3.1 - The Periodic Table

3.1.1 - Describe the arrangement of elements in the periodic table in order of increasing atomic number

Elements in the periodic table are arranged in order of **increasing atomic number** (Z). There is a division between metals and non-metals. Metals are on the left and non-metals are on the right. Metals tend to have a smaller number of electrons in their outer shell

The long metal periods are divided into the **transition metals**, **lanthanides** and **actinides**

Hydrogen is difficult to place, however it is place in group 1 because it displays some of the same characteristics as these elements, although it is a non-metal

Helium is still a noble gas because its outer shell is filled by 2 electrons

1	2											3	4	5	6	7	0
1 H 1.01					Atomic number Element Atomic mass									Non- Metals			2 He 4.00
3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31					Metals						13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.90	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.71	29 Cu 63.55	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc 98.91	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.40	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.30
55 Cs 132.91	56 Ba 137.34	57 † La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.21	76 Os 190.21	77 Ir 192.22	78 Pt 195.09	79 Au 196.97	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.98	84 Po (210)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 ‡ Ac (227)															
		†	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm 146.92	62 Sm 150.35	63 Eu 151.96	64 Gd 157.25	65 Tb 158.92	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97	
		‡	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (254)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)	

3.1.2 - Distinguish between the terms group and period

Group - A vertical column of elements.

These have been classified in a number of ways - IB numbers them 1 to 7, with the noble gases being group 0. Some groups have names, such as Alkali metals (group 1) and Halogens (groups 7). Groups 3 to 6 have both metal and non-metal elements. The metalloids (B, Si, Ge, As, Sb, Te and Po) have characteristics of both metals and non-metals.

Period - A horizontal row of elements

These are numbered 1 to 7. The number matches the number of its outer shell electrons. Elements of the same period have the same number of occupied electron shells

1	2											3	4	5	6	7	0
1 H 1.01				Atomic number Element Atomic mass													2 He 4.00
3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
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		‡	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (254)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)	

Period

Group

3.1.3 - Apply the relationship between the electron arrangement of elements and their position on the periodic table up to Z = 20

The position of elements on the periodic table is linked to their **electron configuration**. Elements in the same group have the same outer shell electron configuration. Elements of the same period have the same number of <u>occupied electron shells</u>. This in turn affects their physical and chemical properties.

e.g. Sulfur is in group 6 and period 3

Its electron arrangement is 2.8.6 (6 outer electrons, 3 shells)

1st Shell	2nd Shell	3rd Shell	4th Shell
2	8	8	2

** The fourth shell can hold more electrons, but at SL, you will only use up to two

3.1.4 - Apply the relationship between the number of electrons in the highest occupied energy level for an element and its position in the periodic table

Group Number

- The same as the number of electrons in the outer shell
- Group 1 = 1 outer shell electron

Period Number

- The same as the number of shells in the atom
- All except the outer shell will be full

3.2 - Physical Properties

3.2.1 - Define the terms first ionisation energy and electronegativity

First Ionisation Energy

The energy required to remove one mole of electrons from one mole of atoms in the gaseous state.

Outer shell electrons are **more easily removed**. This shows how tightly the outer-shell electrons are held in an atom.

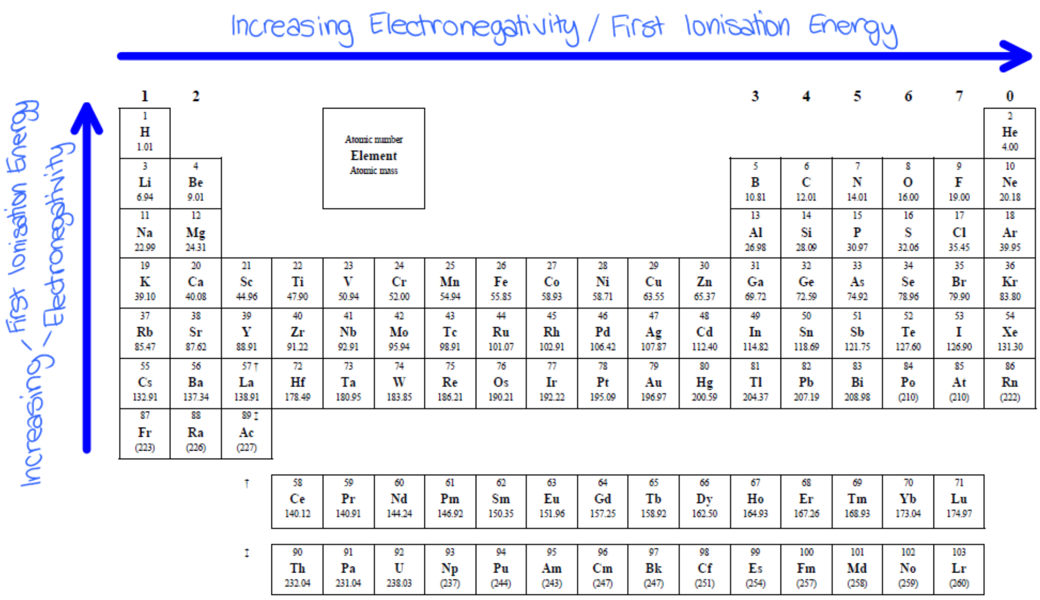
Metals tend to have <u>low ionisation energies</u> because their outer electrons are easily removed

Electronegativity

A measure of the attraction an atom has for a for a shared pair of electrons when it is covalently bonded to another atom

Metals have **low electronegativities** because they lose electrons easily. Non-metals have **high electronegativities** as they gain electrons to complete their outer shell

Electronegativity tends to increase across a period and up a group.



3.2.2 - Describe and explain the trends in atomic radii, ionic radii, first ionisation energies, electronegativities and melting point for the *alkali metals* and the *halogens*

Atomic Radii

Moving down a group, the **atomic radii increases.** This is because the electrostatic attraction decreases as the outer shells are further from the nucleus. There are more shells in the atom.

Ionic Radii

Moving down a group, the **ionic radii will increase** as there are more shells in the atoms, and electrostatic attraction is reduced

First Ionisation Energies

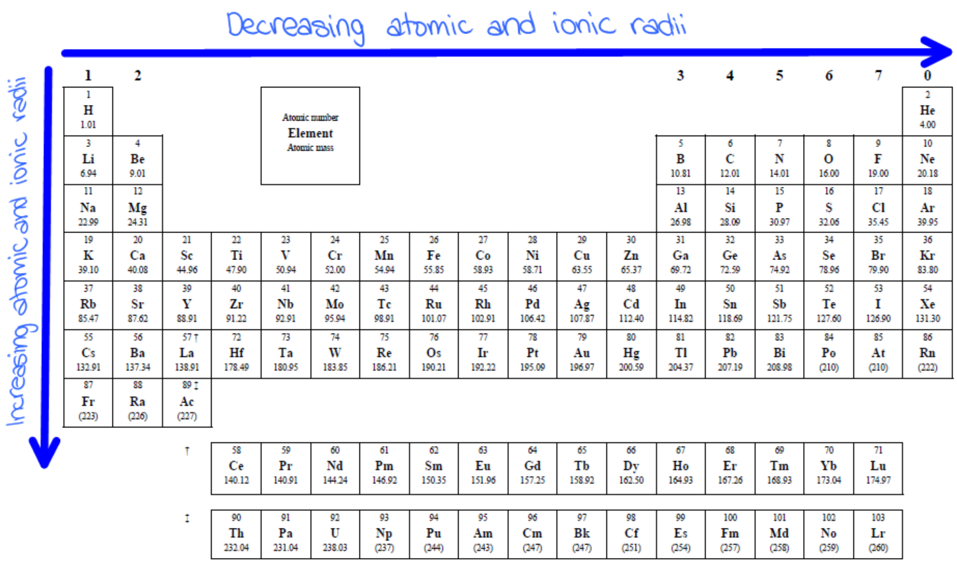
Decreases as you go down a group due to the <u>decreasing electrostatic attraction</u> between the nucleus and outer-shell electrons. This makes it easier to remove the outer electrons

Electronegativities

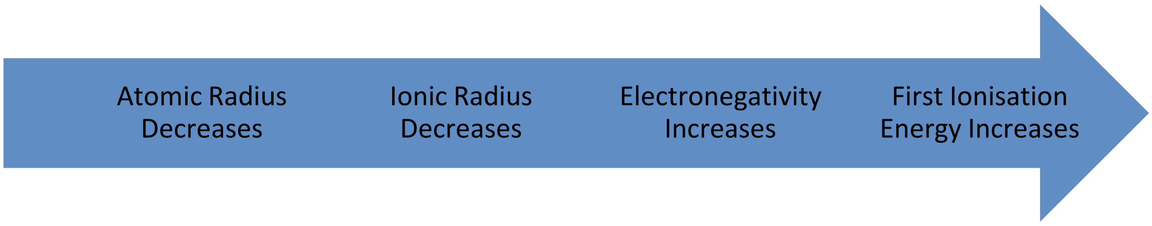
Decreases as you go down a group due to the <u>decreasing electrostatic attraction</u> between the nucleus and outer-shell electrons. This causes less attraction for other electrons to the outer shell

Melting Point

This varies depending on the type of **intermolecular forces** and bonding in a substance. Stronger bonding within a substance will cause a <u>higher melting point</u>



3.2.3 - Describe and explain the trends in atomic radii, ionic radii, first ionisation energies and electronegativities for elements across period 3



Atomic Radius

The charge in the nucleus increases across the period, causing greater electrostatic attraction to the outer shell. This pulls the outer shell closer to the nucleus, causing the atom to become smaller.

Ionic Radius

For the metals, the ionic radius **decreases** across the period as they empty their outer shell.

Non-metal will have a larger radius because they retain their outer shell, but it still decreases as you move to the right.

Electronegativity

This increases as you move right across the period due to greater electrostatic attraction to the outer shell.

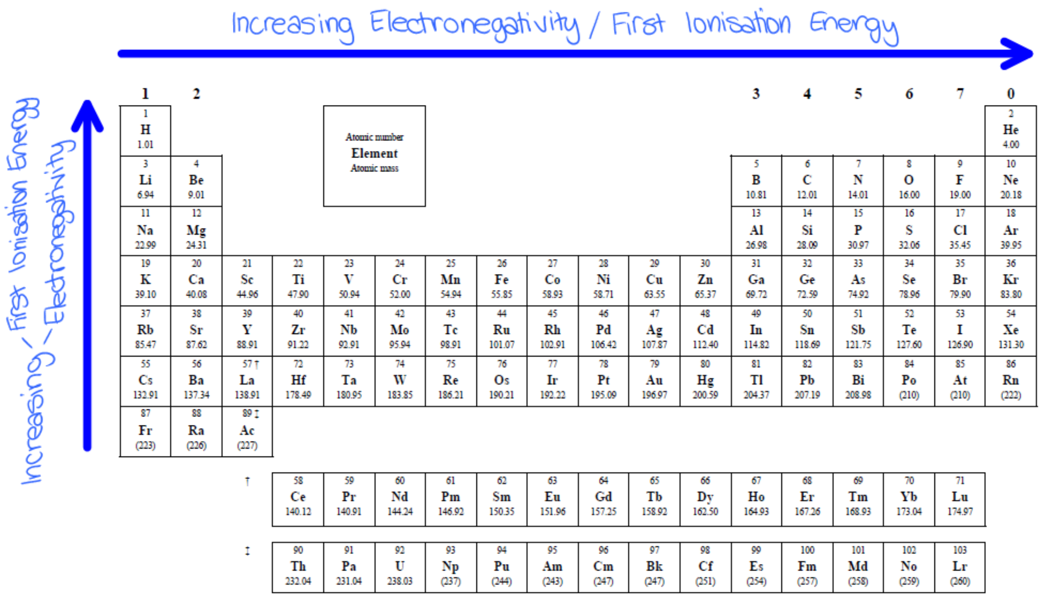
First Ionisation Energy

Overall increase across period, however Aluminium and Sulfur are lower due to their electron configuration and stability.

3.2.4 - Compare the relative electronegativity values of two or more elements based on their positions on the periodic table.

i.e. Oxygen has higher electronegativity than *Phosphorus*

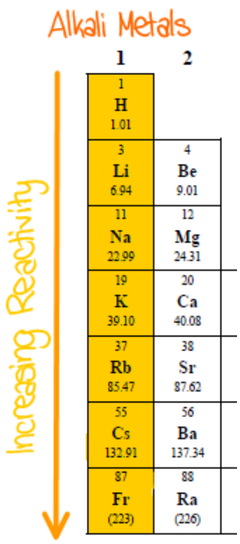
Aluminium has a lower electronegativity than *Boron*



3.3 - Chemical Properties

3.3.1 - Discuss the similarities and differences in the chemical properties of elements in the same groups

Alkali Metals with Water



The alkali metals are very reactive, and will **react violently with water**. They must be stored under oil. Their <u>reactivity increases down the group</u>.

$$2Li_{(s)} + H_2O_{(l)} \rightarrow Li_2O_{(aq)} + H_{2\,(g)}$$

$$2Na_{(s)} + H_2O_{(l)} \rightarrow Na_2O_{(aq)} + H_{2\,(g)}$$

During the reaction, the metal will move across the water. However, if its progress is slowed, it will ignite. The more reactive metals will have a larger flame and are more likely to ignite.

Potassium produces a violet flame.

$$2K_{(s)} + H_2O_{(l)} \rightarrow K_2O_{(aq)} + H_{2\,(g)}$$

In the reactions of alkali metals with water, the result is an **alkaline solution**.

$$Li_2O_{(s)} + H_2O_{(l)} \rightarrow 2LiOH_{(aq)}$$

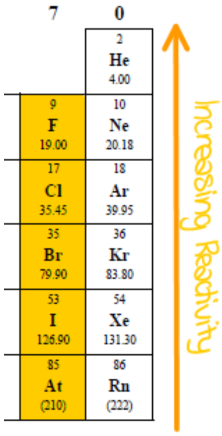
$$Na_2O_{(s)} + H_2O_{(l)} \rightarrow 2NaOH_{(aq)}$$

$$K_2O_{(s)} + H_2O_{(l)} \rightarrow 2KOH_{(aq)}$$

The increase in reactivity down the group is caused by **decreasing electrostatic attraction** to the outer shells, allowing electrons to be lost more easily. This means that the alkali metals are good **reducing agents** because they donate electrons.

Alkali Metals with Halogens

Halogens are good **oxidising agents** because they accept electrons easily. As a result, the reactions between halogens and alkali metals are very violent. They react to produce a salt.



$$2Na_{(s)} + Cl_{2\,(g)} \rightarrow 2NaCl_{(s)}$$

$$2K_{(s)} + I_{2\,(g)} \rightarrow 2KI_{(s)}$$

$$2Li_{(s)} + Br_{2\,(g)} \rightarrow 2LiBr_{(s)}$$

Halogens and Halide Ions

The reactivity of the halogens **increases up the group** because the atoms become smaller, allowing them to gain electrons more easily. Therefore, fluorine is the most reactive halogen.

The larger halide ions can <u>lose electrons more easily</u> because there is a greater distance from the nucleus to the outer shells.

$$Cl_{2\,(g)} + 2I^{-}_{(aq)} \rightarrow 2Cl^{-}_{(aq)} + I_{2\,(s)}$$

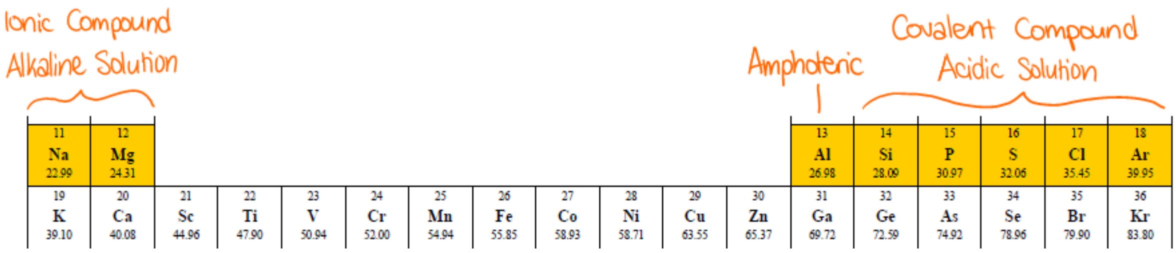
$$Cl_{2\,(g)} + 2Br^{-}_{(aq)} \rightarrow 2Cl^{-}_{(aq)} + Br_{2\,(s)}$$

$$Br_{2\,(g)} + 2I^{-}_{(aq)} \rightarrow 2Br^{-}_{(aq)} + I_{2\,(s)}$$

3.3.2 - Discuss the changes in nature, from ionic to covalent and from basic to acidic, of the oxides across period 3

All the elements across period 3 react with oxygen to form various types of compounds.

The metals will react to form **ionic compounds**, whilst the non-metals react to form **covalent molecules**. The ionic nature of the compounds decreases from left to right across the period.



From left to right, the products form strongly alkaline to strongly acidic solutions. Al_2O_3 is amphoteric because it can act as a base or an acid. It does not dissolve in water.

Acting as a base:

$$Al_2O_{3\,(s)} + 6HCl_{(aq)} \rightarrow 2AlCl_{3\,(aq)} + 3H_2O_{(l)}$$

Acting as an acid:

$$Al_2O_{3\,(s)} + 2NaOH_{(aq)} + 3H_2O_{(l)} \rightarrow 2NaAl(OH)_{4\,(aq)}$$