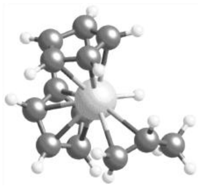
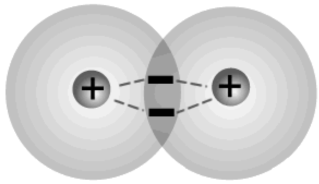
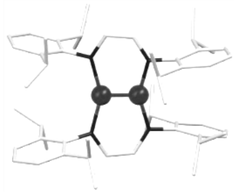
Chemical Bonds







If a mixture of substances produces new substances, a chemical reaction is said to be taken place. On the microscopic level, this means atoms and molecules are being broken apart and re-joined. Of course, we can't see this, but certain events will suggest to us that chemical reaction is occurring or has occurred. For instance,

- The production of a gas
- A colour change
- A temperature change
- A visible new substance, like a precipitate

Chemical reactions always produce new substances; this is how they are defined.

There are three principles we need to understand with how chemical reactions work.

i) Electrons with almost complete shells **attract** electrons.
ii) Electrons with almost empty outer shells **weakly hold** onto electrons.
iii) Atoms like to form **complete** outer electron shells.

In a chemical reaction, bonds form between atoms so that molecules are created. These bonds form simply because of the above principles. There are actually three types of bonds.

1. **Ionic** bonds, between metals and non-metals
2. **Covalent** bonds, between non-metals
3. **Metallic** bonds, between metals

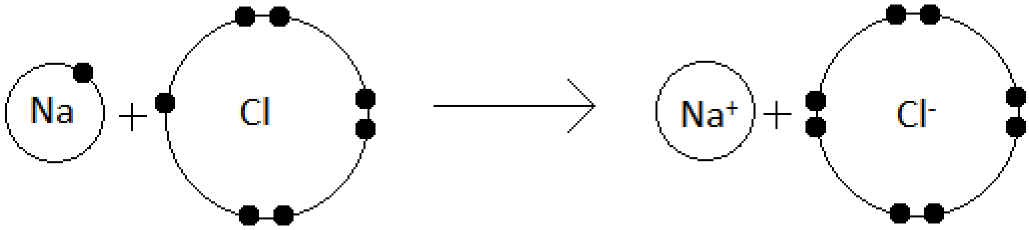
A general rule for these reactions is that atoms must be left **with a complete outer shell** after reaction. If not, then the reaction is generally not possible.

Ionic Bonds

Ionic bonds form between **metal and non-metals**. They occur **because metals only weakly hold** onto their electrons and **non-metals actually want more electrons**. A good example is table salt, NaCl. Sodium is a metal. Chlorine is a non-metal. How do they join?

Well, let's think about sodium to begin with. Sodium is on the **far left** of the periodic table and only has one outer-shell electron. This electron is **very weakly held**, and it would take 7 electrons to fill up the shell.

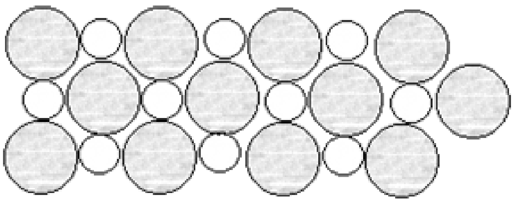
Chlorine, on the other hand, is **missing one electron** in its other shell. Just one. In fact, it desperately wants another one to complete its outer shell. So, you can most likely guess what happens.



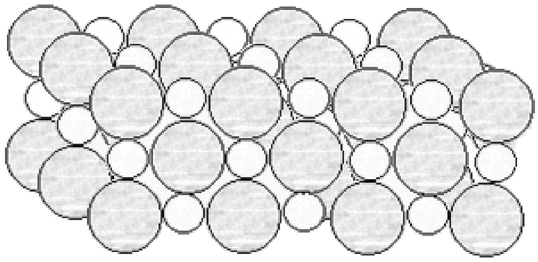
When sodium and chlorine come close, chlorine will steal the outer electron of sodium. Now, they are ions that have joined together – Na has lost an electron and has become positive and Cl has gained an electron, becoming negatively charged. They are oppositely charged, which means they will stick together. Note that in both cases, the atoms are left with complete outer shells.

$Na + Cl \rightarrow Na^+ + Cl^- \rightarrow NaCl$ is the equation. Congratulations, it's our first molecule!

Ionic bonds form what are called **crystal lattices**. Because of the positive and negative charges, we can join many of these atoms together to form a solid, which is made of layers of NaCl molecules.



Two dimension representation



Three dimension representation

A few more examples will help us get the hang of this.

Let's take a look at aluminium and oxygen. This is difficult, as aluminium has **three** outer shell electrons, and oxygen is missing two. It means that we can't just add single atoms together. If we take another 2 oxygen atoms, meaning there are six spaces missing, we can easily join **two aluminium** atoms with **three oxygen** atoms.

$Al + O \rightarrow Al^{3+} + O^{2-} \rightarrow (Al^{3+})_2 + (O^{2-})_3 \rightarrow Al_2O_3$

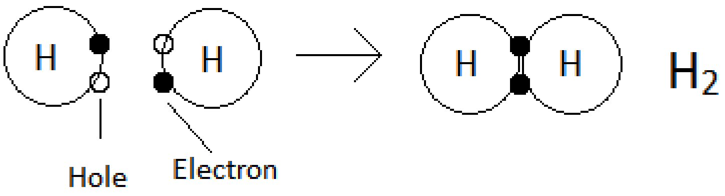
To make it clear, the third step is multiplying the aluminium by two and the oxygen by three. We would write this properly as:

$2Al + 3O \rightarrow Al_2O_3$ You might also have noticed we always write the metal first in any ionic bond.

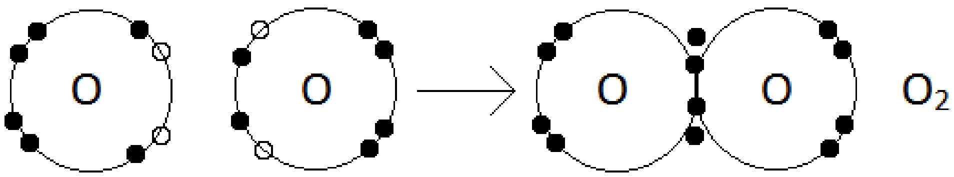
Covalent Bonds

Covalent bonds only occur between **non-metals**. They are, in many ways, more important than ionic bonds. But, how do they occur? It is very hard to remove electrons from non-metals, and they try to steal other electrons. Covalent bonding doesn't occur because electrons are *stolen*. Rather, it occurs when **atoms share electrons** to complete each other's shells.

Let's take the absolutely simplest case of two hydrogen atoms. Both are **missing one electron**, and need one to complete their outer shells. So, they share their electrons with each other, so both end up with complete shells.



Similarly, if we join two oxygen atoms, we can use covalent bonds. This time, we have to share **two pairs** of electrons.



We can represent what is happening by drawing lines from each atom to its neighbour.

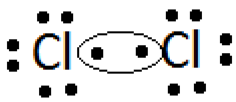
H – H O = O

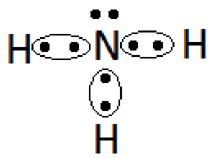
Electron Dot Diagrams

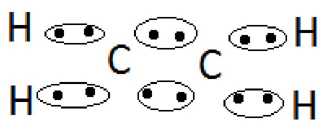
Electron dot diagrams are useful to see whether a covalent bond can take place. You put dots around the chemical symbol to represent the number of electrons in the outer shell. **These diagrams only work between the first 18 elements.** Simply place electrons at each of the four sides of the symbol.

Here are some examples to get the feel of the process. When doing a diagram, you should try to make it symmetrical where possible. Try not to overlap the connections.

Cl + Cl → Cl_2 **N + 3H →/NH_3 (Ammonia)** **C_2H_4 (Ethane)**







Metallic Bonding

Metals can join together to form metallic solids. Metals generally have relatively empty outer shells, meaning **a lot of loose electrons**. These loose electrons can be used to hold the nuclei in place. However, it isn't generally focused much in earlier years.