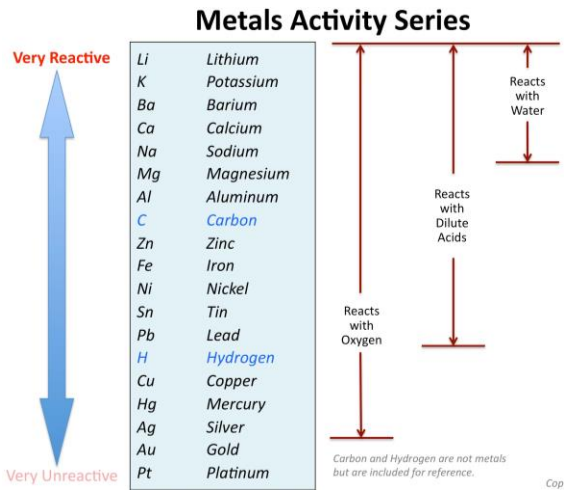
Chemical changes

Metals react with oxygen to produce metal oxides. The reactions are **oxidation reactions** because the **metals gain oxygen**. **Reduction involves the loss of oxygen.** Unreactive metals such as gold are found in the Earth as the metal itself but most metals are found as compounds that require chemical reactions to extract the metal. Metals less reactive than carbon can be extracted from their oxides by reduction with carbon.

Acids react with some **metals** to produce **salts** and **hydrogen** (MASH).

When metals react with other substances the metal atoms form positive ions (ion^{+ve}). The reactivity of a metal is related to its tendency to form positive ions. Metals can be arranged in order of their reactivity in a reactivity series. The metals potassium, sodium, lithium, calcium, magnesium, zinc, iron and copper can be put in order of their reactivity from their reactions with water and dilute acids.

The non-metals hydrogen and carbon are often included in the reactivity series. **A more reactive metal can displace a less reactive metal from a compound.**



HT ONLY: **metals lose electrons** so are oxidised, non metals gain electrons so are reduced (OILRIG), these reactions are known as REDOX reactions. Ionic equation example:

STEP 1: $2Al_{(s)} + 6HCl_{(aq)} \longrightarrow 2AlCl_{3(aq)} + 3H_2O_{(l)}$

STEP 2: $2Al + 6H^+ + 6Cl^- \longrightarrow 2Al^{3+} + 6Cl^- + 3H_2O$

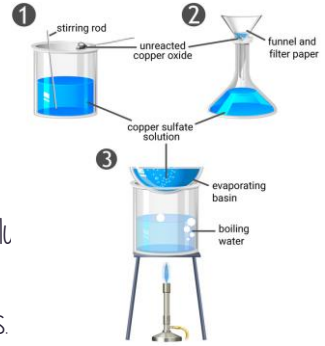
STEP 3: $2Al + 6H^+ + 6\cancel{Cl^-} \longrightarrow 2Al^{3+} + 6\cancel{Cl^-} + 3H_2O$

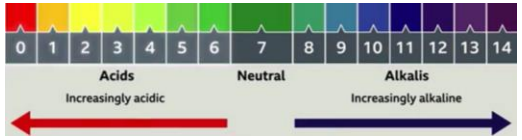
IONIC EQUATION: $2Al + 6H^+ \longrightarrow 2Al^{3+} + 3H_2O$

Soluble salts can be made from **neutralising acids** by reacting them with solid insoluble substances, such as **metals, metal oxides, hydroxides or carbonates**. (metal - MASH, base - BASHO, carbonate - CASHOCO).

The solid is added to the acid **until no more reacts** and the **excess solid is filtered off** to produce a solution of the salt (filtrate). The filtrate is then gently warmed on a water-bath to evaporate the water.

Salt solutions can be left in a warm place and crystallised to produce solid salts.





Examples:

MASH: Metal + **Sulphuric** acid --> metal **sulphate** + hydrogen$_{(g)}$

BASHO: Metal hydroxide + **Hydrochloric** acid --> metal **chloride** + water

CASHOCO: Metal carbonate + **Nitric** acid --> metal **nitrate** + water + carbon dioxide$_{(g)}$

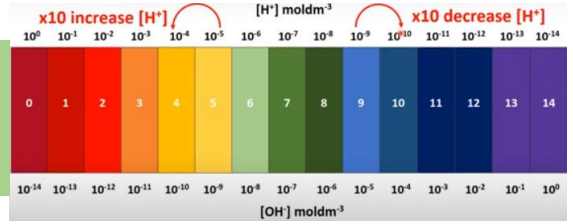
Acids produce hydrogen ions (H^+) in aqueous solutions. Aqueous solutions of alkalis contain hydroxide ions (OH^-).

The pH scale, from 0 to 14, is a measure of the acidity or alkalinity of a solution, and can be measured using **universal indicator** or a **pH probe**.

In neutralisation reactions between an acid and an alkali, hydrogen ions react with hydroxide ions to produce water. $H^+ + OH^- \rightarrow H_2O$

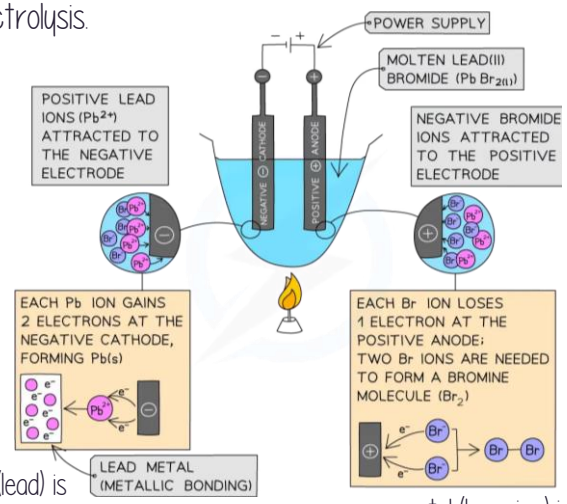
HT ONLY: **A strong acid is completely ionised (H^+) in aqueous solution.** Examples of strong acids are hydrochloric, nitric and sulfuric acids. A **weak acid** is **only partially ionised** in aqueous solution. Examples of weak acids are ethanoic, citric and carbonic acids. For a given concentration of aqueous solutions, the stronger an acid, the lower the pH.

As the pH decreases by one unit, the hydrogen ion concentration of the solution increases by a factor of 10.



Electrolysis: electro (electricity) – lysis (splitting)... splitting ionic substnces with electricity

When an **ionic compound** is **melted** or **dissolved in water**, **the ions are free to move** about within the liquid or solution. These liquids and solutions are able to **conduct electricity and are called electrolytes**.
Passing an electric current through electrolytes causes the **ions to move to the electrodes. Positively charged ions move to the negative electrode (the cathode), and negatively charged ions move to the positive electrode (the anode). Ions are discharged at the electrodes producing elements**. This process is called electrolysis.



the metal (lead) is produced at the cathode

non-metal (bromine) is produced at the anode.

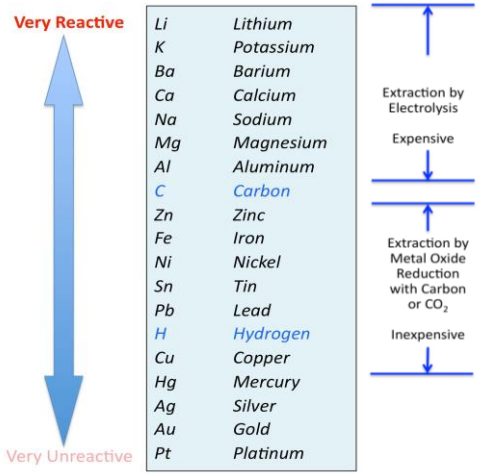
Negative ion	Element given off at anode
Chlor**ide**, Cl^-	Chlor**ine**, Cl_2
Brom**ide**, Br^-	Brom**ine**, Br_2
Iod**ide**, I^-	Iod**ine**, I_2
Sulfate, SO_4^{2-}	Oxygen, O_2
Nitrate, NO_3^-	Oxygen, O_2

HT ONLY: **DISCHARGING**: During electrolysis, at the cathode (negative electrode), positively charged ions (metal) gain electrons and so the reactions are reductions.
At the anode (positive electrode), negatively charged ions (non-metal) lose electrons and so the reactions are oxidations.
Reactions at electrodes can be represented by half equations:

Examples of half equations at the cathde:
$Na^+ + e^- \rightarrow Na$
$Pb^{2+} + 2e^- \rightarrow Pb$
$2H^+ + 2e^- \rightarrow H_2$

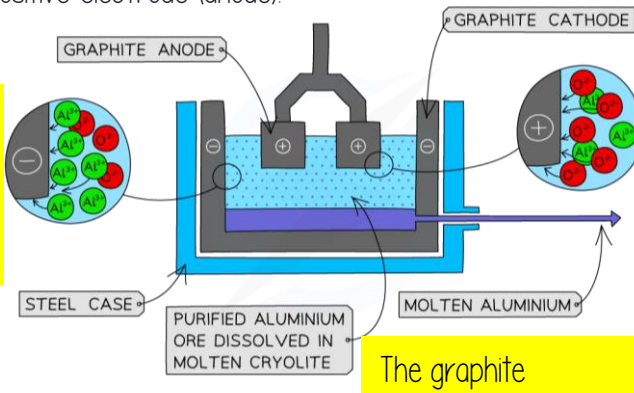
Examples of half equations at the anode:
$2Cl^- \rightarrow Cl_2 + 2e^-$
$2O^{2-} \rightarrow O_2 + 4e^-$
$4OH^- \rightarrow O_2 + 2H_2O + 4e^-$

Electrolysis of aluminium oxide (bauxite)



Metals can be extracted from molten compounds using electrolysis. Electrolysis is used if the metal is too reactive to be extracted by reduction with carbon or if the metal reacts with carbon. **Large amounts of energy** are used in the extraction process **to melt the compounds** and to **produce the electrical current.**
Aluminium is manufactured by the electrolysis of a molten mixture of aluminium oxide (bauxite) and cryolite using carbon as the positive electrode (anode).

Cryolite reduces the **temperature** at which **aluminium oxide (bauxite) melts** – this means the reaction **requires less energy = cheaper!**



Electrolysis of an aqueous solution - ionic compound dissolved in WATER

EXAMPLE: A solution of aqueous sodium chloride will produce the following ions:

H^+ OH^- — *Ions from the water*
Na^+ Cl^- — *Ions from the ionic compound*

What will be produced at the ANODE?

F Cl Br I At — *A Halide is any element from Group 7*

Is there a Halide ion present?
- YES → The **halogen** will be produced at the Anode.
- NO → **Oxygen** will be produced at the Anode.

What will be produced at the CATHODE?

Is the metal less reactive than hydrogen?
- YES → The **metal** will be produced.
- NO → Hydrogen gas will be produced.

The ions discharged when an aqueous solution is electrolysed using inert electrodes depend on the relative reactivity of the elements involved.
At the negative electrode (cathode), hydrogen is produced if the metal is more reactive than hydrogen.
At the positive electrode (anode), oxygen is produced unless the solution contains halide ions when the halogen is produced.
This happens because in the aqueous solution water molecules break down producing hydrogen ions and hydroxide ions that are discharged.

The graphite (carbon) electrodes need replacing because the **oxide** ions (O^{2-}) **lose electrons** at the anode forming **oxygen**. This then reacts with the carbon electrode **producing carbon dioxide**.