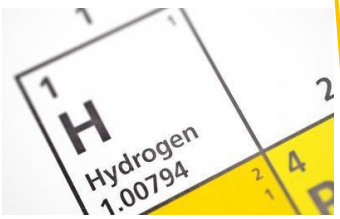
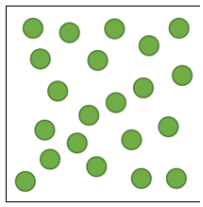
GCSE Chemistry Year 10

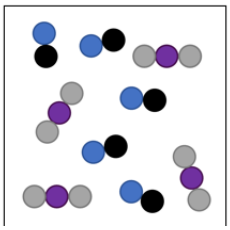


Symbols
The first letter in a chemical symbol is always an uppercase letter, and the other letters are always lowercase. So, the symbol for a magnesium atom is Mg and not mg, MG or mG.

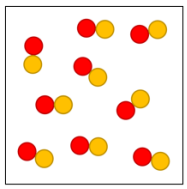
An element is a substance that cannot be broken down into anything simpler by a chemical reaction. Elements are made up of atoms that are all the same.



Mixtures are made up of two or more different elements or compounds which are not held together by chemical bonds.

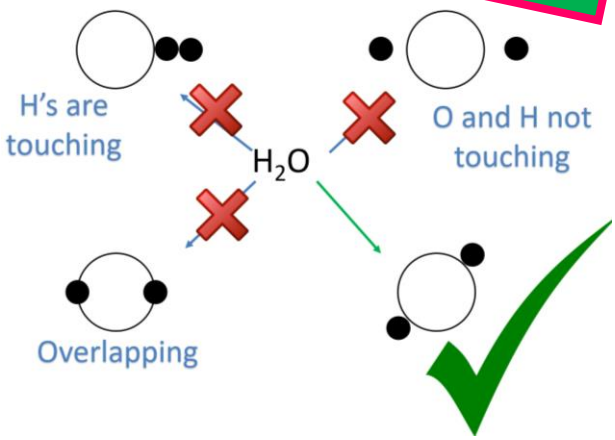


Compounds are made up of two or more different atoms which are held together because of chemical bonds.



Chemical Reactions
Atoms are rearranged during a chemical reaction. *None are created or destroyed.*

Space filler diagrams rules



Naming compounds rules

Rule 1 – The name of the metal always comes first in the compound name

Rule 2 – When two elements join the end is usually _____ide.

Rule 3 – When three or more elements combine and one of them is oxygen the ending is _____ate

Interpreting chemical formulae

1. HCl
H = 1
Cl = 1
Total = 2

2. $CaCl_2$
Ca = 1
Cl = 2
Total = 3

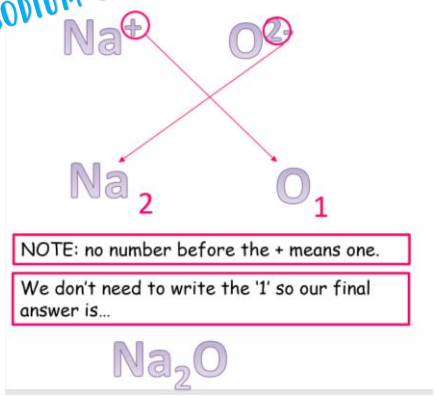
3. $Ca(OH)_2$
Ca = 1
O = 2
H = 2
total = 5

4. $Ca(NO_3)_2$
Ca = 1
N = 2
O = 6
Total = 9

Writing formulae – swap and drop

1. Find the ions in the ions table
2. Circle 'floating' numbers
3. Draw arrows
4. Re-write anything not circled
5. Swap and drop numbers (plus and minus cancel out)

Sodium oxide

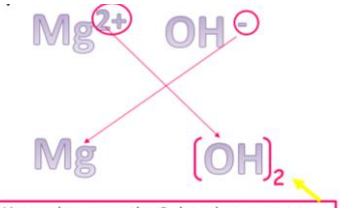


NOTE: no number before the + means one.

We don't need to write the '1' so our final answer is...

Na_2O

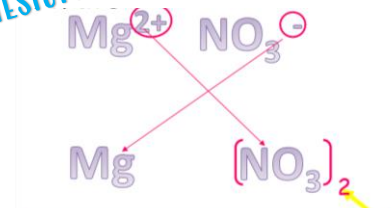
Magnesium hydroxide



We need to move the 2 down but we want BOTH the O and H to be multiplied by 2. Therefore we put it in brackets!

$Mg(OH)_2$

Magnesium nitrate



Remember the 3 isn't floating so doesn't move. As we want to move the 2 down, we need brackets again.

$Mg(NO_3)_2$

Physical change

Does not make a new substance.
It is reversible.

E.g. Water freezing to ice

5 signs of a chemical change:

Colour Change
Formation of a precipitate
Gas formation
Temperature change
Sound production

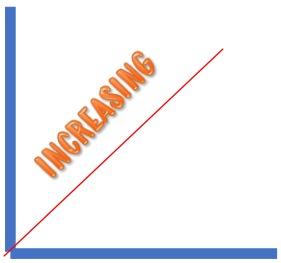
Chemical change

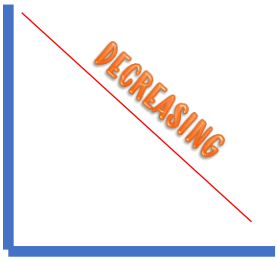
A new substance is made.

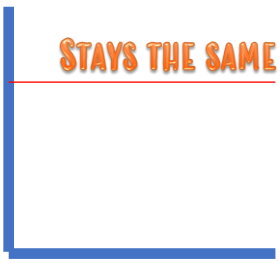
It is irreversible.

E.g. Burning magnesium.

Trends you must know





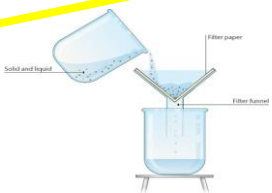


Separating mixtures

Filtration

Insoluble solid from liquid

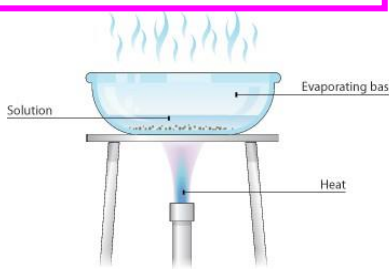
Filtration is good for separating an insoluble solid from a liquid. (An insoluble substance is one that *does not dissolve*).



Evaporation

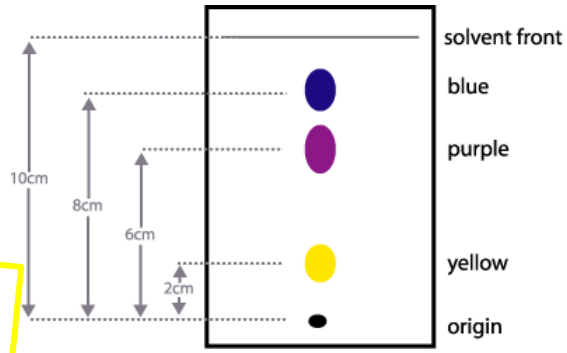
Soluble solid from liquid

This is good for separating a **soluble solid** from a **liquid** (a soluble substance *does dissolve*, to form a *solution*



Chromatography

Separating liquids due to solubility
Chromatography can be used to separate mixtures of coloured compounds.



Insoluble inks will not move from the pencil line

More soluble inks travel faster and are higher up the paper.

Mixtures = multiple dots. If the dots line up, it is the same ink.

Different chromatograms and the separated components of the mixtures can be identified by calculating the Rf value using the equation:

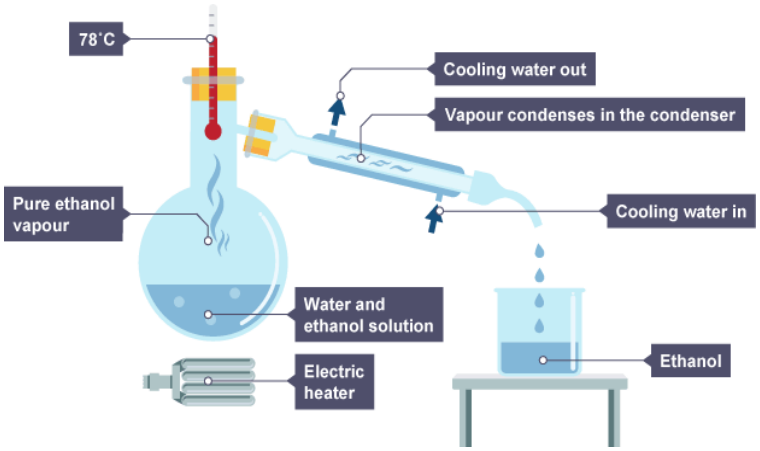
$$Rf = \frac{\text{distance moved by solute}}{\text{distance moved by solvent}}$$

1. Using a pencil, draw a horizontal line 1.5cm above the bottom edge of the paper.
2. Place a small drop of black ink on the middle of your pencil line.
3. Pour a small volume of water into the beaker provided.
4. Place the bottom edge of your chromatography paper into the water in the beaker. The water will now start moving up the paper. Make sure the ink dot does not go below the surface of the water.
5. Remove the paper. In pencil, carefully mark the height which the water reached (this is called the solvent front) . Then mark the height which the different coloured inks reached(place your mark in the centre of the different colours) . Leave your paper to dry.

Separating liquids due to boiling point

Distillation – Separating water and miscible liquids.

Pure liquids have specific boiling points, e.g. water boils at 100°C. Ethanol boils at 78°C. Water and ethanol are miscible *(when two liquids mix together easily without separating into layers)*. This method works because the liquids in the mixture have different boiling points. When the mixture is heated, one liquid evaporates before the other.

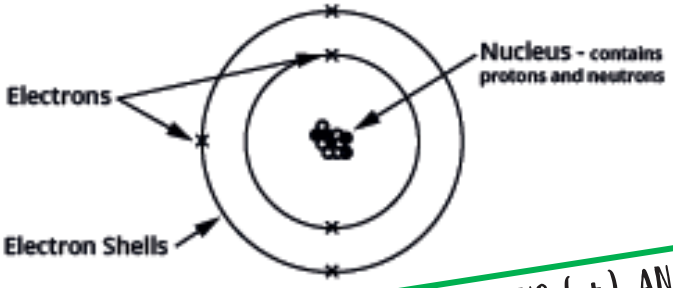


ATOMIC STRUCTURE

STRUCTURE OF THE ATOM:

ATOMS ARE THE SMALLEST PARTICLES OF MATTER. EVERYTHING IS MADE FROM ATOMS.

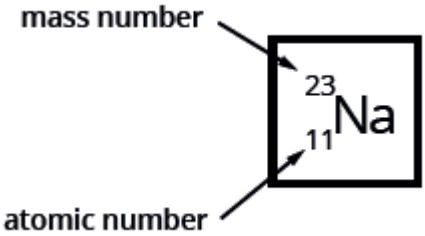
ATOMS ARE MADE UP OF THREE SUB-ATOMIC PARTICLES – PROTONS, NEUTRONS AND ELECTRONS



PARTICLE	MASS (AMU)	CHARGE
PROTON	1	+1
NEUTRON	1	0
ELECTRON	TRACE	-1

THE NUMBER OF PROTONS (+) AND ELECTRONS (-) ARE ALWAYS EQUAL IN AN ATOM – SO ATOMS HAVE NO OVERALL CHARGE.

ATOMIC AND MASS NUMBERS



- ATOMIC NUMBER – THE NUMBER OF PROTONS IN THE ATOM (11)
- MASS NUMBER – THE TOTAL NUMBER OF PARTICLES IN THE NUCLEUS (23)

THE NUMBER OF NEUTRONS IS CALCULATED BY SUBTRACTING THE ATOMIC NUMBER FROM THE MASS NUMBER (23 – 11 = 12)
THE NUMBER OF ELECTRONS IS ALWAYS THE SAME AS THE NUMBER OF PROTONS IN ATOMS (11)

ISOTOPES:

ISOTOPES – ATOMS OF THE SAME ELEMENT WITH THE SAME NUMBER OF PROTONS BUT DIFFERENT NUMBERS OF NEUTRONS

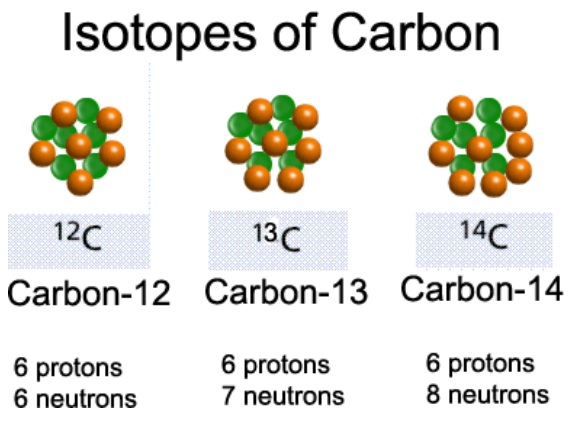
TRIPLE: RELATIVE ATOMIC MASS (AR) – THE WEIGHTED AVERAGE OF THE MASSES OF ALL OF THE ISOTOPES OF AN ELEMENT.

$$AR = \frac{(\text{MASS} \times \% \text{ ISOTOPE 1}) + (\text{MASS} \times \% \text{ ISOTOPE 2})}{100}$$

ELEMENT	RELATIVE MASS OF ISOTOPE	RELATIVE ABUNDANCE
CHLORINE (CL)	35	75
	37	25

$$Ar = \frac{(35 \times 75) + (37 \times 25)}{100}$$

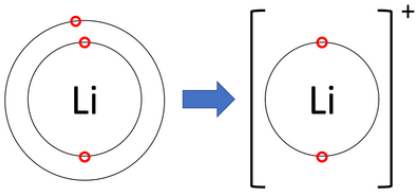
$$= 35.5$$



Ion – a charged particle. Has different numbers of protons and electrons.

Positive ion – has more protons (+) than electrons (–). Formed when an atom loses electrons.

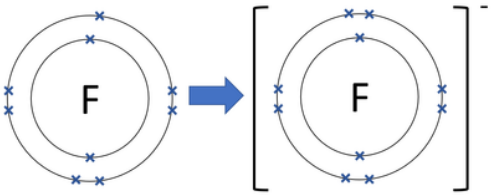
E.g. lithium



The charge of an ion is equal to the number of electrons lost / gained

Negative ion – has more electrons (–) than protons (+). Formed when an atom gains electrons.

E.g. fluorine



Atoms lose / gain electrons in order to achieve a full outer shell

Electronic configuration

Electrons orbit the nucleus of an atom in shells.

Shells are filled from the inside shell outwards

Electrons cannot fill a new shell until the current one is full

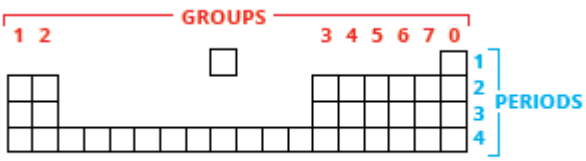
Electron configuration – the number of electrons in each shell, e.g. for sodium 2,8,1

Outer shell – the outermost electron shell (last to be filled).

Electron Shell	Can hold...
1st	2
2nd	8
3rd	8

The Periodic Table

The Periodic Table lists all of the elements in order of atomic number.



Group – number of electrons in the outer shell

Period – the number of shells containing electrons

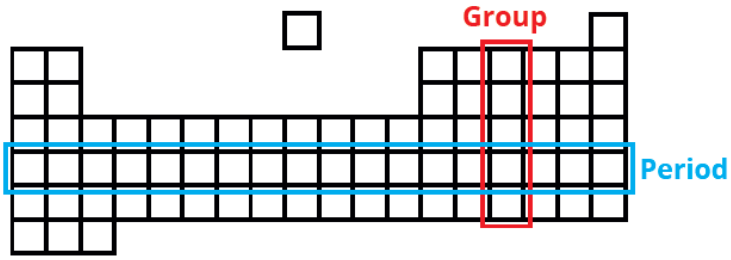
Atomic number – the total number of electrons in all shells.

The Periodic Table

Layout:

- The table contains all of the known elements
- The elements are arranged in order of increasing atomic number

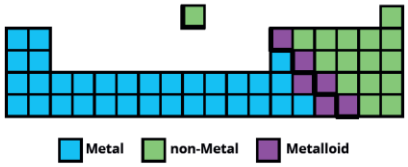
Groups – The vertical columns



Periods – The horizontal rows. Remember to number these from the right hand side!

Arrangement – The elements and similar elements are grouped together

- Metals – shiny, good conductors, high melting/ boiling points, malleable, dense
- Non-metals – dull, poor conductors, low melting/ boiling points, brittle, low density
- Metalloid – has properties of both metals and non-metals.



Group 1: The Alkali Metals

Li Lithium
Na Sodium
K Potassium
Rb Rubidium
Cs Caesium
Fr Francium

Group 1 metals all have 1 electron in their outer shell

Reactivity:

The elements get more reactive as you go down the group

Higher: outer shell gets further from nucleus so easier to lose 1 electron as nuclear attraction is less.

They are stored in oil to prevent contact with air (oxygen) and water.

Reactivity **increases**

Density **increases**

Melting point **decreases**

Boiling point **decreases**

Reaction with oxygen:

- The metals tarnish when they react with oxygen, forming the metal oxide

sodium + oxygen → sodium oxide

They are shiny when cut, then turn dull as they react with oxygen.

Reaction with water:

- The metals react with water, forming the metal hydroxide and hydrogen gas

potassium + water → potassium hydroxide + hydrogen

	Float	Fizz	Move	Melt	Burn
Li	✓	✓	✓		
Na	✓	✓	✓	✓	
K	✓	✓	✓	✓	✓

Group 7: The Halogens

F	Fluorine
Cl	Chlorine
Br	Bromine
I	Iodine
At	Astatine

Group 1 metals all have 7 electrons in their outer shell

Reactivity:

The elements get less reactive as you go down the group

Higher: outer shell gets further from nucleus so harder to gain 1 electron as nuclear attraction is less.

Non-metallic properties – poor conductors, low melting/boiling points, low density

Diatomic molecules – F_2, Cl_2, Br_2

Reactivity **decreases**

Melting point **increases**

Boiling point **increases**

Opposite trend to group 1

Chlorine = pale green gas

Bromine = orange/brown liquid

Iodine = grey solid

Reactions of halogens and iron wool

Halogens react with iron wool to form iron halides

E.g. iron + chlorine → iron chloride

The speed of which indicates reactivity

HIGHER: DISPLACEMENT

A MORE REACTIVE HALOGEN DISPLACES A LESS REACTIVE HALIDE ION FROM ITS SOLUTION

HALOGEN	HALIDE ION SOLUTION		
	POTASSIUM CHLORIDE	POTASSIUM BROMIDE	POTASSIUM IODIDE
CHLORINE	~~✓~~	✓	✓
BROMINE	✓	~~✓~~	✓
IODINE	✓	✓	~~✓~~

USES:

CHLORINE – KILLS BACTERIA IN WATER (DRINKING WATER, SWIMMING POOLS)

IODINE – ANTISEPTIC FOLLOWING HOSPITAL PROCEDURES

SAFETY

FUME CUPBOARD USED FOR REACTIONS – HALOGENS PRODUCE TOXIC VAPOURS.

FLAME TESTS

LITHIUM RED

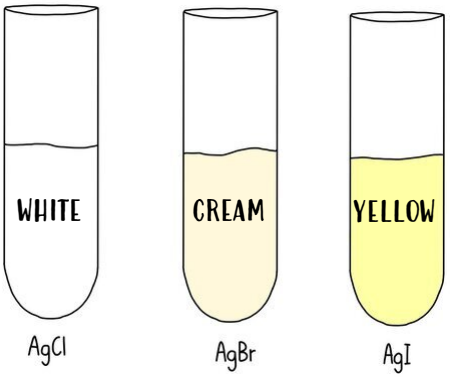
SODIUM YELLOW

POTASSIUM LILAC

CALCIUM BRICK RED

BARIUM APPLE GREEN

SILVER NITRATE TEST



TEST FOR CHLORIDE, BROMIDE OR IODIDE IONS

- DISSOLVE COMPOUND IN WATER
- ADD SILVER NITRATE
- A SILVER HALIDE IS PRECIPITATED.

$Ag^+_{(aq)} + Cl^-_{(aq)} \rightarrow AgCl_{(s)}$

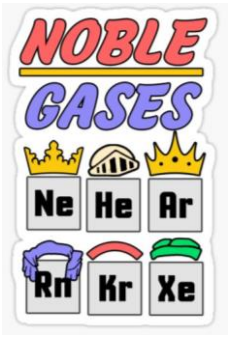
$Ag^+_{(aq)} + Br^-_{(aq)} \rightarrow AgBr_{(s)}$

$Ag^+_{(aq)} + I^-_{(aq)} \rightarrow AgI_{(s)}$

STATE SYMBOLS:
(S) = SOLID
(L) = LIQUID
(G) = GAS
(AQ) = AQUEOUS

Group 0: The Noble Gases

Group 0 elements all have full outer shells. This makes them unreactive (inert)



2 He Helium — **Unreactive & low density**
Used in party balloons & weather balloons

10 Ne Neon — **Emits light when electricity passes through it**
Used in advertising signs

18 Ar Argon — **unreactive**
Used as inert atmosphere for welding & in lightbulbs

Chemical calculations

Calculating Mr

E.G. $Mg(OH)_2$

Number of atoms

Mg x 1 = 24 x 1 = 24
O x 2 = 16 x 2 = 32
H x 2 = 1 x 2 = 2
58

Mass numbers

Calculating % mass

E.G. Calculate the percentage of oxygen in $Mg(OH)_2$

Step 1: Calculate the Mr:

Mg x 1 = 24 x 1 = 24
O x 2 = 16 x 2 = 32
H x 2 = 1 x 2 = 2
58

Step 2:

Number of atoms of oxygen

Mass number of oxygen

$$\frac{2 \times 16}{58} \times 100 = 55\%$$

Mr compound

Percentage yield

The amount of product we get from a chemical reaction is called the **yield**. The more reactants we put in, the higher the **actual yield** will be.

The **percentage yield (%)** tells us the overall success of the experiment. It compares the **predicted yield** (what we should get) with the **actual yield** (what we actually get in practice) .

$$percentage\ yield = \frac{actual\ yield}{theoretical\ yield}$$

Simplest formula (higher only)

When 4 g of copper oxide is reduced in a steam of hydrogen, 3.2 g of copper remains.

Work out how much oxygen was contained in the copper oxide.

1. First step — *Find the mass difference* $4 - 3.2 = 0.8$ g

Elements	Cu	O
Mass	3.2	0.8
Ar (mass number)	64	16)
÷	0.05	0.05
Ratio	1	1
Formula	Cu	O

Moles (Higher Tier)

To calculate the number of moles, we use this equation:

$$\text{Number of moles} = \frac{\text{mass (g)}}{\text{Mr}}$$

The mole is a term that describes a specific number – like the word 'dozen' represents the number 12. The mole however is a much larger number 6.02×10^{23} atoms. (6 followed by 23 zeros).
This number is also called Avogadro constant or Avogadro's number.

Example 1:

How many moles of atoms are there in 4.8 g of carbon?

$$moles = \frac{mass}{Ar} = \frac{4.8g}{12} = 0.4\ moles$$

A_R C = 12

Calculating the masses of reactants or products (Higher Tier)

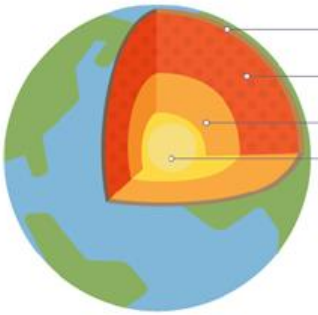
What mass of magnesium oxide is produced when 60g of magnesium is burned in air?

$$2Mg + O_2 \rightarrow 2MgO$$

Step 1: cross out the part of the equation not mentioned in the question. In this case the oxygen.

Moles	Ratio	Mass
Work out the moles of the one you know the mass of. In this case the Mg. N = mass/Mr = 60/24 = 2.5 moles	Use the equation to find the mole ratio. Ignoring the crossed out part(s): $2Mg \rightarrow 2MgO$ 2 : 2 1 : 1 2.5 : 2.5	Now find the mass of the one asked in the question. In this case the magnesium oxide. Mass = n x Mr = 2.5 x 40 = 100g Mr MgO = 24 +16 = 40

The ever changing earth



Rocky

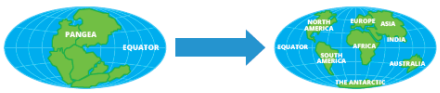
Semi solid rock

Liquid nickel and iron

Solid nickel and iron

Alfred Wegener and continental drift:

In 1912 Alfred Wegener suggested that all of the continents were once joined together in one supercontinent, called Pangaea. And over millions of years they drifted apart



This idea of 'continental drift' is based on the following observations:

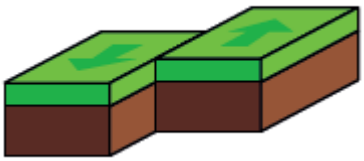
1. Jigsaw-like fit of the edges of continents, e.g. the west coast of Africa and the east coast of South America
2. Similar rocks of the same age found on different continents
3. Similar plant and animal fossils found on opposite sides of huge oceans.

Wegener's theory did not include any attempt to explain how the continents moved and it was dismissed by more renowned scientists of the time.

Convection currents in the mantle were proposed by some scientists as an explanation for plate movement as far back as the 1930s and this was generally accepted as being correct by the 1960s. Wegener's theory of continental drift was refined and became known as 'plate tectonics'.

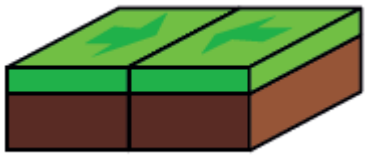
Tectonic plates:

The surface of the Earth is divided into a number of tectonic plates. These plates are constantly moving due to convection currents in the mantle. The movement of the plates causes the continents to move.



Conservative boundary:

Plates move in opposite directions (side by side). They overcome friction and move suddenly. This is an earthquake.

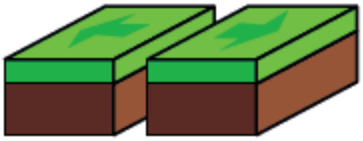


Destructive boundary:

Plates move towards each other. The denser plate sinks and melts. The less dense plate rises, forming mountains. Causes volcanoes and earthquakes.

Constructive boundary:

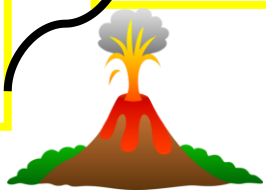
As two plates move apart, magma rises into the gap. Then the magma cools and solidifies to form new igneous rocks. Causes volcanoes



The evolution of the atmosphere

Early atmosphere was made up of mainly CO_2, water vapour, methane and ammonia

Volcanoes released gases that formed the early atmosphere



Earth cooled and water vapour condensed forming the oceans

Plants could now grow; photosynthesis took in much of the CO_2 and released oxygen into the atmosphere.

Ammonia reacted with oxygen forming nitrogen.

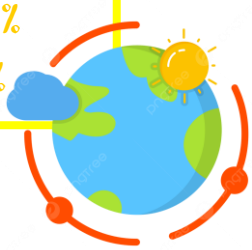
Today our atmosphere remains constant:

Nitrogen 78%

Oxygen 21%

Argon 0.9%

CO_2 0.04%



Today's atmosphere

The composition of the atmosphere has remained stable for millions of years

Photosynthesis
CO_2 in -> O_2 out

=

Respiration and combustion
O_2 in -> CO_2 out

Humans have disrupted this balance by increased combustion of fossil fuels and decreased photosynthesis due to deforestation

Global warming and acid rain

	What causes it?	Effects	Solution
Global Warming	Carbon dioxide is released when fossil fuels are burned. Light from the sun passes through the atmosphere and is absorbed by the Earth's surface, warming it. Greenhouse gases act like a blanket, trapping heat near the surface and raising the _temperature. It is a natural process that warms the planet but human activities are increasing the enhanced global warming.	Rising sea levels Habitat destruction Ice caps melting Drought Flooding Changing weather patterns	Be a responsible consumer of energy Carbon capture and storage
Acid Rain	Fossil fuels contain sulfur impurities which, when burned forms sulfur dioxide. This then forms a solution of sulfuric acid on contact with water in the atmosphere. This falls as acid rain with a pH of 2-4.	Lowers the pH of lakes and rivers, damaging aquatic life Damages vegetation Damages stone statues / buildings Corrodes metal structures.	Be a responsible consumer of energy Sulfur scrubbing

Gas tests

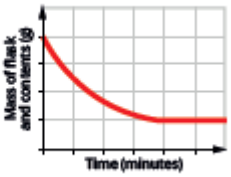
Name of gas	Test to identify	Result of test
Oxygen	Place in the presence of a glowing splint.	Relights the glowing splint.
Hydrogen	Place in the presence of a lit splint.	Hear a squeaky 'pop'.
Carbon dioxide	Bubble the gas through limewater.	Limewater turns milky.

Rates of Reaction

Measuring Rates of Reaction:

- Rate of Reaction – the speed at which a reaction takes place.
- To measure the rate of reaction you:
  - » measure how quickly the reactants are used up
  - » measure how quickly the products are formed.

Measuring Rates of Reaction: 1. Change in Mass

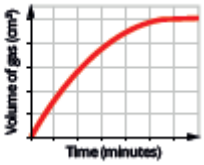


The mass of the flask and contents decreases as the gas formed leaves the flask.

- Recording the loss in mass over time gives an accurate rate measurement.

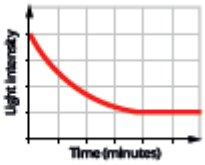
Measuring Rates of Reaction: 2. Volume of Gas Formed

A gas syringe is used to measure the volume of gas as it is produced.



Recording the volume of gas produced over time gives an accurate rate measurement.

Measuring Rates of Reaction: 2. Volume of Gas Formed

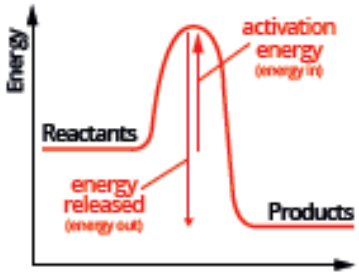


The solution turns milky/cloudy as the precipitate (insoluble solid) is formed.

Recording the decrease in light intensity over time gives an accurate rate measurement.

Collision Theory:

- For a reaction to happen the reacting particles must successfully collide
- A successful reaction is one that leads to a reaction happening
- A successful collision happens when the reacting particles have sufficient energy

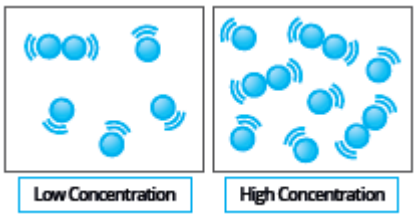


HIGHER: ACTIVATION ENERGY IS THE MINIMUM AMOUNT OF ENERGY THAT PARTICLES MUST HAVE WHEN THEY COLLIDE IN ORDER TO REACT

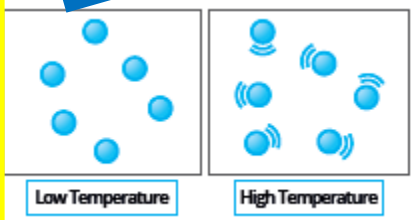
CONCENTRATION

AT A HIGHER PRESSURE THERE ARE MORE REACTING PARTICLES IN THE SAME SPACE.

THIS INCREASES THE CHANCE OF SUCCESSFUL COLLISIONS – SO A FASTER RATE OF REACTION.



TEMPERATURE:



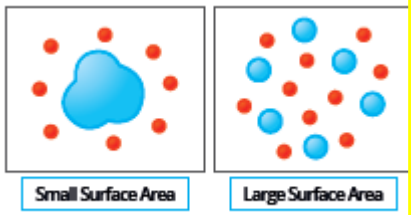
AT A HIGHER TEMPERATURE THE PARTICLES HAVE MORE KINETIC ENERGY AND MOVE FASTER

THIS INCREASES THE CHANCE OF SUCCESSFUL COLLISIONS – SO A FASTER RATE OF REACTION.

SURFACE AREA

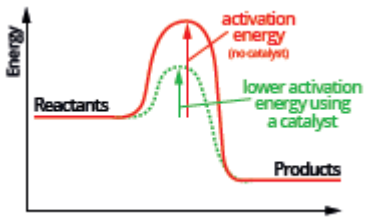
A LARGER SURFACE AREA PROVIDES MORE SPACE FOR THE REACTING PARTICLES TO COLLIDE.

- THIS INCREASES THE CHANCE OF SUCCESSFUL COLLISIONS – SO A FASTER RATE OF REACTION.



CATALYST

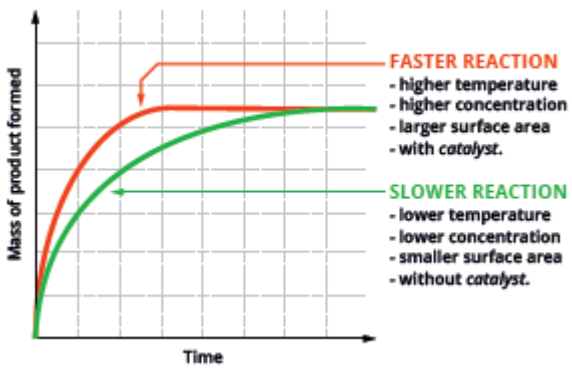
- A CATALYST IS A SUBSTANCE THAT SPEEDS UP A REACTION WITHOUT BEING USED UP
- BY LOWERING THE ACTIVATION ENERGY IT INCREASES THE CHANCE OF SUCCESSFUL COLLISIONS – SO A FASTER RATE OF REACTION.



RATE GRAPHS:

A GRAPH IS USED TO FOLLOW THE COURSE OF REACTION

COMPARING GRAPHS SHOW THE DIFFERENCES IN THE RATES OF SIMILAR REACTIONS



WATER

Water contains:

- **Ions** – As water flows over the ground, it picks up various ions from minerals. E.g. Mg^{2+}, Ca^{2+}, Na^{+} and K^{+}
- **Gases** – As water falls as rain, **oxygen** (essential for marine life) and **carbon dioxide** (essential for plant life, reduces pH of the water) **dissolve** in the water.

Other things that water picks up on its travels contain **microorganisms**, which are **natural pollutants** and include **bacteria** and **viruses**, and **man-made pollutants** including **fertilisers**, **pesticides** and **household** and **industrial waste**.

Treatment of public water

We need to know the process in which water is made safe for consumption:

1. **Sedimentation** – in reservoirs / tanks, larger solid particles settle under gravity.
2. **Fine filtration** – through layers of sand and gravel, removes smaller insoluble particles.
3. **Chlorination** – chlorine added to kill bacteria, prevents disease / makes it safe to drink.

Desalination of sea water

The simplest method for **desalination** of sea water is **distillation**. This involves **boiling sea water** which uses **large amounts** of costly **energy**, preventing it from being a viable process in many parts of the world.

You should also be able to discuss the potential of desalination as a **source** of **drinking water** in different parts of the world in terms of **proximity** to the **sea**, availability of '**cheap**' **energy** and a country's **wealth**.

Fluoridation

It can help to **prevent tooth decay**, which is why it's added to many brands of **toothpaste** and, in some areas, to the **water supply** through a process called **fluoridation**.

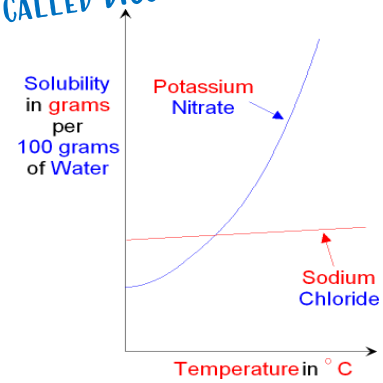
The link between fluoride ions and a reduction in incidence of tooth decay has been established by **surveying** school children of various ages, and that the **data is reliable** because all school children are surveyed and only absentees on the day are excluded.

Many people object to proposals to fluoridate water supplies for several reasons:

- Fluoride can be harmful in high concentrations, e.g. causing **discolouring** or **decay of teeth** (fluorosis).
- High fluoride intake has also been linked to **stomach** and **bone cancers** and to **infertility**.
- Some argue against fluoridation because it is '**mass medication**' and that no one should be forced to consume fluoride.

Solubility

Sometimes when you add a solid to a liquid, the bonds between the solid particles break and the particles mix with the liquid – forming a solution. This process is called dissolving.



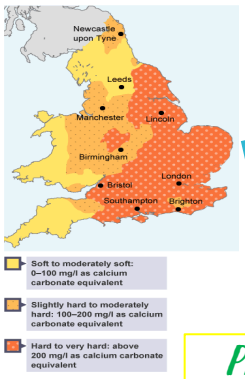
Term	Definition
Solution	Mixture of solid (solute) and liquid (solvent) that doesn't separate out e.g. brine
Solute	Solid (or substance) being dissolved e.g. salt
Solvent	The liquid being dissolved into e.g. water
Soluble	Means it will dissolve
Insoluble	It won't dissolve
Solubility	How much of the solute will dissolve in the solvent

Solubility curves

Every solid has a **different** rate of solubility.

Hard and soft water

If rainwater passes along **limestone** (calcium carbonate) rocks on its way to a reservoir, **calcium ions** Ca^{2+} will collect in the water. Other ions such as magnesium ions Mg^{2+} can also collect in water. **These additional ions make the water hard.**



Soap in hard water does not readily lather, scum is formed

Temporary hard water

Calcium hydrogen carbonates $(Ca(HCO_3)_2)$ and magnesium hydrogen carbonates $(Mg(HCO_3)_2)$ form temporary hard water because when this water is boiled, hardness is removed as hydrogen carbonates are decomposed.

$Ca(HCO_3)_2(aq) \rightarrow CaCO_3(s) + H_2O(l) + CO_2(g)$

This process forms magnesium carbonate and calcium carbonate which are insoluble. This forms **lime scale** and collects on kettles as 'fur'.

Permanently hard water

When insoluble calcium and / or magnesium **sulfates** exist in water it is called **permanently** hard water.

Treating permanently hard water

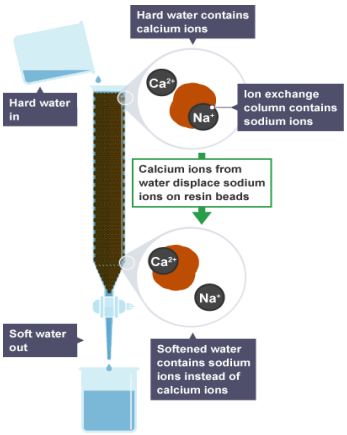
1. Washing soda

Sodium carbonate (Na_2CO_3), also known as **washing soda**, can soften both temporary and permanent hard water. It adds a large amount of **carbonate** ions to the water.

These react with dissolved calcium ions, forming a precipitate of calcium carbonate:

2. Ion-exchange

Ion-exchange resins can also soften both temporary and permanent hard water. The ion-exchange resin starts with sodium ions stuck to it. As the hard water passes through the column, sodium ions come off the resin and go into the water, while calcium ions come out of the water and stick to the resin. In effect, calcium ions that cause hardness are swapped for sodium ions that do not cause hardness. The resin needs recharging with dishwasher salt (sodium chloride) once it becomes full of calcium ions.



Experiment to determine if water is soft, permanently hard or temporarily hard

Soap solution is added every 1 cm^3 to the water and the flask shaken to try and form lather (bubbles). Soft water lathers easily therefore little amount of soap solution is used. Hard water lathers slowly therefore more soap solution is needed.

If two samples of water seem to be hard water, samples of both types of water could be boiled. The same experiment as above could then be undertaken.
If the water is still difficult to lather, then the water is permanently hard.

The health benefits of hard water and its negative effects

Advantages

1. Strengthens teeth and bones
2. Reduces the risk of heart disease

Disadvantages

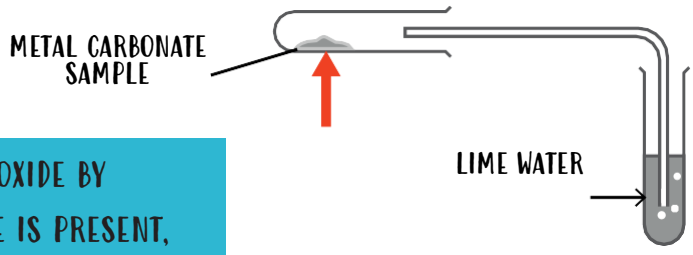
1. Lime scale on kettles make them less efficient at boiling water and therefore waste energy. Hot water pipes can also block up with lime scale
2. Removing scale can be expensive
3. More soap is needed with hard water

Limestone – triple only

Thermal decomposition:

Thermal decomposition is the process of breaking down a compound to simpler compounds or elements using heat.

As the calcium carbonate is heated, it decomposes to form calcium oxide and carbon dioxide.



We can prove that the gas produced is carbon dioxide by bubbling it through limewater. If carbon dioxide is present, the limewater will turn milky.

Metal carbonate → metal oxide + carbon dioxide

XCO_3 (s) → XO (s) + CO_2 (s)

	Metal carbonates		
	Sodium carbonate Na_2CO_3	Calcium carbonate $CaCO_3$	Copper(II) carbonate $CuCO_3$
Colour before heating	White	White	Green
Colour after heating	White	White	Black
Gas evolved	None	Carbon dioxide	Carbon dioxide
Ease of decomposition	Very difficult	Fairly easy	Easy

No reaction is observed with sodium carbonate, as the more reactive the metal, the more stable the carbonate.

Calcium is less reactive than sodium therefore heat is able to decompose calcium carbonate fairly easily.

Copper is the least reactive metal and decomposes rapidly and easily.

Uses of limestone:
- Manufacturing iron
- Manufacturing steel
- Road building
- Making cement
- Neutralising acidic soil

Advantages
- Provides materials for the construction industry.
- More local jobs.
- Creates more wealth for the community.
- Build better road systems.

Disadvantages
- Dust from lorries and explosions.
- Spoils the landscape.
- Noise of explosions.
- Destruction of habitats.

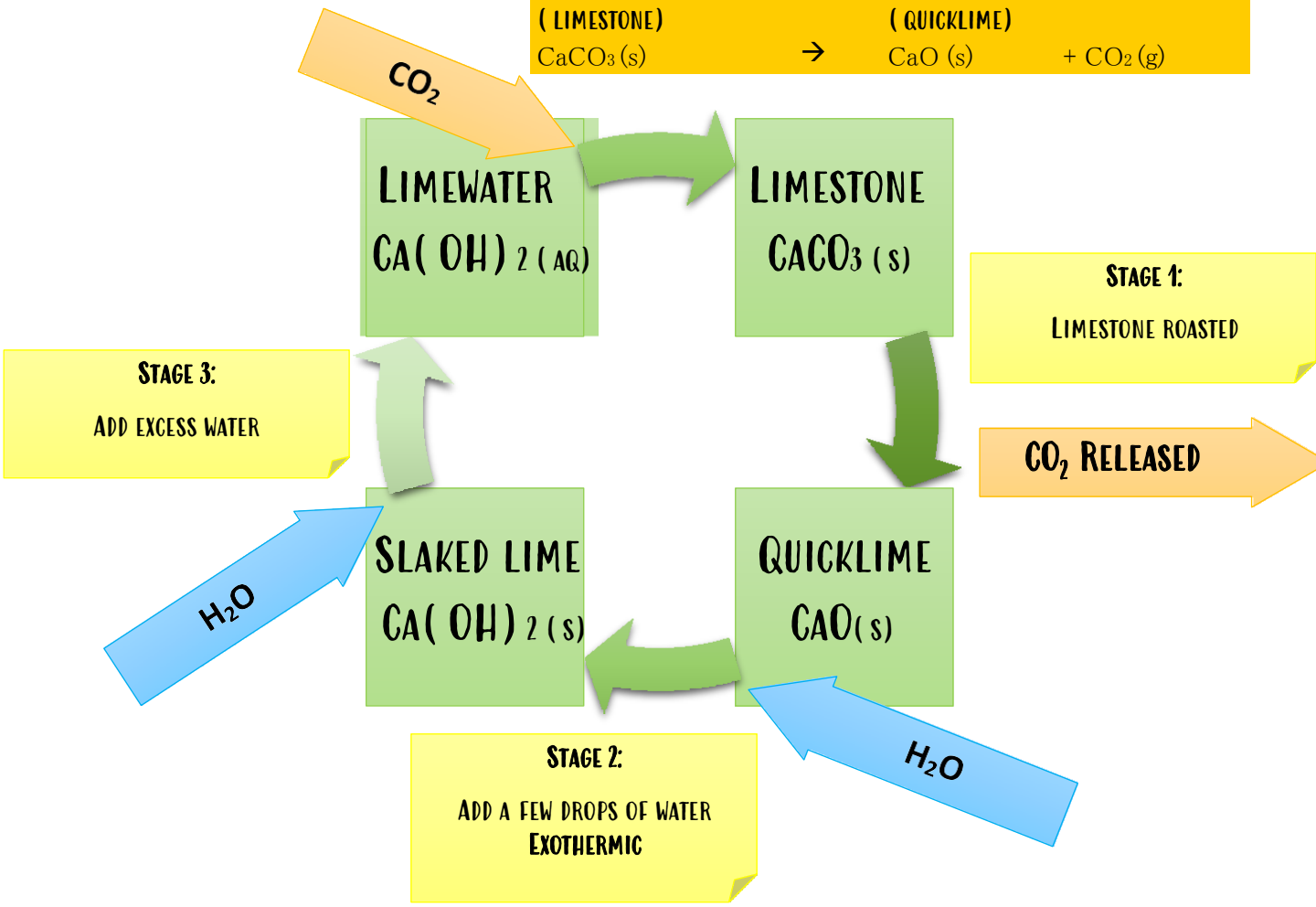
Limestone quarrying

Limestone cycle

Stage 1:
Calcium carbonate (limestone) is heated for 20 minutes. Limestone glows and becomes crumbly. This is the decomposition to calcium oxide (quicklime) .

Equation:

Calcium carbonate (limestone)	→	Calcium oxide (quicklime)	+ carbon dioxide
$CaCO_3$ (s)	→	CaO (s)	+ CO_2 (g)



Stage 2:

Add a few drops of water

A few drops of water are added to the calcium oxide (quicklime) . This causes the compound to sizzle and release steam. This forms calcium hydroxide (slaked lime) . The reaction is exothermic.

Equation:

Calcium oxide + water → calcium hydroxide
(quicklime) *(slaked lime)*

CaO (s)+ H_2O (l) → $Ca(OH)_2$ (s)

Stage 3:
Add excess water
Calcium hydroxide (slaked lime) dissolves a little in water. Excess water is added to form an alkaline solution called limewater.