Reaction Types

There are lots of types of **chemical reaction**. You will need to know all of them quite well. These pages give you types, explanations and examples (in alphabetical order).

Addition

This is a reaction in which atoms are **added** to an **unsaturated** bond so that the bond becomes **saturated**.

e.g. ethene (C_2H_4) + H_2O → ethanol (C_2H_5OH)

Combustion

This is the chemical reaction between a **fuel** and **oxygen**. Normally the fuel is an organic compound and the products are **carbon dioxide** and **water** — this is **complete combustion**.

e.g. $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

Without enough oxygen, **incomplete combustion** occurs, producing poisonous carbon monoxide.

e.g. $C_3H_8 + 3\frac{1}{2}O_2 \rightarrow 3CO + 4H_2O$

Condensation

This is similar to an **addition** reaction in which a **simple molecule** like water is also formed.

Cracking

This is the (thermal) **decomposition** of **long-chain** hydrocarbon molecules from crude oil into **shorter-chain** alkanes and alkenes. This requires **high temperatures** and **pressures** and a **catalyst** (usually aluminium oxide), and makes hydrocarbons that are more useful.

e.g. decane ($C_{10}H_{22}$) → octane (C_8H_{18}) + ethene (C_2H_4)

Dehydration

This is the removal of **water** from a compound by **heating**.
In organic molecules it usually results in the formation of a **C=C** bond.

e.g. ethanol (C_2H_5OH) → ethene (C_2H_4) + H_2O

Displacement

This is a reaction where one element **displaces** another, **less reactive**, element from a compound. This usually takes place between **metals**, but also with **halogens**.

e.g. $2Al_{(s)} + Fe_2O_{3\,(s)} \rightarrow Al_2O_{3\,(s)} + 2Fe_{(s)}$ (the Thermite Reaction)

Disproportionation

This is a rare type of chemical reaction where an **element** in a reactant is **oxidised** and **reduced** at the same time. **Chlorine** can undergo disproportionation reactions.

e.g. $Cl_{2(aq)} + H_2O_{(l)} \rightarrow \underset{\text{Chloric(I) acid}}{HOCl_{(aq)}} + \underset{\text{Hydrochloric acid}}{HCl_{(aq)}}$

The chlorine has been: **oxidised** **reduced**

Reaction Types

Electrolysis

This is a process that uses **electricity** to **break down** a compound. The reactant or reactants must be in the **liquid** state — either **molten** or in **solution**. The particles have to be able to move.

An example is the electrolysis of bauxite to obtain pure aluminium.

Elimination

This is just the **removal** of a **small molecule** from a larger molecule.
Usually H_2O or H_2 is removed (and not replaced by anything else).

e.g. propanol ($CH_3CHOHCH_3$) + sulfuric acid catalyst → propene ($CH_2{=}CHCH_3$) + water

Endothermic

Any chemical reaction that **takes in** heat energy. This means that the **reactants** will have **less energy** than the **products**. The **enthalpy change** of reaction, ΔH (see page 41), is **positive**.

Exothermic

Any chemical reaction that **gives out** heat energy. This happens because the **products** have **less energy** than the **reactants**. The **enthalpy change** of reaction, ΔH, is **negative**.

Hydrogenation

This is the **addition** of a molecule of **hydrogen** (H_2) across a **C=C** bond.
One atom attaches to each carbon.

e.g. ethene (C_2H_4) + H_2 → ethane (C_2H_6)

Neutralisation

This is the reaction between a **basic compound** and an **acid**. The products always include the **salt** of the acid, **water** and other products dependent on the acid and base.

e.g. $2KOH_{(aq)} + H_2SO_{4\,(aq)} \rightarrow K_2SO_{4\,(aq)} + 2H_2O_{(l)}$

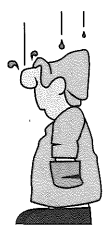
$Na_2CO_{3\,(aq)} + 2HCl_{(aq)} \rightarrow 2NaCl_{(aq)} + CO_{2\,(g)} + H_2O_{(l)}$

Oxidation

There are two possible definitions for this — the best is the **loss of electrons**.
Another useful one is the **gain of oxygen**. It is the opposite of reduction.

Precipitation

A precipitate is a **solid** that is formed in a **solution** by a chemical reaction or by a change in temperature affecting solubility. Precipitates are **insoluble** in the solvent.
A precipitation reaction is simply any reaction that **produces a precipitate**.



Reaction Types

Radical (Chain) Reactions

Reactions involving radicals — an atom or compound with an **unpaired electron**. Often, one of the **products** of the reaction is also a radical which can perform further reactions. This makes the process a **chain reaction**.

Redox

This is the name for a reaction that involves both **reduction** and **oxidation** processes. It is usually used to describe reactions that just involve **electron transfer**.

e.g. $Fe_{(s)} + Cu^{2+}_{(aq)} \rightarrow Fe^{2+}_{(aq)} + Cu_{(s)}$

reduction

oxidation

Reduction

There are two possible definitions for this — the best is the **gain of electrons**. The other useful one is the loss of oxygen. Important point: oxidation and reduction **ALWAYS** happen **together** — it is impossible to have one without the other.

Reversible

This is the name given to any chemical reaction that can go **forwards** and **backwards** at the **same time**. That means that the reactants will form the products, but that the products will also react (or decompose) to give the reactants.

e.g. $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

Substitution

This is simply a reaction in which an atom (or group of atoms) in a molecule is **swapped** for a different atom (or group of atoms).

Thermal Decomposition

This is where one compound **breaks down**, under **heating**, into two or more simpler compounds. A classic example is the breakdown of any carbonate compound,

e.g. $CaCO_3 + \text{heat} \rightarrow CaO + CO_2$

Cracking of hydrocarbons is also an example.

I'm in the middle of a chain reaction...

1) Write down all the different types of reaction that each of the following could be classed as.
   a) burning ethanol
   b) iron + copper sulfate → iron sulfate + copper
   c) hydrochloric acid + sodium hydroxide → sodium chloride + water + heat
   d) propene (C_3H_6) + H_2 → propane (C_3H_8)

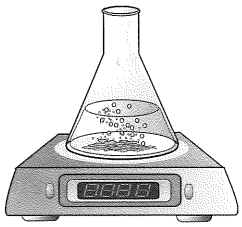
Reaction Rates

Measuring the Rate of a Reaction

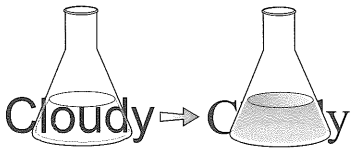
The **rate** of reaction is just a measure of how **fast** a particular reaction is going.

You need to know some of the ways that you can follow the rates of different reactions. They're all about measuring how fast the **reactants** are being **used up**, or measuring how fast the **products** of the reaction are **forming**.

There are lots of ways of measuring the rate of a reaction:



1) You can measure the **change in mass** that occurs during a reaction where gas is released as one of the products.



2) You can follow the **colour change** of a reaction. This includes precipitation reactions, where the solution turns cloudy as more of the product is made.

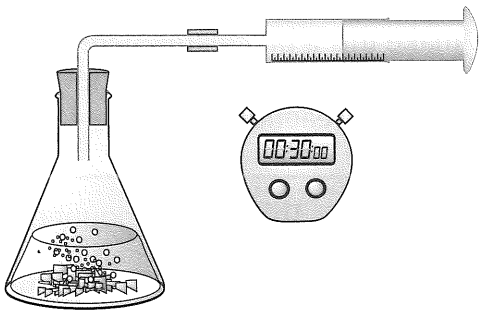
3) You can measure changes in **temperature** or **pH** that occur during the reaction.

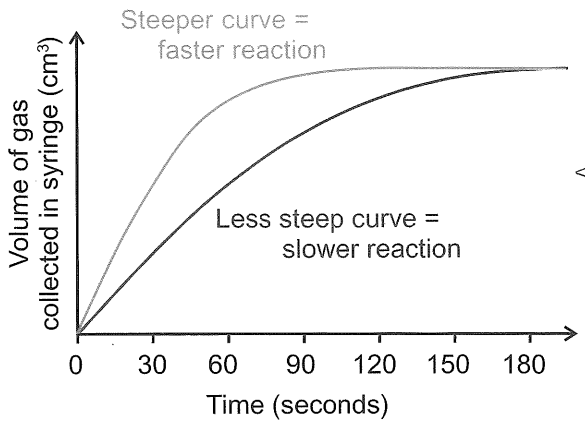
4) You can measure the **volume of gas** produced during a reaction.

EXAMPLE: Measuring the rate of reaction between hydrochloric acid and magnesium metal.

magnesium + hydrochloric acid → magnesium chloride + hydrogen

- Use a **gas syringe** to collect the hydrogen gas that is given off during the reaction.
- Use a **stopwatch** to **time** the reaction.
- At **timed intervals**, say every 30 seconds, **record** how much hydrogen gas has been produced.





Plotting graphs lets you compare rates of reactions.

(Another way to measure the rate of this reaction would be to measure the decrease in **mass** as hydrogen gas is lost from the reaction container.)

My rate of chocolate biscuit consumption is worryingly high...

1) Describe how you could measure the rates of the following reactions:
   a) The endothermic reaction between citric acid and sodium bicarbonate to give carbon dioxide, water and a sodium salt.
   b) The precipitation reaction between sodium thiosulfate and hydrochloric acid to form a sulfur precipitate, sulfur dioxide gas, sodium chloride and water.
   c) The reaction between solid calcium carbonate and hydrochloric acid to produce calcium chloride and carbon dioxide gas.