation energy value. This can be explained in the following way.



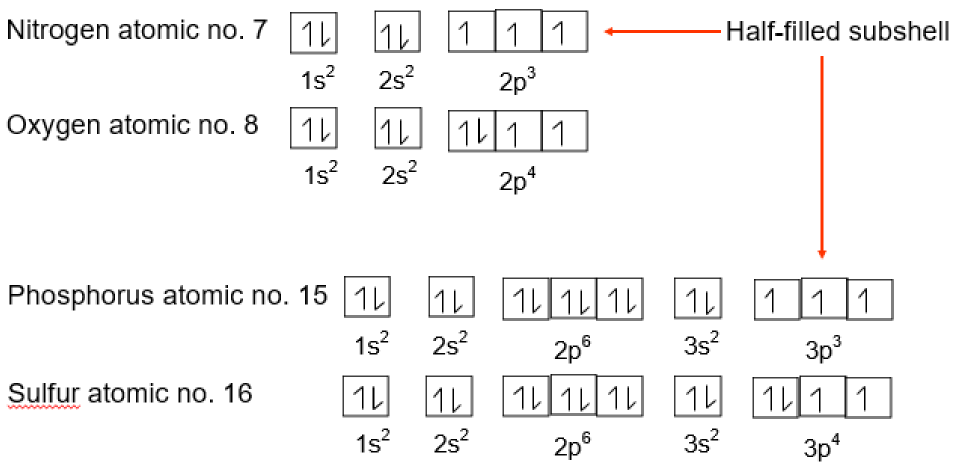


*A full subshell is a STABLE ARRANGEMENT. Therefore more energy is required to remove the electron.

For an element that begins a new subshell there is a drop in stability.

B-Half Shell Stability

Between the elements nitrogen and oxygen (atomic numbers 7 and 8) and phosphorus and sulfur (atomic numbers 15 and 16) there is also a decrease in the ionisation energy value. This can be explained in the following way.



*A **half-filled subshell** is also a **STABLE ARRANGEMENT**. Therefore more energy is required to remove an electron.

Additional Resources

-Watch the clips on Youtube:

→ https://www.youtube.com/watch?v=hJ0WwAGSjlc

→ The Periodic Table: Atomic radius, Ionisation energy and electronegativity, Professor Dave (4 minutes 30 seconds-5 minutes 36 seconds).

https://www.youtube.com/watch?v=hePb00CqvP0

-Read Scholar Sections 2.6.1 and 2.7

-Read BrightRed textbook pages 16 and 17

-Answer the Question from Sheet 1.10 and check the answers when you have completed them.

-If there are any questions regarding this lesson or the questions from sheet 1.10 then please leave a post on Microsoft Teams.

1.10 Energy Levels

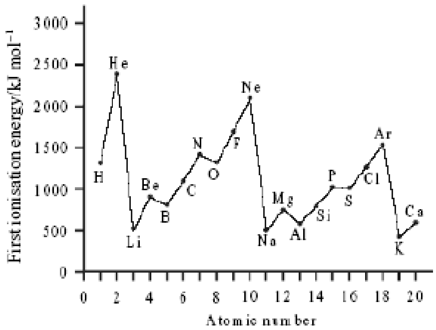
1. Ionisation energies show regular changes as we descend a group in the periodic table. The table below shows the ionisation energies for some of the alkali metals

	Ionisation Energies/KJ mol^{-1}			
Element	1st	2nd	3rd	4th
Lithium	526	7310	11800	-
Sodium	502	4560	6920	9450
Potassium	425	3060	4440	5880

(a) (i) Write equations for the first ionisations of lithium and sodium.
(ii) Explain why the first ionisation energy of sodium is less than that of lithium.

(b) (i) Write equations for the first and second ionisations of potassium.
(ii) Explain why the second ionisation energy of potassium is so much greater than the first ionisation energy.

2. The first 20 elements show many periodic properties, e.g. the variation in first ionisation energy (IE).



(a) Explain why the noble gases have the highest values of IE in each period.
(b) Explain the general increase in value of IE from Li to Ne.
(c) (i) Explain the drop in value of IE from Be to B.
(ii) Explain the drop in value of IE from N to O.

3. The table below which shows the ionisation energies (I.E.) in kJmol^{-1} for selected elements.

Element	1st	2nd	3rd	4th
A	520	7300	11500	-
B	2100	3900	6100	9400
C	580	1800	2800	11400
D	740	1450	7700	10600

Identify the element(s)
(a) In group two of the periodic table.
(b) In group one of the periodic table.
(c) Which would require the least energy to convert an atom of the element into an ion with a three positive charge.

4. Identify the block in The Periodic Table in which the following elements are found.
a) Polonium b) Radium c) Fermium d) Hafnium e) Thallium f) Zirconium