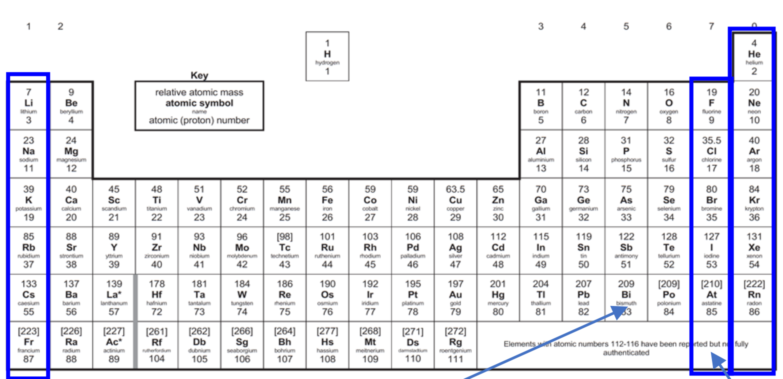
CC13-CC15: Groups, rates and energy

CC13: Groups in the periodic table knowledge organiser (H)

Overview

The Periodic Table of the Elements



Group 1
Alkali Metals
A group of very reactive metals

Li Lithium
Na Sodium
K Potassium
Rb Rubidium

Group 7
Halogens
A group of very reactive non- metals

F Fluroine
Cl Chlorine
Br Bromine
I Iodine

Group 8
Noble gases
A group inert gases

He Helium
Ne Neon
Ar Argon
Kr Krypton
Xe Xenon

Lesson 1 Group 1 Alkali metals

Group 1 are a group of very reactive metals. They are so reactive they are not like conventional metals. Group 1 metals have 1 electron in their outer shell and lose it to form +1 ions.

Physical properties	Chemical properties
Low melting points	Highly reactive
Soft and easily cut	React with oxygen and water
Conduct electricity	Readily form positive ions

Reaction with oxygen

Alkali metals react quickly with oxygen, so are stored under oil

Potassium + oxygen → potassium oxide

$4K(s) + O_2(g) \rightarrow 2K_2O(s)$

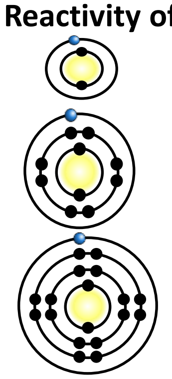
Reaction with water

Alkali metals react with water to give the metal hydroxide (an alkali) and hydrogen gas. When you add the metal to water you <u>see</u> fizzing and the metal disappears as it reacts to give the soluble metal hydroxide.

Potassium + water → potassium hydroxide + hydrogen

$2K(s) + 2H_2O(l) \rightarrow 2KOH(aq) + H_2(g)$

Reactivity of Alkali metals



lithium
2,1

sodium
2,8,1

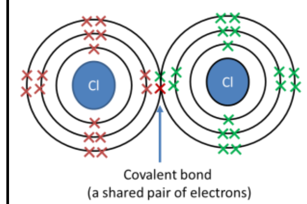
potassium
2,8,8,1

increase in reactivity

Group 1 metals react by losing an electron to form a +1 ion. As you go down the group the electron that is lost is further from the nucleus and the negative charge of the electron is less attracted to the positive charge of the nucleus.
This means that the electron is more easily lost and the metal is more reactive

Lesson 2 Group 7 Halogens

The halogens are a group of very reactive non- metals. Atoms of the halogens have 7 electrons in their outer shell. They readily gain 1 electron to form -1 ions.



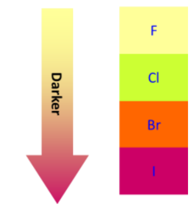
Cl - Cl

Cl_2

All halogens form diatomic molecules (F_2, Cl_2, Br_2, I_2) which have low melting and boiling points (Strong covalent bonds between atoms, weak inermolecualr forces between molecules

The halogens are soluble in water and form solutions of different colours e.g. bromine water is orange

fluorine is pale yellow
chlorine is green-yellow
bromine is red-brown
iodine is blue-black.



Reactions with metals

Halogens react with group 1 metals to form salts. These are ionic compounds containing halide ions. Halide ions are colourless in solution

sodium + chlorine → sodium chloride

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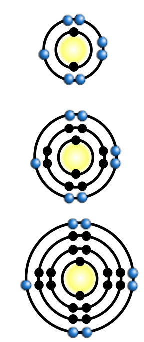
Reactivity of Halogens



decrease in reactivity

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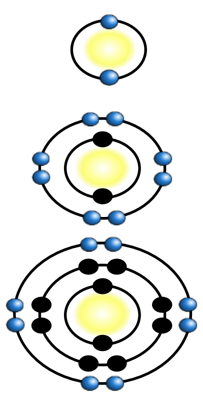
Lesson 4 Group 8 Noble gases

The noble gases are a group of inert (unreactive) gases. Atoms of noble gases have either 2 or 8 electrons in their outer shell meaning they are stable (full outer shell). The atoms are found on their own (mono-atomic) and their full outer shell means they do not bond with other atoms.



helium
2

neon
2,8

argon
2,8,8

Physical properties
Colourless gases
Very low melting and boiling points
Poor conductors of heat and electricity

All noble gases are unreactive

Trends in properties

Density increases down the group. Melting and boiling points are very low but do increase down the group

Uses

Noble Gas	Use
Helium (He)	Very low density and is non-flammable so is used in weather balloons and airships
Neon (Ne)	Neon tubes for illuminated signs
Argon (Ar)	Denser than air. Used filling air gap in wine barrels
Krypton (Kr)	Gives superman special powers!

Lesson 3 Halogen reactivity (Halogen displacement reactions)

In a halogen displacement reaction a more reactive halogen displaces a less reactive halogen from a solution of a salt of the less reactive metal halide. (The more reactive halogen 'steals' the metal from a less reactive metal halide)

Chlorine + potassium iodide → potassium chloride + iodine

$Cl_2(aq) + 2KI(aq) \rightarrow 2KCl(aq) + I_2(aq)$

The halogen waters are the colours of the halogens (Chlorine – green, bromine – orange, iodine – brown solution / purple solid)
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bromine + potassium iodide → potassium bromide + iodine $Br_2(aq) + 2KI(aq) \rightarrow 2KBr(aq) + I_2(aq)$	Orange to brown

Equations

Word equation

Chlorine + potassium iodide → potassium chloride + iodine

Symbol equation

$Cl_2(aq) + 2KI(aq) \rightarrow 2KCl(aq) + I_2(aq)$

Ionic equation

The metal ion is a spectator ion so can be left out

$Cl_2(aq) + 2I^-(aq) \rightarrow 2Cl^-(aq) + I_2(aq)$

Redox

Oxidation **I**s **L**oss of electrons
Reduction **I**s **G**ain of electrons

The chlorine gains an electron to become a chloride ion, so is <u>reduced</u>
The Iodide loses and electron to become iodine, so is <u>oxidised</u>

CC13: Groups in the periodic table knowledge organiser (S)

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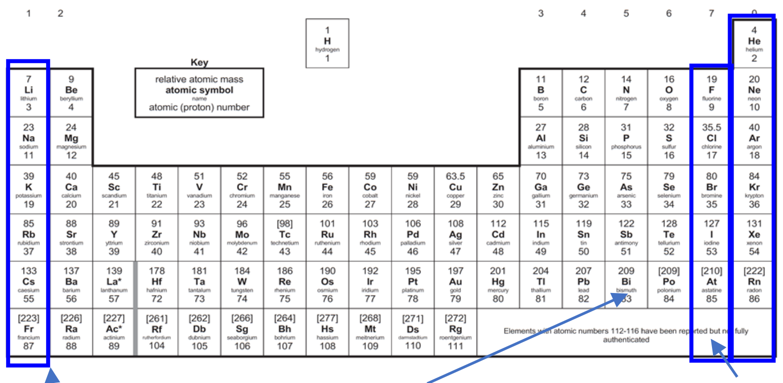

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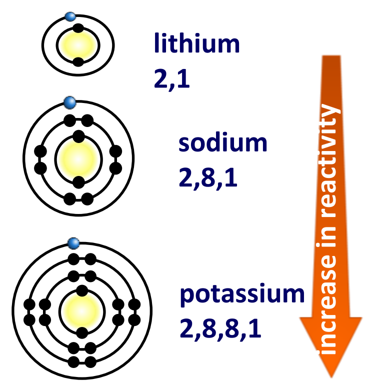

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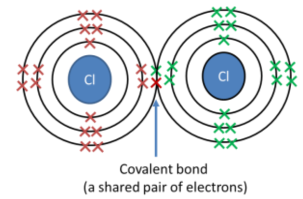

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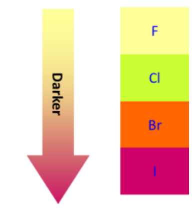

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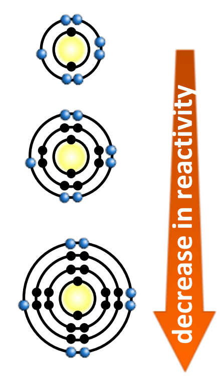

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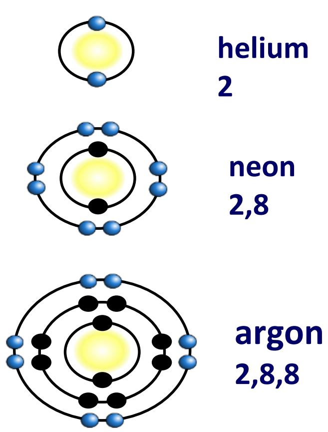

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Noble Gas	Use
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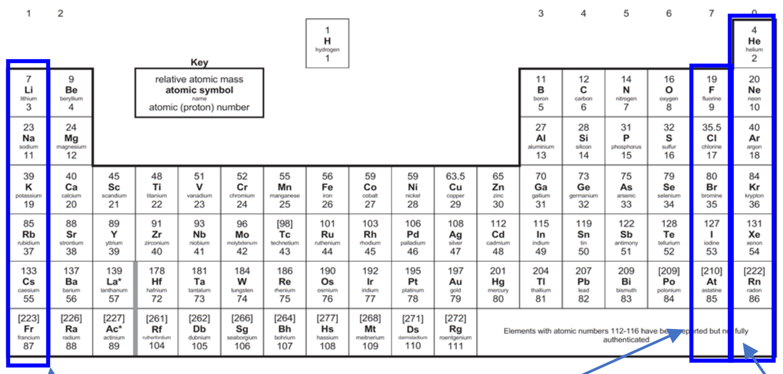

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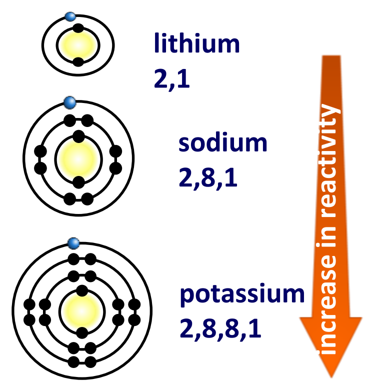

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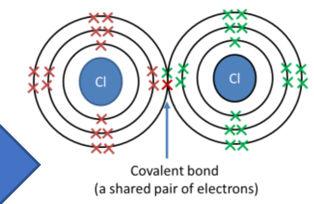

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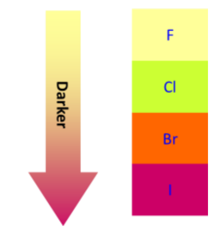

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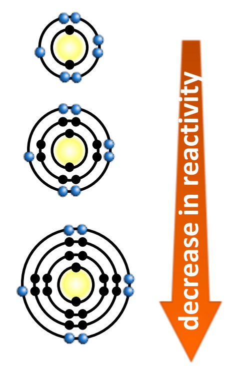
Reactivity of Halogens



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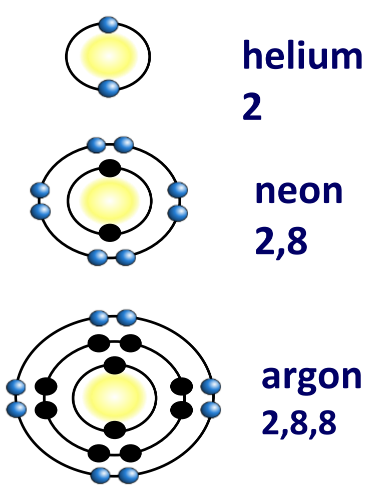


Physical properties
Colourless gases
Very low melting and boiling points
Poor conductors of heat and electricity

All noble gases are unreactive

CC14: Rates of reaction knowledge organiser (H)

Lesson 1 Rate of reaction

Chemical reactions can go fast or they can go slow. The rate is reaction is a measure of how fast a reaction goes

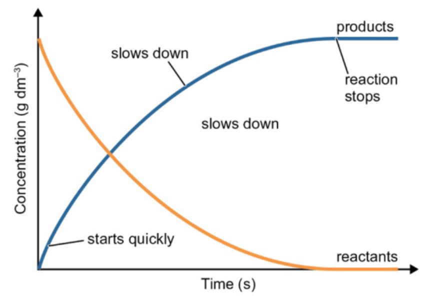
In a chemical reaction reactants turn into products

Reactants → Products

The rate of reaction is measure of how fast reactants are used up or how quickly products are made.

Rate of reaction = $\frac{\text{Change in amount of reactants / products}}{\text{Time}}$

The rate of a chemical reaction can be followed by measuring something that changes with time. This could be the volume of gas produced, a colour change, a pH change etc.
A plot of how this thing changes with time is known as a concentration / time graph. During a reaction the concentration of reactants decreases and the concentration of products increases.



The gradient (how steep) a concentration / time graph is tells you how fast the reaction is going. Most chemical reactions start off quickly and slow down as the reaction proceeds until they stop

Lesson 2 Factors effecting rate of reaction and collision theory

The rate of a chemical reaction depends on:

- The concentration / pressure of reactants
- The temperature
- The particle size (surface area) of reactants
- Whether a catalyst is present

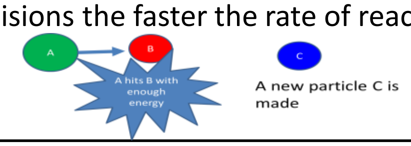
You need to be able to **state** how each of these factors effects the rate of reaction and **explain** (using collision theory) why this is so.

Collision Theory

Chemical reactions happen because particles collide with enough energy. This energy is known as the activation energy. If particles collide with energy greater than or equal to the activation energy a **Successful Collision** will result in a reaction. The greater the **frequency** of successful collisions the faster the rate of reaction.

e.g. in the reaction

A + B → C



The concentration / pressure of reactants

State – the higher the concentration or pressure the faster the reaction

Explain – Increasing pressure or concentration increases the number of particles in a given volume. More particles = more collisions = more frequent successful collisions = faster rate of reaction.

Temperature

State - The higher the temperature the faster the reaction. A small rise in temperature results in much faster reaction (10°C doubles rate)

Explain – Increasing temperature increases the energy of particles (they move faster) = more collisions **and** more energetic collisions = more frequent successful collisions = faster rate of reaction

Particle size

State – The smaller the particles the higher the surface area the faster the rate

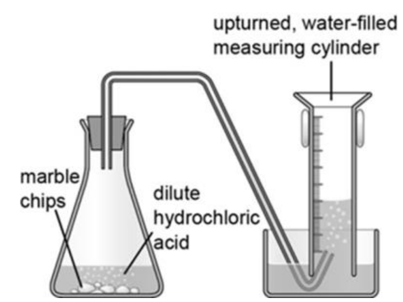
Explain – Small particles have larger surface area and there are more places for particles to collide = more collisions = more frequent successful collision = faster rate of reaction

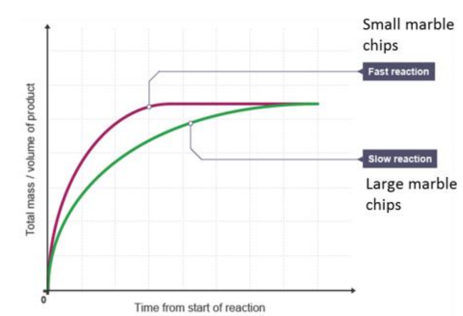
Lesson 3 Core practical – Marble chips and acid

Marble chips are made from calcium carbonate. This reacts with hydrochloric acid to produce carbon dioxide gas

Calcium carbonate + hydrochloric acid → calcium chloride + water + carbon dioxide

The carbon dioxide can be collected and how quickly it is produced will tell us the rate of reaction





To measure the rate of the reaction - plot a graph of volume of carbon dioxide against time. Draw a tangent to the curve and measure the gradient:

gradient = $\frac{\text{change in y}}{\text{change in x}}$

Concentration of acid

Measure the volume of gas produced in one minute.
The higher the concentration of acid the greater the amount of gas that is produced in one minute and the faster the rate of the reaction.

Size of marble chips

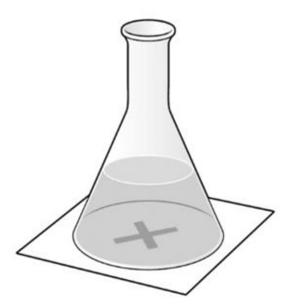
Measure the volume of gas produced ever 30 seconds for 5 minutes
The smaller the marble chips the larger the surface area and the faster the gas is produced. The same volume of carbon dioxide is produced with small and large marble chips, but it is produced more quickly with small marble chips.

Lesson 4 Core practical – Disappearing cross

In the reaction two reactants are added together and a white precipitate slowly forms. The time that it takes to produce the precipitate is inversely proportional to the rate of the reaction.

Rate of reaction = $\frac{1}{\text{Time take for precipitate to form}}$

The longer the time the slower the rate the shorter the time the faster the rate.



The cross improves the accuracy of the experiment. The stopwatch is stopped when you cant see the cross because enough precipitate has formed

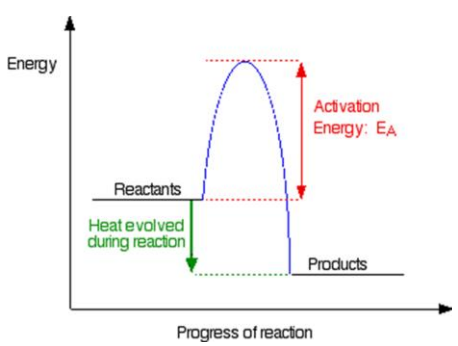
Temperature of reaction

The reaction can be done at different temperatures and the time taken for the precipitate to form recorded.

At higher temperatures the precipitate forms more quickly (the time taken is less). This is because at higher temperature the rate of reaction is higher. Roughly a 10°C rise in temperature results in the rate of reaction doubling.

At higher temperature the particles have more energy and they are moving around faster. They collide more frequently and they collide with more energy. This means you have a lot more successful collisions per unit time and the rate of reaction is much faster.

Lesson 5 Catalysts and activation energy



The activation energy is the amount of energy that needs to be put in before a reaction can happen.
The activation energy acts as a 'hurdle ' which has to be overcome before the reaction happens.

A catalyst is a substance which speeds up the rate of a chemical reaction, but is not used up in the reaction

Because catalysts are not used up only a small amount of catalyst is needed. Some catalysts such as platinum are expensive, but it is still economical to use them as they are not used up.
Catalysts work by lowering the activation energy for the reaction. (The hurdle to overcome is lower) so more particles have enough energy to react.

CC14: Rates of reaction knowledge organiser (S)

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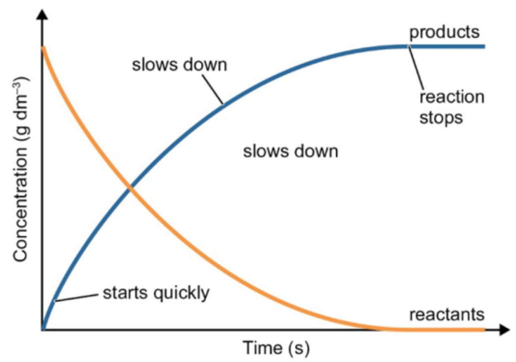

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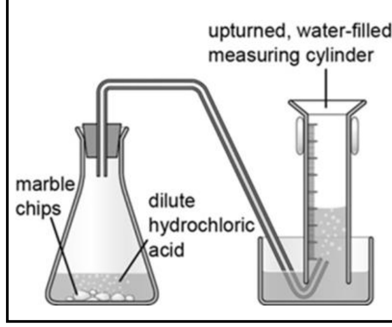
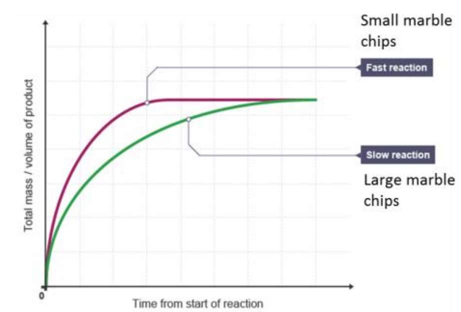
The carbon dioxide can be collected and how quickly it is produced will tell us the rate of reaction





Concentration of acid

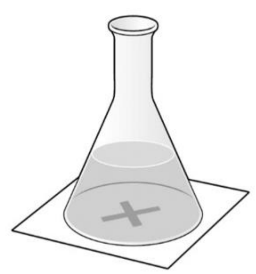
The higher the concentration of acid the greater the amount of gas that is produced in one minute and the faster the rate of the reaction.

Size of marble chips

The smaller the marble chips the larger the surface area and the faster the gas is produced. The same volume of carbon dioxide is produced with small and large marble chips, but it is produced more quickly with small marble chips.

Lesson 4 Core practical – Disappearing cross

In the reaction two reactants are added together and a white precipitate slowly forms. The time that it takes to produce the precipitate is inversely proportional to the rate of the reaction.



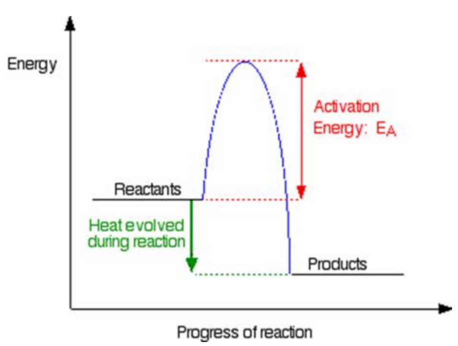
The longer the time the slower the rate the shorter the time the faster the rate.

Temperature of reaction

At higher temperatures the precipitate forms more quickly (the time taken is less). This is because at higher temperature the rate of reaction is higher. Roughly a $10^{o}C$ rise in temperature results in the rate of reaction doubling.

At higher temperature the particles have more energy and they are moving around faster. They collide more and with more energy. This means you have more collisions and the rate of reaction is much faster.

Lesson 5 Catalysts and activation energy



The activation energy is the amount of energy that needs to be put in before a reaction can happen.

A catalyst is a substance which speeds up the rate of a chemical reaction, but is not used up in the reaction

Because catalysts are not used up only a small amount of catalyst is needed. Some catalysts such as platinum are expensive, but it is still economical to use them as they are not used up.
Catalysts work by lowering the activation energy for the reaction.

CC14: Rates of reaction knowledge organiser (C)

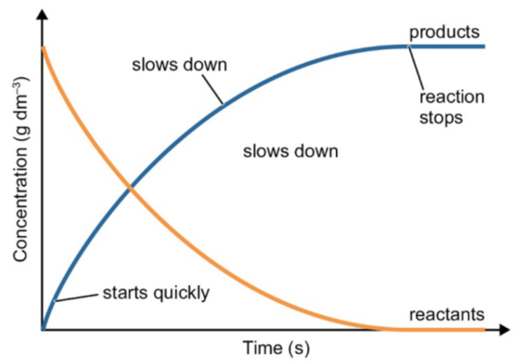
Lesson 1 Rate of reaction

Chemical reactions can go fast or they can go slow. The rate is reaction is a measure of how fast a reaction goes

In a chemical reaction reactants turn into products

Reactants → Products

The rate of reaction is measure of how fast reactants are used up or how quickly products are made.



Most chemical reactions start off quickly and slow down as the reaction proceeds until they stop.

Lesson 2 Factors effecting rate of reaction and collision theory

The rate of a chemical reaction depends on:

- The concentration / pressure of reactants
- The temperature
- The particle size (surface area) of reactants
- Whether a catalyst is present

Collision Theory

Chemical reactions happen because particles collide with enough energy. This energy is known as the activation energy. If particles collide with energy greater than or equal to the activation energy a reaction happens. The more collisions the faster the rate of reaction.

The concentration / pressure of reactants

State – the higher the concentration or pressure the faster the reaction

Explain – More particles = more collisions = faster rate

Temperature

State - The higher the temperature the faster the reaction. (10^{o}C doubles rate)

Explain – Particles move faster = more collisions **and** more energetic collisions = faster rate

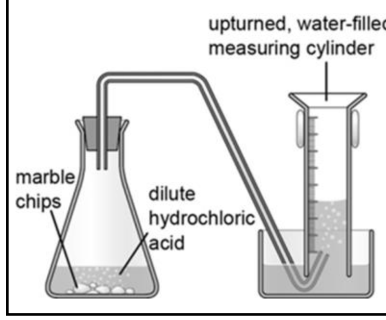
Particle size

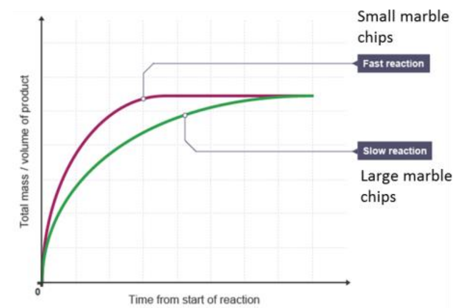
State – The smaller the particles the higher the surface area the faster the rate

Explain – Small particles have larger surface area and there are more places for particles to collide = more collisions = faster rate

Lesson 3 Core practical – Marble chips and acid

Marble chips react with acid to produce carbon dioxide gas The carbon dioxide can be collected and how quickly it is produced will tell us the rate of reaction





Concentration of acid

The higher the concentration of acid the greater the rate of the reaction.

Size of marble chips

The smaller the marble chips the larger the surface area and the greater the rate of reaction.

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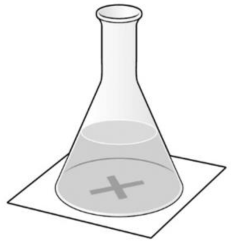

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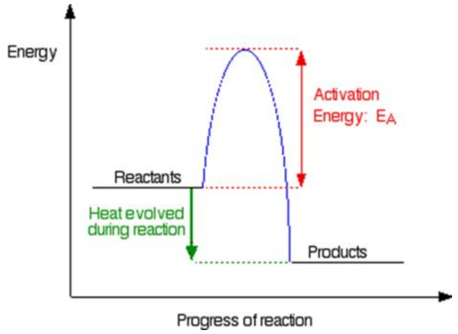
Lesson 5 Catalysts and activation energy



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A catalyst is a substance which speeds up the rate of a chemical reaction, but is not used up in the reaction

Because catalysts are not used up only a small amount of catalyst is needed. Catalysts work by lowering the activation energy for the reaction.

CC15: Energy in reactions knowledge organiser (H)

Lesson 1 Exothermic and endothermic reactions

Chemical reactions involve the transfer of energy between the surroundings and the chemical bonds in the chemicals reacting (the system).

Exothermic reaction

In an exothermic reaction heat energy is transferred from chemical bonds to the surroundings. Heat energy is given out and the temperature of the surroundings increases.

Endothermic reactions

In an endothermic reaction heat energy is transferred from the surrounding to chemical bonds (the system). Heat energy is taken in and the temperature of the surroundings decreases.

Measuring temperature

When measuring temperature you measure the temperature of the surroundings (the solution surrounding a reaction or the heat produced by combustion)

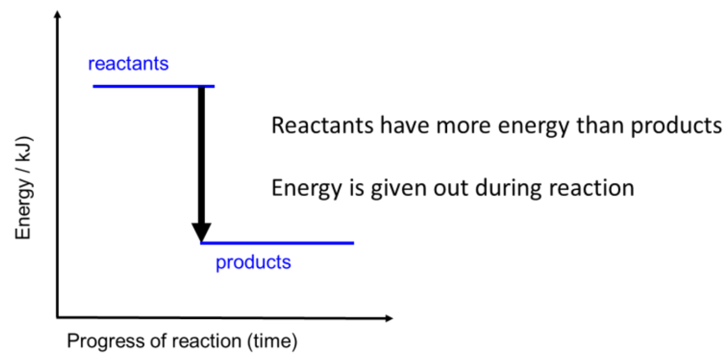
Exothermic reaction – temperature increases. The energy of the surroundings increase because the reaction is giving out energy. The energy of the reaction decreases.

Endothermic reaction- temperature decreases. The energy of the surroundings decreases because the reaction takes in energy. The energy of the reaction increases.

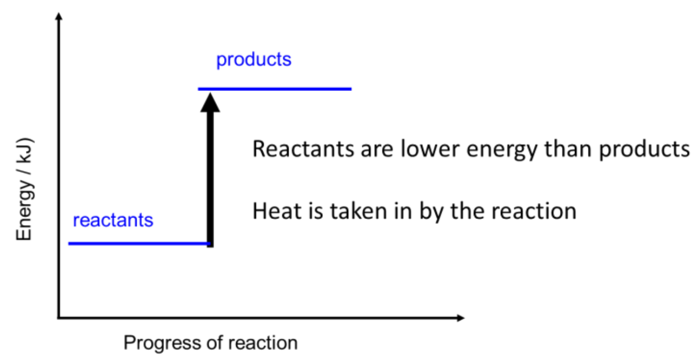
Lesson 2 Reaction profile diagrams

A reaction profile is used to model the energy change during a chemical reaction. The energy of the reaction is plotted on the y axis and the progress of the reaction on the x axis

Exothermic reaction



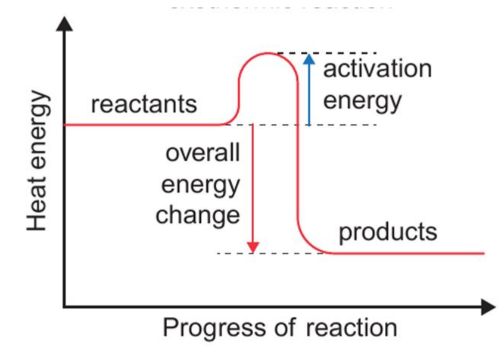
Endothermic reaction



Activation energy

The activation energy is the minimum amount of energy for a successful collision between particles. The activation energy can be shown on a reaction profile as a 'hump' that needs to be overcome for the reaction to happen

Exothermic reaction



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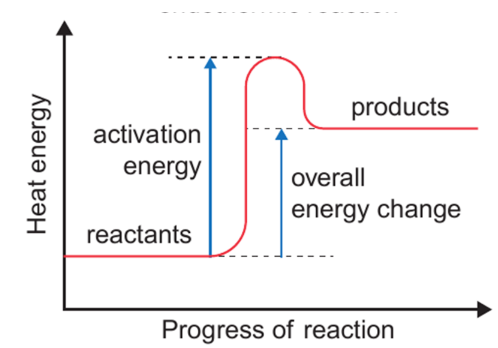
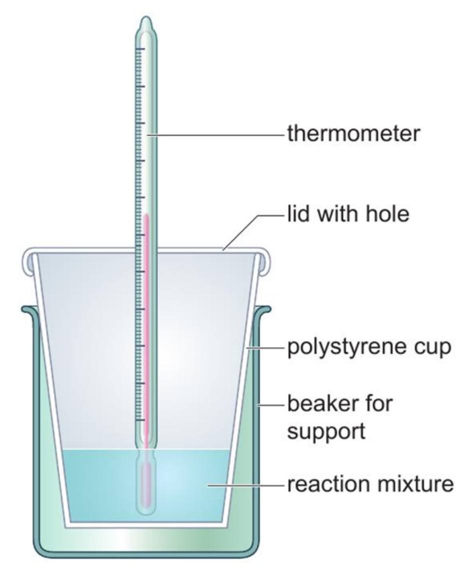


Lesson 3 Measuring energy changes

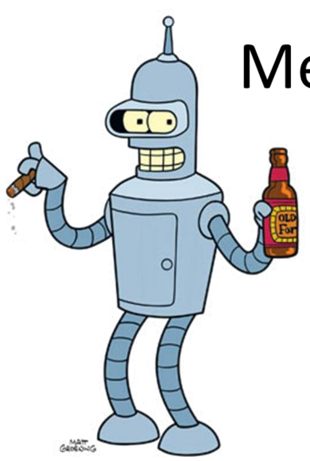
A cup calorimeter is a more accurate way of measuring temperature changes. Different types of reaction are either exothermic or endothermic

- Neutralisation reactions are always exothermic
- Displacement reactions are always exothermic
- Precipitation reactions may be either exothermic or endothermic
- Salts dissolving in solution may be either exothermic or endothermic



D The air trapped between the beaker and the cup reduces energy transfers by heating, to and from the surroundings.

Lesson 4 Bond energies



Mexican Bender

M aking
E xothermic
X

B reaking
E ndothermic
N
D

During a chemical reaction the bonds in the reactants are broken – the atoms then change places and new bonds in products are made

Breaking bonds in the reactants is an endothermic process (it requires energy)

Making bonds in the products is an exothermic process (it produces energy)

Exothermic reaction
In an exothermic reaction energy is given out overall – so overall more energy is released in making the bonds in the products then is used breaking the bonds in reactants.

Endothermic reaction
In an endothermic reaction energy is taken in overall – so overall more energy is used breaking the bonds of reactants than is released making the bonds in the products

Bond energy (KJ/mol) = the energy required to break 1 mole of a particular bond

Energy change in reaction (KJ/mol) = Energy of bonds broken (KJ/mol) - Energy of bonds made (KJ/mol)

To find the energy change for a reaction add up all of the energy of all of the bonds broken in the reactants and subtract the energy for all the bonds made in the products.

If energy change is –ve the reaction is exothermic

If energy change is +ve reaction is endothermic

CC15: Energy in reactions knowledge organiser (S)

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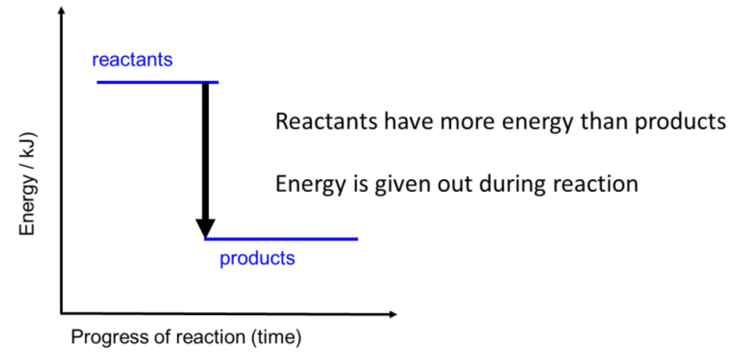

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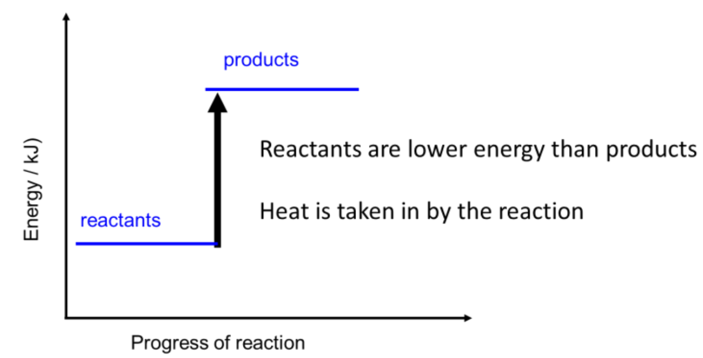

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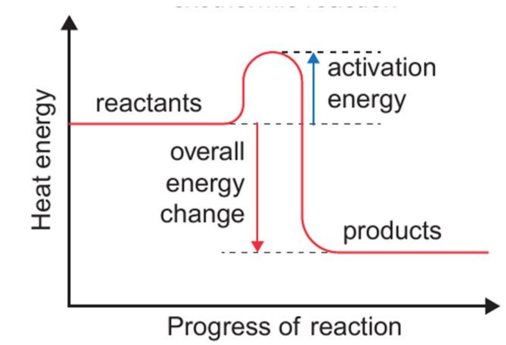

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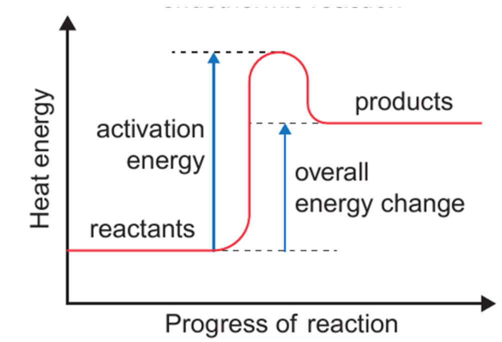

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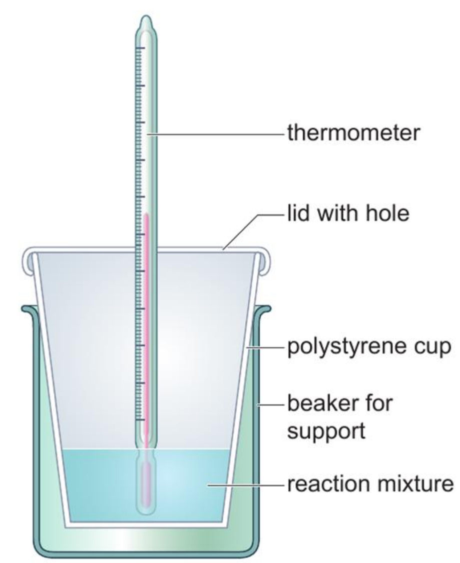
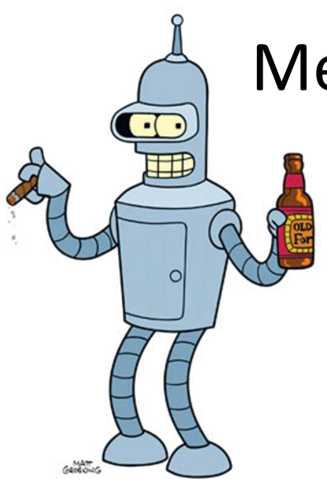


Lesson 4 Bond energies



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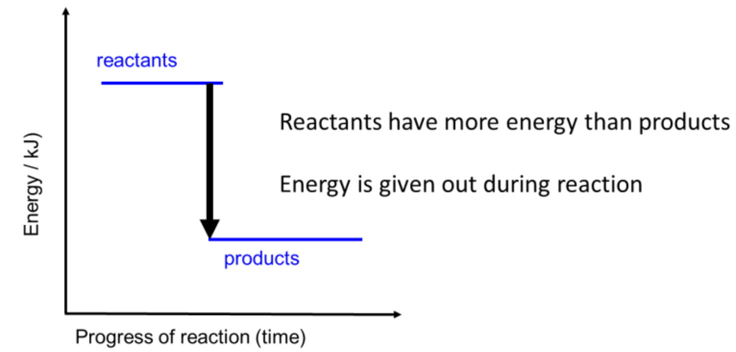

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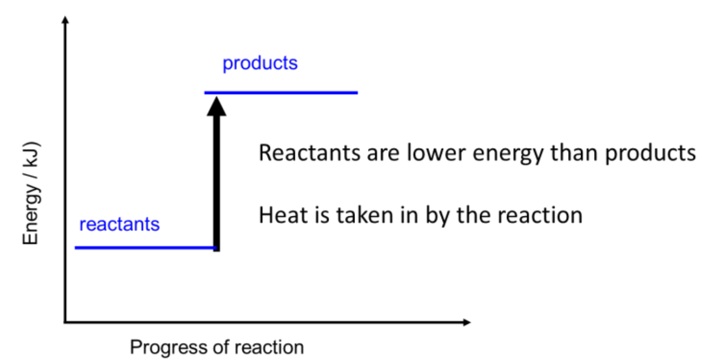

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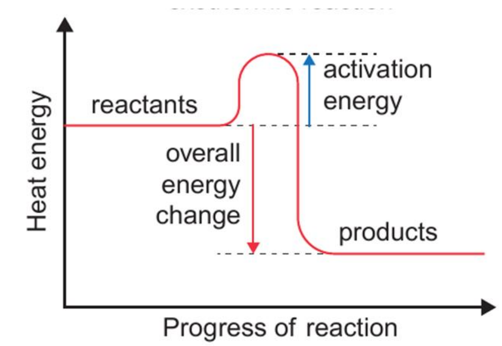

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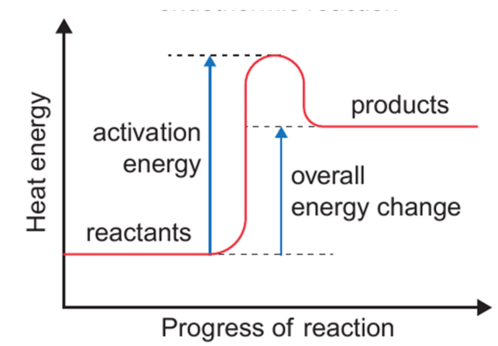

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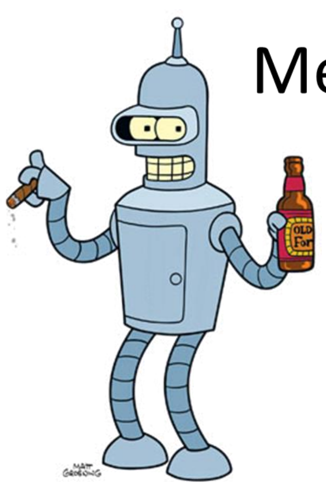

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