4.1 – Ionic Bonding

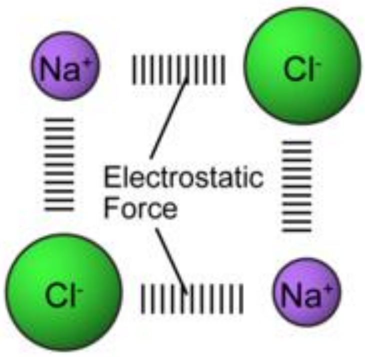
4.1.1 - Describe the ionic bond as the electrostatic attraction between oppositely charged ions

Ions are formed when electrons are transferred from a metal atom to a non-metal atom in order to produce a full outer shell for both ions. The metal will have a **positive charge**, whilst the non-metal will have a **negative charge**.

These opposite charges create and electrostatic attraction between the ions, causing them to form a neutral lattice. The charges of the ions in the lattice will cancel each other out. Ionic bonds are very strong, so ionic compounds have <u>high melting points</u>.

Ions have different charges, depending on how many electrons they lost or gained to form their stable configuration. Ions with a positive charge are called **cations**, and ions with a negative charge are called **anions**. The transition metals are able to form ions of more than one charge.

Ionic compounds are often called **salts**.

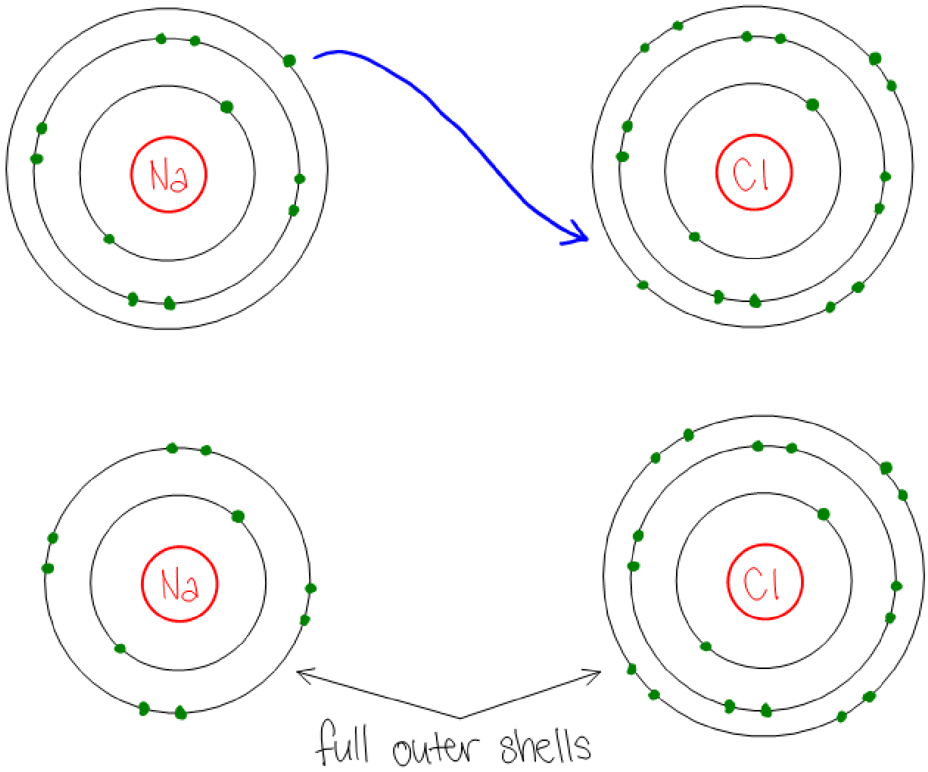


4.1.2 - Describe how ions can be formed as a result of electron transfer

The electrons in the outer shell of an atom are called the **valence electrons**. During electron transfer, the valence electrons of the metal atom are donated to the non-metal atom in order to <u>fill its outer shell</u>.

The result of this is that the metal becomes a **positively charged cation**, and the non-metal becomes a **negatively charged anion**.

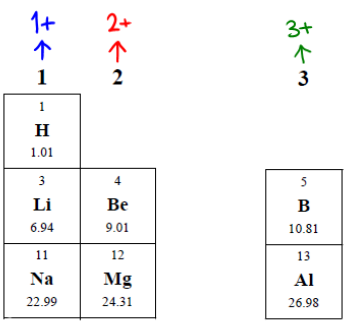
The cation loses its entire valence shell, so the ion will be smaller than the atom. The anion increases in size because of the repulsion of the additional electrons.



The configuration of the ions in the lattice will depend on the size of the ions. The ratio of ions will depend on the charges of the ions. However, it will always work out that the ions neutralise each other.

4.1.3 - Deduce which ions will be formed when element in groups 1, 2 and 3 lose electrons

Looking at the periodic table, there are trends in the ions that form in each group.



In groups 1, 2 and 3, the atoms form positive ions by losing their electrons. Their charge is the same as their group number.

Note that Boron **does not** form an ion, as it does not form an octet by doing so.

4.1.4 - Deduce which ions will be formed when elements from groups 5, 6 and 7 gain electrons

Likewise, the atoms in groups 5, 6 and 7 form ions based on the group they are in.

3-	2-	1-
↑	↑	↑
5	**6**	**7**

7 **N** 14.01	8 **O** 16.00	9 **F** 19.00
15 **P** 30.97	16 **S** 32.06	17 **Cl** 35.45

These trends occur because atoms in the same group have <u>the same number of valence electrons in their outer shell</u>. Therefore, when they lose or gain electrons, the atoms in the same group will lose or gain the same number of them.

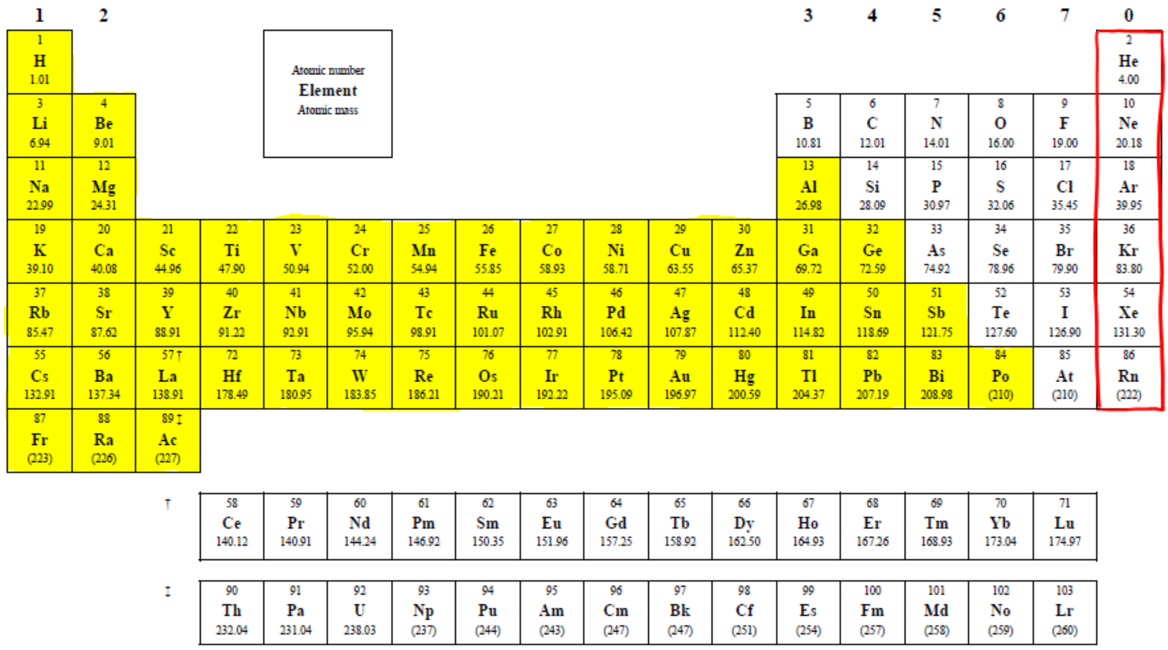
4.1.5 - State that transition elements can form more than one ion

Transition metals have a complex electron arrangement, which means that they form more than one type of ion. They still form cations. For example:

$$Fe \rightarrow Fe^{2+} \text{ or } Fe^{3+}$$

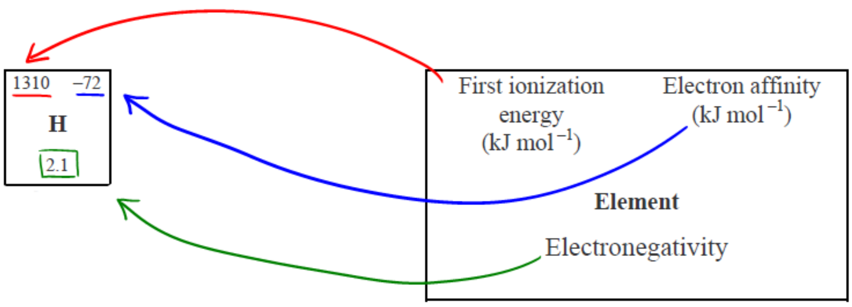
4.1.6 - Predict whether a compound of two elements would be ionic from the position of the elements in the periodic table or from their electronegativity values

The non-metals occur on the right side of the periodic table [the white ones below]. The metals are on the left [highlighted in yellow]. An ionic compound can only form between a metal and a non-metal.



Each atom has an electronegativity value assigned to it. If the two atoms forming the compound have a difference in their electronegativities of over 1.8, then their bonding would be ionic.

For example, the electronegativity of Lithium is 1.0, whilst the electronegativity of Chlorine is 3.0. The difference is 2.0, which is greater than 1.8. Therefore, they will form an ionic bond.



4.1.7 - State the formula of the common polyatomic ions formed by non-metals in periods 2 and 3

A polyatomic ion is when more than one element forms a single ion. The formula of the ionic compound is still found the same way, by neutralising the charge on each ion. Polyatomic ions are simply treated as a single ion.

Examples include:

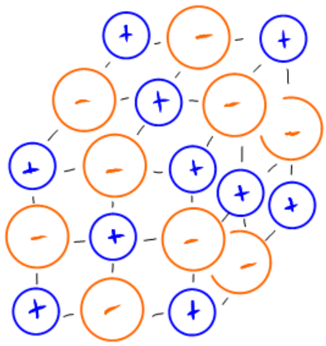
SO_4^{2-} CO_3^{2-} PO_4^{3-} OH^- NO_3^- NH_4^+ H_3O^+ HSO_4^- HCO_3^- CN^- CH_3COO^- MnO_4^-

If more than one polyatomic ion occurs in a compound, then brackets are placed around it to indicate it is a separate entity:

$Al(OH)_3$

4.1.8 - Describe the lattice structure of ionic compounds

Ionic compounds exist in a regular pattern called a lattice structure, or **ionic lattice**. This can contain millions of ions that <u>extend in all three dimensions</u>. There is no fixed number of ions that can be involved, however the ratio of positive to negative ions must be the same as in the **empirical formula** to ensure that all the charges on the ions are neutralised.



For the most stable arrangement, positively charged ions are packed as closely as possibly to the negatively charged ions, whilst ions of the same charge are as far apart as possible. This **maximises electrostatic attraction between the ions**, while minimising repulsion. Many different arrangements can be generated to do this, which depends on the size of the ions and their ratio. It will result in the lattice structure for that compound.