Redox

Oxidation numbers

Oxidation numbers give an indication of how many **electrons** that an element has **gained or lost** when it bonds to another atom. There are certain **rules** you need to follow when assigning oxidation numbers:

- Atoms unbound to other elements are always **0**.
- Hydrogen is always **+1**
- Oxygen is always **-2**
- The whole molecule needs to be **neutral** — adding up all the oxidation numbers of the elements in the compound will give 0.

There are a couple of **exceptions**: hydrogen has a -1 oxidation state in metal hydroxides e.g. LiH and oxygen has a -1 oxidation state in hydrogen peroxide, H_2O_2.

In general, elements in group 1 will have a +1 oxidation state and those in group 2 have a +2 oxidation state. Likewise, group 7 elements usually have a -1 oxidation state and -2 for group 6. If in doubt, think about the charge that an ion of that element would form.

Sometimes oxidation numbers are given to you in the name of a compound. For example, you may have seen iron hydroxide written as iron (II) hydroxide or iron (III) hydroxide. Those roman numbers in brackets indicate the oxidation state of iron. This is usually done for transition metals which can exist in a variety in different oxidation states.

Worked example – assigning oxidation numbers

Work out the oxidation numbers of each element in magnesium sulfate, $MgSO_4$

- Sulfate ions have a -2 charge (SO_4^{2-}) so Mg must have a +2 charge to form a neutral ionic compound. (This makes sense — it's a group 2 element).
- O is always -2 (see rules above), but we have four of them, so there is a total of -8 for oxygen.

- S must be +6 because we know that the whole molecule needs to add up to zero. If we have +2 from Mg and -8 from O, then we need another +6 to bring the total up to zero.

Now work out the oxidation numbers of each element in potassium dichromate, $K_2Cr_2O_7$.

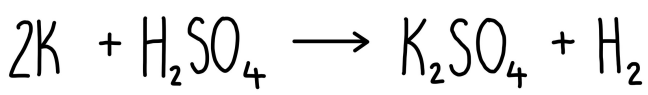
- O is always -2 and we have seven of them, so there is -14 in total from the oxygen.
- K is in group 1 so it has a +1 oxidation state. There are two of them, which means a total of +2 from potassium.
- We can work out the chromium by knowing that everything together needs to equal zero. Right now we have -14 and +2 = -12 so I need +12 more to make the whole thing neutral. Since there are two chromium atoms in the compound, each chromium atom must be +6. (It's always best to assign an oxidation number to the transition metal last, as these cannot be predicted based on their positions in the periodic table and can exist in multiple different oxidation states.)

Redox reactions

Redox reactions are reactions in which **oxidation and reduction** are happening simultaneously.

- **Oxidation** is the **loss of electrons** and **reduction** is the **gain of electrons**.
- The thing that is oxidised is referred to as the **reducing agent** — it's causing the reduction of something else by giving away its electrons.
- The thing that is reduced is called the **oxidising agent** — it's oxidising something else by taking its electrons.

For example, look at the reaction between potassium and sulfuric acid below.



- Potassium is oxidised — its oxidation state increases from 0 to +1.
- Hydrogen is reduced — its oxidation state decreases from +1 to 0.
- Therefore, potassium is the reducing agent and hydrogen is the oxidising agent.