Adept Tuition

CHEMISTRY

CHEMISTRY ULTIMATE GUIDE

HIGHER

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Qualified Teacher Status (QTS), PGCE (Distinction), BSc (Hons),

NVQ Speech and Language & Enhanced DBS checked.

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Contents

Carbon dioxide – Limewater is used to test for carbon dioxide. It turns limewater cloudy.

Carbohydrates – found in bread

Protein – found in meat, eggs and fish

Chemical changes during cooking

The shapes of protein molecules change irreversibly during cooking. This change is called **denaturing**. We say that proteins become denatured when heated. For example, the proteins in eggs and meat are denatured by cooking.

When potato is cooked, changes happen in the cell wall of potato cells. Cell walls are made of a tough substance called cellulose. During cooking, this substance breaks down and becomes soluble. This makes the potato easier to digest.

Emulsifiers – help oil and water to mix and not separate e.g. found in mayonnaise.

Emulsifiers are molecules that have two different ends:

- a hydrophilic end - 'water-loving' - that forms chemical bonds with water but not with oils; and
- a hydrophobic end - 'water-hating' - that forms chemical bonds with oils but not with water.

Perfumes - properties

property	why it is important
non-toxic	does not poison the wearer
does not irritate the skin	prevents the wearer from suffering rashes
evaporates easily - very volatile	perfume molecules reach the nose easily
insoluble in water	it is not washed off easily
does not react with water	avoids the perfume reacting with perspiration

Ester equation:

alcohol + organic acid → ester + water

Solvents - higher

Whether or not a substance will dissolve in a particular solvent depends on the relative strengths of the attractive forces:

- between the solute particles
- between the solvent particles
- between the solute particles and solvent particles

Water will not dissolve nail varnish because the attractive forces between nail varnish particles, and between water particles, are stronger than those between nail varnish particles and water particles.

Volatility - higher

Volatile liquids evaporate easily - change from a liquid to a gas. This is because there are only weak attractive forces between particles in the substance. These are overcome easily, so particles with enough energy can escape from the liquid.

Fractional distillation of crude oil

Because they have different boiling points, the substances in crude oil can be separated using fractional distillation. The crude oil is evaporated, and its vapours allowed to condense at different temperatures in the fractionating column. Each fraction contains hydrocarbon molecules with a similar number of carbon atoms.

Fractional tower	Boiling point	Molecule size	Forces between molecules
Top	High	Large	Strong intermolecular forces
Bottom	low	Small	Weak intermolecular forces

Alkanes and alkenes

Alkenes are 'unsaturated' - meaning they contain a *double bond*.

Testing for alkenes

Bromine water is a dilute solution of bromine that is normally orange-brown in colour, but becomes **colourless** when shaken with an **alkene**. Alkanes – the bromine water stays brown.

Gore-Tex®

Nylon has some desirable properties. It does not let ultraviolet light pass through it, and it is:

- tough
- lightweight
- waterproof

Unfortunately, nylon does not let water vapour pass through it either. This means nylon waterproof clothing traps sweat, so that after a while the inside of the clothing becomes wet, making it unpleasant to wear. Gore-Tex® has the desirable properties of nylon, but is also 'breathable'. It lets water vapour from sweat pass to the outside, but it stops rain drops from passing to the inside.

Choosing a fuel – Remember 'Teacup'

Toxicity

Energy

Availability

Cost

Use (Ease of)

Pollution

Complete combustion

Complete combustion needs a plentiful supply of air so that the elements in the fuel react fully with oxygen.

Incomplete combustion

Incomplete combustion occurs when the supply of air or oxygen is poor. Water is still produced, but carbon monoxide and carbon are produced instead of carbon dioxide.

Carbon monoxide is a poisonous gas, which is one reason why complete combustion is preferred to incomplete combustion. Gas fires and boilers must be serviced regularly to ensure they do not produce carbon monoxide.

Complete combustion (balanced)

Complete combustion of methane, CH_4

Write formulae for each substance

$CH_4 + O_2 \rightarrow CO_2 + H_2O$

Balance the number of H atoms

Incomplete combustion (balanced)

Incomplete combustion of ethane, C_2H_6

Write formulae for each substance

$C_2H_6 + O_2 \rightarrow CO + C + H_2O$

Balance the number of H atoms

$CH_4 + O_2 \rightarrow CO_2 + 2H_2O$ Balance the number of O atoms $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$	$C_2H_6 + O_2 \rightarrow CO + C + 3H_2O$ Balance the number of O atoms $C_2H_6 + 2O_2 \rightarrow CO + C + 3H_2O$
Exothermic Energy is released when new bonds form. **Bond-making** is an **exothermic** process.	**Endothermic** Energy is absorbed to break bonds. **Bond-breaking** is an **endothermic** process.

Calculating energy transferred

What is the energy transferred to 100cm^3 of water to raise its temperature by 20ºC?

It is useful to remember that 1cm^3 of water has a mass of 1g. So 100cm^3 of water has a mass of 100g.

energy transferred =

mass of water heated × 4.2 × temperature rise =

100 × 4.2 × 20 = 8,400J

It is also useful to remember that 1 kilojoule, 1kJ, equals 1,000J. So the energy transferred is 8.4kJ.

If 0.5g of fuel was used, the energy output of the fuel would be:

8.4 ÷ 0.5 = 16.8kJ/g

Paint

- used to make an area attractive and protect surfaces
- **Pigment** – colour
- **Binding medium** – sticks paint to a surface
- **Solvent** – thins the paint
- **Colloid** – a mixture of solid pigment powder dispersed in a liquid
- **Emulsion paint** dries when the solvent (water) evaporates
- **Oil paints dry** – by an oxidation reaction. The oil reacts with the air.
- **Thermochromic** – change colour at certain temperatures e.g. baby spoons
- **Phosphorescent** – absorb energy from daylight and then slowly release the energy as light.

Construction materials

e.g. brick, steel, aluminium and glass

Limestone

Limestone and marble have the chemical formula CaCO3. Its chemical name is Calcium carbonate. It is made of 1 x Calcium, 1 x Carbon and 3 x oxygen atoms. This means there are three elements or 5 atoms)

Reinforced concrete is a composite material – combines the hardness of concrete with the strength of steel.

Limestone is a sedimentary rock, marble is a metamorphic rock. The particles of) limestone rock are compressed and/or heated together to make marble

Problems of quarrying

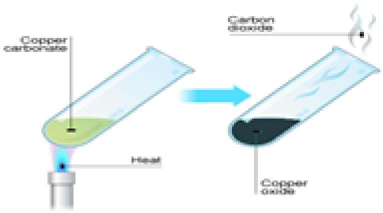
- noise,
- dust
- ruins the landscape

Thermal decomposition

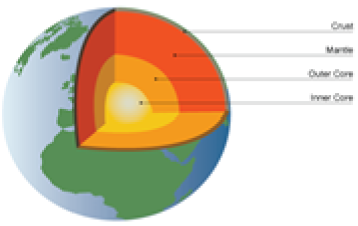
Breakdown of a substance using heat

Calcium carbonate $\xrightarrow{\text{heat}}$ Carbon dioxide + calcium oxide

$CaCO_3 \rightarrow CO_2 + CaO$



Structure of the Earth



Plates

Continental plates

carry the continents

Continental plates

underneath the oceans

Volcanoes

- Igneous rock is volcanic rock e.g. basalt and granite
- Hard rock that contains crystals
- Cooled slowly – large crystals
- Cooled quickly – small crystals
- People live near volcanoes as the land is fertile
- It is important that we study volanoes to find out about the structure of the Earth and predict volcanoes, protect lives and develop evacuation plans
- Magma can rise up through the crust as it is less dense. Some eruptions are more violent due to the different type of magma/lava and the different temperatures and pressures.

Electrolysis	**Recycling copper**
- Pure copper is extracted using electrolysis	- saves resources

Alloys	**Solder**
- bronze - brass - solder - steel - amalgam	- contains lead and tin - It has a low melting point and can be used to join metals together

Rusting – is an oxidation reaction

Iron + Oxygen + water → Hydrated iron (III) oxide
(Rust)

Iron and oxygen are needed to make iron rust.

Cars near the sea rust quicker. Salt increases the rate of rusting.

Cars

Similarities - Both steel and aluminium conduct electricity and are malleable (can be shaped.

Differences:

	Steel	**Aluminium**
Advantages	Cheaper, stronger and harder than aluminium	Lighter than aluminium – better fuel economy, doesn't corrode as easily as steel as it has a protective layer of aluminium oxide.
Disadvantages	Rusts	More expensive

Pollution

Air consists of Oxygen (21%), Nitrogen (78%), carbon dioxide (0.035%), water vapour and noble gases.

Level of gases depends on:

- combustion (burning of fossil fuels) increase carbon dioxide
- respiration – increases levels of carbon dioxide
- Photosynthesis – decreases levels of carbon dioxide and increases Oxygen levels. This reduces global warming

Pollutant	Comes from,,,	Environmental effects
Carbon monoxide	Incomplete combustion of petrol	Poisonous gas
Oxides of nitrogen	Internal combustion engines	Acid rain
Sulphur dioxide	Combustion of fossil fuels that contain Sulphur impurities	Acid rain

Catalytic convertors changes carbon monoxide into carbon dioxide:

Word and balanced symbol equation:

Carbon monoxide + Oxygen → Carbon dioxide

$2CO + O_2 \rightarrow 2CO_2$

Rates of reaction

Increasing temperature

Particles move faster as the temperature increases. The reacting particles have more kinetic (movement) energy and so the number of collision increases.

Increasing surface area

The reaction rate is faster if you use powdered reactants rather than a lump. The particles in the solution will have more area to work on.

Increasing concentration

A higher concentration means that there are more reacting particles. More particles means that there are more collisions

Catalysts

Using a catalyst speed up the reaction. It is not used up in the reaction. Some catalysts work by giving the particles a surface to stick to.

Examples of questions.

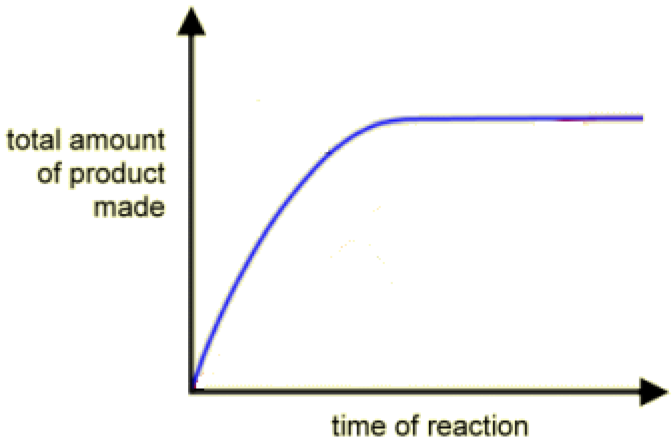
1. Phil and Anne investigate the reaction between Zinc and hydrochloric acid. Zinc chloride and hydrogen gas is made. Write a word equation for the reaction.

Zinc + Hydrochloric acid → Zinc chloride + Hydrogen

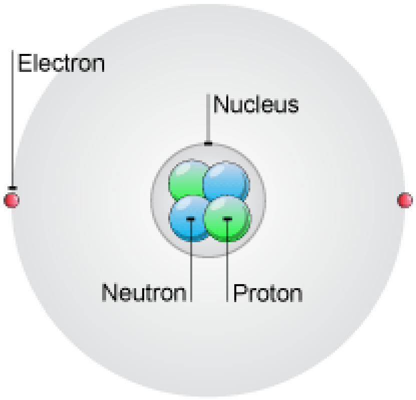
2. Make sure you know the reactants (what is reacting) and the products (what is produced/made)

Magnesium + Hydrochloric acid → Magnesium chloride + Hydrogen

3. If there are any reactants left at the end of the reaction it is because one of the reactants has been used up.



There are **just over one hundred different types of atom, called elements.**

	**Proton** – positive charge **Electron** – negative charge **Neutron** – **neu**tral/ no charge **E.g. Phosphorus** $^{31}_{15}P$ **Has 15 protons** **Has 15 electrons** **Has 16 Neutrons (mass number – (atomic [proton] number)**

Atomic structure

Remember that there are 2 electrons in the first shell, 8 in the second shell, 8 in the third shell. The number of electrons in the outer shell tell you what group the element/atom belongs to.

An atom with the electronic structure 2, 8, 1 is Sodium (Sodium has 11 electrons in total)

Comparing the charge and mass of electrons, protons and neutrons

	Proton	Neutron	Electron
Charge	+1	0	-1
Mass	1	1	0.0005 (almost zero)

Isotopes

Isotopes are atoms of the **same element** with different numbers of neutrons. They will, therefore, have the same atomic number but a different mass number. E.g.

Compare these two atoms of chlorine.

$^{35}_{17}Cl$ $^{37}_{17}Cl$.

Both isotopes have **17 protons**. The isotope with mass number 35 has 18 neutrons. The isotope with mass 37 has 20 neutrons.

Ionic Bonding – bonding between a metal and a non- metal. It is the transfer of electrons.

Ionic Compounds

Ionic compounds like magnesium oxide and sodium chloride have **high melting points** and **do not** conduct electricity when **solid**. They do conduct electricity when **molten**. Sodium chloride is soluble in water and the **solution** conducts electricity.

Why they have high melting points and do not conduct electricity.

The ions in a crystal lattice are very **strongly bonded** together so a high temperature is required to **separate** the particles and **melt** the crystal. The ions are held strongly in position so they cannot **move** and carry an **electric current**.

If an ionic compound is melted or dissolved in water the ions are then free to move and so the substance can be **electrolysed**.

Covalent bonding – is bonding between a non-metal and a non metal. It is sharing electrons.

Covalent compounds are usually **gases or liquids** with **low** melting points or boiling points and they **don't** conduct **electricity**. This is because there are no free electrons or ions.

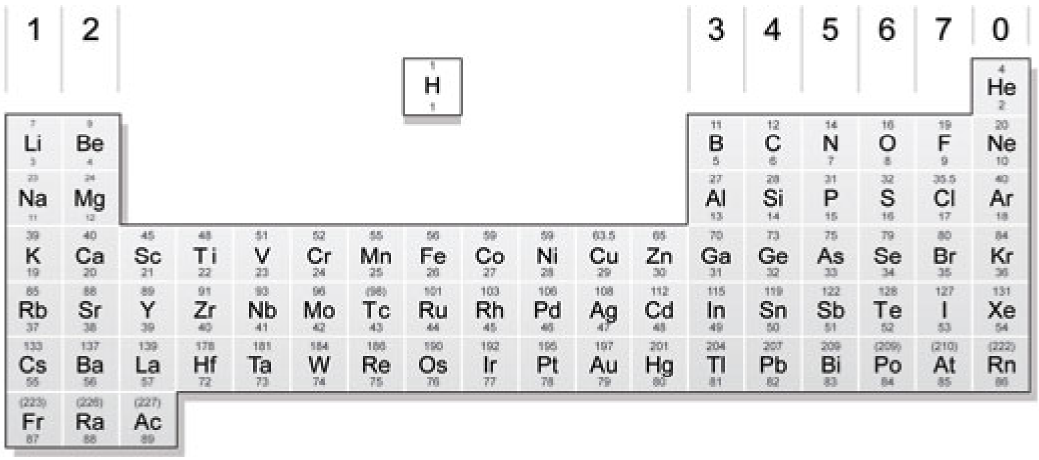
The covalent bonds binding the atoms together are very **strong** but there are only very **weak** forces holding the molecules to each other (the **intermolecular** forces). Therefore, only a **low temperature** is needed to **separate** the molecules when they're melted or boiled

Example:

Carbon dioxide is a gas with a boiling point of -44°C. It doesn't conduct electricity.

Water is a liquid with a melting point of 0°C. It doesn't conduct electricity.

Periodic table



Group 1 alkali metals e.g. Lithium, sodium and potassium

- react vigorously with water. Hydrogen gas is given off (pop test)
- When they react with water an **alkali i**s formed e.g. sodium hydroxide
- They need to be stored in oil to prevent them reacting with oxygen and water vapour in the air
- Reactivity increases as you go down the group.
- Reactivity increases as you go down the group – this is because the atoms are bigger as you go down the group. The bigger the atom the easier it is for the outer electron to be lost. This is because the force of attraction between the nucleus and the outer electron is weaker.

Flame tests

A cleaned, moistened flame test wire is dipped into a solid sample of the compound and then put into a blue Bunsen flame. The **flame colour** indicates which alkali metal ion is present in the compound.

Flame colour	Ion present
red	lithium
orange	sodium
lilac	potassium

Oxidation - You need to be able to write balanced symbol equations for the reactions of the alkali metals with water.

Sodium + Water -> Sodium Hydroxide + Hydrogen

$$2Na + 2H_2O \rightarrow 2NaOH + H_2$$

As the sodium reacts, each sodium atom loses an electron to become a sodium ion.

$$Na \rightarrow Na^+ + e^-$$

Whenever an atom or ion loses electrons it's called **oxidation**.

Whenever an atom or ion gains electrons it's called **reduction**.

Remember **OIL RIG** → **O**xidation **I**s **L**osing, **R**eduction **I**s **G**aining (electrons).

Group 7 – Halogens e.g. fluorine, chlorine, bromine and iodine,

halogen	symbol	atomic number	appearance	state at room temperature	melting point (in °C)	boiling point (in °C)
fluorine	F	9	pale yellow	gas	–219.62	–188.12
chlorine	Cl	17	green	gas	–101.50	–34.04
bromine	Br	35	orange	liquid	–7.30	58.78
iodine	I	53	grey	solid	113.70	184.30

Halogen	Use	Appearance	Reaction with sodium	Reactivity
Chlorine	Sterilise drinking water, making plastics and pesticides	pale green gas	sodium + chlorine → sodium chloride	extremely reactive
Bromine		orange liquid	sodium + bromine → sodium bromide	very reactive
Iodine	Sterilise wounds	grey solid	sodium + iodine → sodium iodide	reactive

The lower an element in the Periodic Table, the bigger the atom. The bigger the atom the less easy it is to gain an electron. That's why the lower halogens are **less reactive**. Again, the force of attraction is weaker between the nucleus and the outer shell/electrons.

chlorine	sodium iodide	chlorine	chlorine + sodium iodide → sodium chloride + iodine
bromine	sodium chloride	chlorine	no reaction

Transition metals

The elements in the middle section of the Periodic Table are the transition elements. They're all metals with typical metallic properties e.g. conducting heat and electricity. They often form coloured compounds.

- Copper compounds are blue
- Iron(II) compounds are light green
- Iron(III) compounds are orange/brown

Thermal decomposition

A reaction in which a substance is broken down into at least two other substances by heat is called **thermal decomposition**.

Transition metal carbonates often undergo thermal decomposition.

If limewater is shaken with a sample of the gas produced, the limewater turns milky. This shows that the gas is carbon dioxide.

Examples

iron carbonate → iron oxide + carbon dioxide

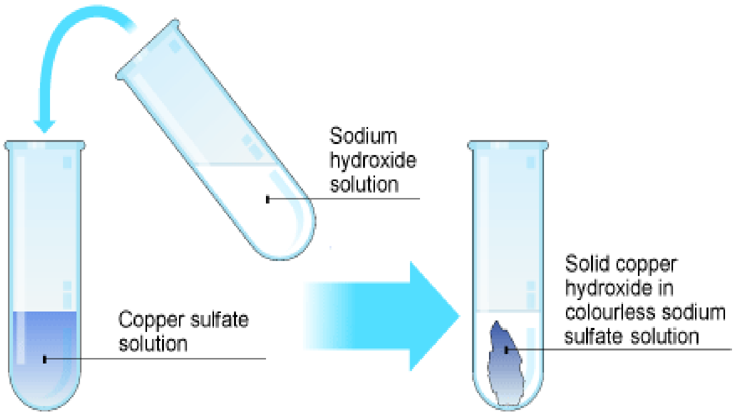
$FeCO_3$ → FeO + CO_2

manganese carbonate → manganese dioxide + carbon dioxide

$MnCO_3$ → MnO + CO_2

Precipitation

Transition metal hydroxides are insoluble in water. If a solution of any soluble transition metal compound is mixed with sodium hydroxide solution then we get a solid produced. A solid produced in a liquid in this way is called a **precipitate**.



The colour of the precipitate indicates which transition metal ion was in the initial solution.

Transition metal ions in solution	Precipitate formed when mixed with sodium hydroxide solution	Colour of the precipitate
Cu^{2+}	copper hydroxide	blue
Fe^{2+}	iron(II)hydroxide	grey/green
Fe^{3+}	iron(III)hydroxide	orange/red

Metals

Properties – good conductors of heat and electricity, ductile (drawn into wires), malleable(shaped), shiny, high melting points. E.g. copper is used for wires because it has a high melting point, ductile and conducts electricity. It is used to make saucepans because it is a good conductor of heat and has a high melting point.

Metallic bonding

The particles in a metal are held together by strong **metallic bonds**. It takes a lot of energy to **separate** the particles. That is why they have high melting points and boiling points.

Solid metals are crystalline - the particles are close together and in a regular arrangement.

Metals have loose electrons in the outer shells which form a 'sea' of delocalised negative charge around the close-packed positive ions. There are strong electrostatic forces holding the particles together.

The loose electrons in metals can all move together through the metal – an **electric current**.

Superconductors

At very low temperatures some metals conduct electricity very easily indeed. They have little or no resistance and so enormous currents can be produced without using large amounts of energy. They're called **superconductors**.

Advantage - In the future, the low resistance of superconductors may allow transmission of electricity without losing energy as heat on the way. Superconductors may be used to make super-fast electronic circuits so that computers will work even faster.

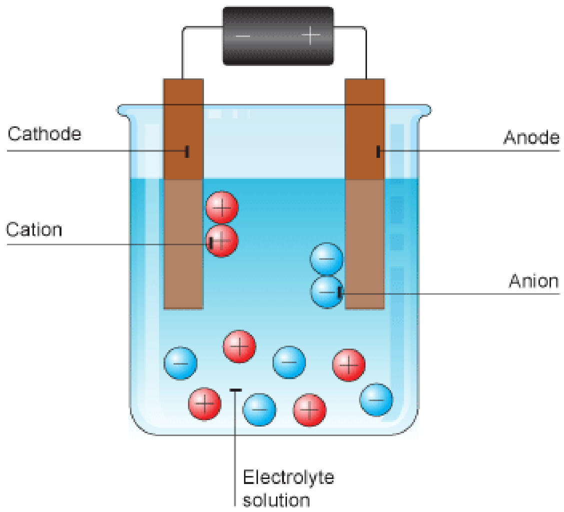
Disadvantage - At present superconductors only work at very low temperatures so they have to be kept very cold with liquid nitrogen and liquid helium. A lot of work is going into developing superconductors that will work at normal temperatures.

Electrolysis – breaking down of a substance using electricity

When ionic compounds are molten or dissolved in water the ions are free to **move**. When electricity is passed through the liquid the compound may be **broken down** into different substances.

Some important terms

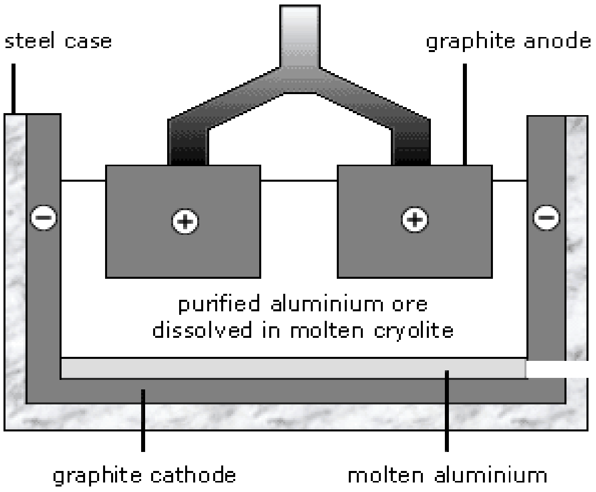
- **Electrolyte** - a liquid which conducts electricity
- **Anode** - the positive electrode
- **Cathode** - the negative electrode
- **Anions** - negative ions - attracted to the anode
- **Cations** - positive ions - attracted to the cathode



Making aluminium by extracting it from bauxite using electrolysis

Bauxite is a mineral containing **aluminium oxide**. The aluminium oxide is melted and electrolysed. The anode is made of **graphite**, a form of carbon. Oxygen ions move to the anode where they're converted to oxygen. The anodes are gradually worn away by oxidation (i.e. the oxygen reacts with the carbon anode and carbon dioxide is formed). Note – test for oxygen is it relights a glowing splint.

The cathode is also made of graphite. Molten aluminium is produced there. The process requires a lot of electrical energy which is one reason why aluminium is more expensive than steel. **Cryolite** is therefore used to lower the melting point of the aluminium oxide.



aluminium oxide → aluminium + oxygen

The aluminium ions are **oxidised** at the cathode:

Al^{3+} +3e$^-$ → Al

While the oxygen ions at the anode are **reduced**:

$2O^{2-}$ → O_2 + 4e$^-$

pH scale

1	2	3	4	5	6	7	8	9	10	11	12	13	14

Strong acid **Weak acid** **neutral** **Weak alkali** **Strong alkali**

If you have an acid and you add an alkali the pH increases (becomes more alkali)
If you have an alkali and you add an acid the pH decreases (becomes more acid)

Neutralisation

If **Hydrochloric acid** is used – a **chloride** is produced e.g.
Sodium Hydroxide + **Hydrochloric acid** → Sodium **chloride** + water

If **Sulphuric acid** is used – a **sulphate** is produced e.g.
Sodium Hydroxide + **Sulphuric acid** → **Sodium Sulphate** + water

If **Nitric acid** is used – a **nitrate** is produced e.g.
Sodium Hydroxide + **Nitric acid** → Sodium **Nitrate** + water

Uses of sulphuric acid:

- fertilisers
- explosives
- plastics
- paints

Percentage yield

$$\text{Percentage yield} = \frac{\text{Actual yield}}{\text{Predicted yield}} \times 100$$

Reacting masses

12
C
6

Relative formula Mass

e.g. CO2

1 Carbon = 12
2 Oxygen = 2 x 16 = 32

32 + 12 = 44

Mass number is always the largest number – Carbon is 12

<u>Fertilisers</u>

Nitric acid + potassium hydroxide → potassium nitrate + water

Sulphuric acid + ammonium hydroxide → Ammonium sulphate + water

Eutrophication

A major problem with the use of fertilisers occurs when they're washed off the land by rainwater into rivers and lakes. The increase of nitrate or phosphate in the water encourages algae growth, which forms a bloom over the water surface. This prevents sunlight reaching other water plants, which then die. **Bacteria** break down the dead plants and use up the oxygen in the water so the lake may be left completely lifeless.

Haber Process – makes Ammonia.
Ammonia can be used to make fertilisers

Uses Nitrogen from the air and hydrogen cracking oil/ natural gas.

Nitrogen + Hydrogen Ammonia

Means reversible

Conditions needed are:

- high temperature (450°C) a higher temperature would decrease the yield and a lower temperature would decrease the rate of reaction.
- High pressure
- Iron catalyst (speeds up the reaction)

A problem of using high pressure is the high cost. It is also dangerous.

Costs involved (in any manufacturing industry)

- building the plant/ factory
- labour costs
- cost of chemicals/ resources
- energy

Batch process
Is when something is needed in small amounts e.g. medicine. When supplies run low, more are made

Continuous process
Is when something is needed in large amounts e.g. ammonia. Factory can run 24hrs a day.

<u>Medicines</u>

<u>Costs include:</u>

- labour
- research and testing
- marketing and legal costs
- energy costs
- time for development

Sometimes the materials for a medicine are **<u>extracted</u>** from <u>plants</u>
Other medicines are made in the **<u>laboratory</u>**, they are **<u>synthetic</u>**.

To extract materials from plants:

- crush/grind the plant material
- dissolve in a solvent
- separate the compound needed using **<u>chromatography</u>**.

<u>Detergents</u>

Contains	Used for…
Perfume	Makes clothes smell nice
Bleach	Removes coloured stains
Optical brightener	Makes clothes appear whiter than white
Water Softener	Softens hard water
Enzymes	Remove food stains
Detergent	Lifts dirt off clothes

Why wash clothes at low temperatures?

- less damage done to clothes e.g. colour won't run
- Better for the environment as less energy is used to heat the water
- Enzymes won't work if temperature is too high

How detergents work

Detergent molecules are long and thin. One end is **hydrophilic** - it loves water but hates oily liquids. The other end is the opposite - **hydrophobic** - it likes oil but hates water.

The hydrophobic ends of the detergent molecules stick to the surface of the oily dirt on clothes or dishes. This leaves the dirt coated in the hydrophilic ends of the molecules so it 'likes' being in water and can easily be washed away.

Washing up liquid contains:

- **detergent** – lift dirt off crockery
- **perfume and colouring** – attractive to use
- **rinse agent** – helps water run off the crockery
- **water softener** – softens hard water
- **thinning agent** – makes the detergent runnier and easier to squeeze out the bottle

Dry cleaning

Washing clothes in an organic solvent ie not water. This is because some fabrics could be damaged in water.
Also, most stains are food stains which do not dissolve in water, but they will in the dry cleaning solvent.

Allotropes of carbon

Allotrope	Properties	Used for
Diamond	Transparent, high melting point, hard, don't conduct electricity	Jewellery and cutting tools
Graphite	Conducts electricity,	Lubricant
Buckminster Fullerene	60 carbon atoms. The nanotubes conduct electricity	Catalysts. Could be used to carry drugs around the body.

Note:

Diamond

Every atom in a diamond is bonded to its neighbours by **four strong covalent bonds** leaving no free electrons and no ions. That's why diamond does not conduct electricity. The bonding also explains the **hardness** of diamond and its **high melting point**. A lot of energy would be needed to separate atoms so strongly bonded together.

Graphite

Each carbon atom is bonded into its layer with three strong covalent bonds. This leaves each atom with a **spare electron**, which together form a delocalised 'sea' of electrons loosely bonding the layers together. These delocalised electrons can all move along together – making graphite a good electrical conductor. Because the layers are only weakly held together they can easily slip over one another:

hence the slipperiness of graphite. Melting graphite is not easy however. It takes a lot of energy to break the strong covalent bonds and separate the carbon atoms.

Water purification

Sources	Water is used for	Pollutants in water	Purification process
Aquifers (Underground rocks) Reservoirs Rivers Lakes	Raw material Solvent Coolant	Microbes Pesticides Lead compounds	1) Sedimentation 2) Filtration 3) chlorination

Filtration - The water is sprayed onto specially prepared layers of sand and gravel. As it trickles through, different sized insoluble solids are removed. The filter beds are cleaned periodically by pumping clean water backwards through the filter.

Sedimentation - A chemical is added which causes tiny solid particles (which would pass through a filter) to clump together into larger particles. These can then be allowed to settle out or may be filtered.

Chlorination – chlorine is bubbled through the water to kill microbes

Water tests

Chlorides – white precipitate
Bromides – cream precipitate
Iodides – yellow precipitate

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FOUNDATION

Principal and sole tutor: Mr Shamik Amin

Qualified Teacher Status (QTS), PGCE (Distinction), BSc (Hons),

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Contents

Thermal decomposition – breakdown of a substance using heat.

Sodium Hydrogencarbonate → Carbon dioxide + water + sodium carbonate

$2NaHCO_3 \rightarrow CO_2 + H_2O + Na_2CO_3$

Carbon dioxide – Limewater is used to test for carbon dioxide. It turns limewater cloudy.

Carbohydrates – found in bread

Protein – found in meat, eggs and fish

Chemical changes during cooking

We cook food to kill microbes, improve taste and texture and it makes food easier to digest.

The shapes of protein molecules change irreversibly during cooking. This change is called **denaturing**. We say that proteins become denatured when heated. For example, the proteins in eggs and meat are denatured by cooking.

When potato is cooked, changes happen in the cell wall of potato cells. Cell walls are made of a tough substance called cellulose. During cooking, this substance breaks down and becomes soluble. This makes the potato easier to digest.

Emulsifiers – help oil and water to mix and not separate e.g. found in mayonnaise.

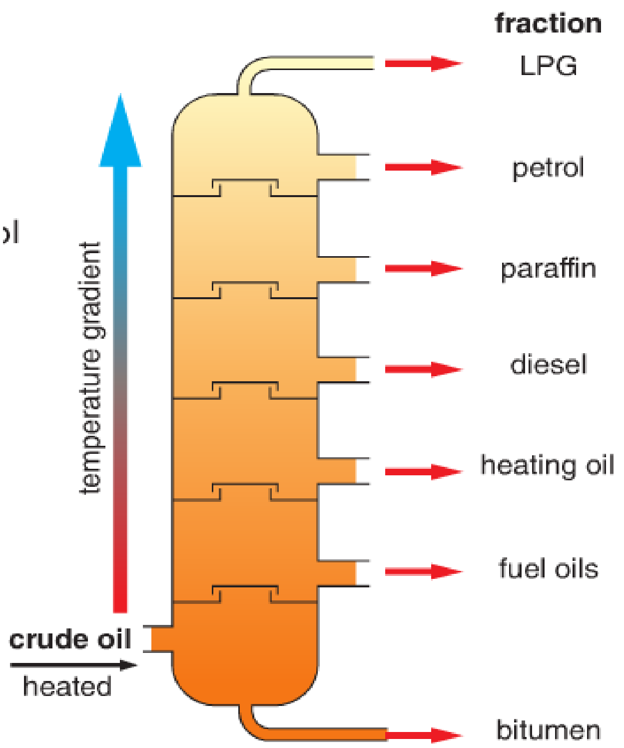
Antioxidants – stop food reacting with oxygen
Food colourants – improve colour
Flavour enhancers – improve flavour

Perfumes - properties

property	why it is important
non-toxic	does not poison the wearer
does not irritate the skin	prevents the wearer from suffering rashes
evaporates easily - very volatile	perfume molecules reach the nose easily
insoluble in water	it is not washed off easily
does not react with water	avoids the perfume reacting with perspiration

Ester equation:

alcohol + organic acid → ester + water



Fractional distillation of crude oil

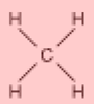
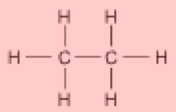
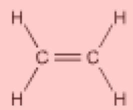
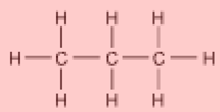
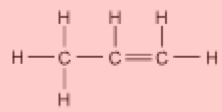
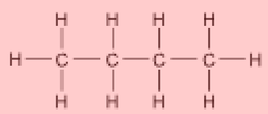
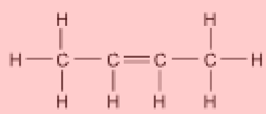
Because they have different boiling points, the substances in crude oil can be separated using fractional distillation. The crude oil is evaporated, and its vapours allowed to condense at different temperatures in the fractionating column. Each fraction contains hydrocarbon molecules with a similar number of carbon atoms.

Fractional tower	Boiling point	Molecule size	Forces between molecules
Top	High	Large	Strong intermolecular forces
Bottom	low	Small	Weak intermolecular forces

Hydrocarbon – compound that contains **Hydrogen** and **carbon** only.

Alkanes and alkenes

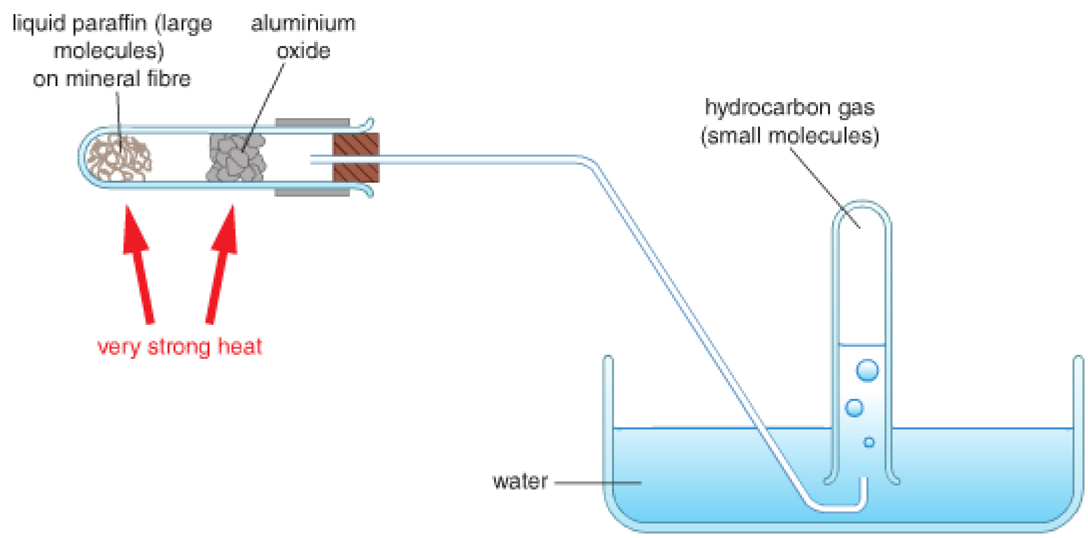
Alkenes contain a *double bond*. (remember a double 'e')

	Alkane	Displayed formula	Alkene	Displayed formula
Many	methane		–	–
Elephants	ethane		ethene	
Play	propane		propene	
Basketball	butane		butene	

Testing for alkenes

Bromine water is a dilute solution of bromine that is normally orange-brown in colour, but becomes **colourless** when shaken with an **alkene**. Alkanes – the bromine water stays brown.

Cracking – breaking long chain hydrocarbons into shorter more useful chains e.g. petrol. Need high temperatures and a catalyst.



Gore-Tex®Nylon has some desirable properties. It does not let ultraviolet light pass through it, and it is:

tough
lightweight
waterproof
Unfortunately, nylon does not let water vapour pass through it either. This means nylon waterproof clothing traps sweat, so that after a while the inside of the clothing becomes wet, making it unpleasant to wear. Gore-Tex® has the desirable properties of nylon, but is also 'breathable'. It lets water vapour from sweat pass to the outside, but it stops rain drops from passing to the inside.

Plastics

Monomer	**Polymer**	**Properties**	**Use**
Vinylchloride	**POLY**Vinylchloride	Waterproof, flexible	Raincoat
Ethene	**POLY**Ethene	Waterproof, flexible	Plastic bags
Styrene	**POLY**Styrene	Insulator, absorbs shock	Packaging
Propene	**POLY**Propene	Strong and flexible	Ropes

Disposing of plastics

Method	**Advantage**	**Disadvantage**
Landfill	Easy	Takes up land
Incinerate	Little left	Toxic gases
Recycle	Saves resources	Has to be sorted which takes time.

Problems of plastic

- **harms wildlife**

Choosing a fuel – Remember 'Teacup'

Toxicity

Complete combustion

Energy Availability Cost Use (Ease of) Pollution	Complete combustion needs a plentiful supply of air so that the elements in the fuel react fully with oxygen. **Incomplete combustion** Incomplete combustion occurs when the supply of air or oxygen is poor. Water is still produced, but carbon monoxide and carbon are produced instead of carbon dioxide. **Carbon monoxide is a poisonous gas,** which is one reason why complete combustion is preferred to incomplete combustion. Gas fires and boilers must be serviced regularly to ensure they do not produce carbon monoxide.
Complete combustion (balanced) Complete combustion of methane, CH_4 Write formulae for each substance $CH_4 + O_2 \rightarrow CO_2 + H_2O$ Balance the number of H atoms $CH_4 + O_2 \rightarrow CO_2 + 2H_2O$ Balance the number of O atoms $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$	**Incomplete combustion (balanced)** Incomplete combustion of ethane, C_2H_6 Write formulae for each substance $C_2H_6 + O_2 \rightarrow CO + C + H_2O$ Balance the number of H atoms $C_2H_6 + O_2 \rightarrow CO + C + 3H_2O$ Balance the number of O atoms $C_2H_6 + 2O_2 \rightarrow CO + C + 3H_2O$

Pollution

Air consists of Oxygen (21%), Nitrogen (78%), carbon dioxide (0.035%), water vapour and noble gases.

Level of gases depends on:

- combustion (burning of fossil fuels) increase carbon dioxide
- respiration – increases levels of carbon dioxide
- Photosynthesis – decreases levels of carbon dioxide and increases Oxygen levels. This reduces global warming

Pollutant	Comes from,,,	Environmental effects
Carbon monoxide	Incomplete combustion of petrol	Poisonous gas
Oxides of nitrogen	Internal combustion engines	Acid rain
Sulphur dioxide	Combustion of fossil fuels that contain Sulphur impurities	Acid rain

Paint

- used to make an area attractive and protect surfaces
- **Pigment** – colour
- **Binding medium** – sticks paint to a surface
- **Solvent** – thins the paint
- **Colloid** – a mixture of solid pigment powder dispersed in a liquid

- **Emulsion paint** dries when the solvent (water) evaporates
- **Oil paints dry** – by an oxidation reaction. The oil reacts with the air.
- **Thermochromic** – change colour at certain temperatures e.g. baby spoons
- **Phosphorescent** - absorb energy from daylight and then slowly release the energy as light.

Construction materials

e.g. brick, steel, aluminium and glass

Limestone

Limestone and marble have the chemical formula $CaCO_3$. Its chemical name is **Calcium carbonate.** It is made of 1 x Calcium, 1 x Carbon and 3 x oxygen atoms. This means there are three elements or 5 atoms)

Concrete is reinforced with steel.

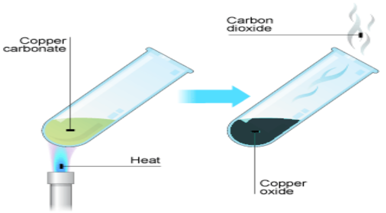
Problems of quarrying

- noise,
- dust
- ruins the landscape

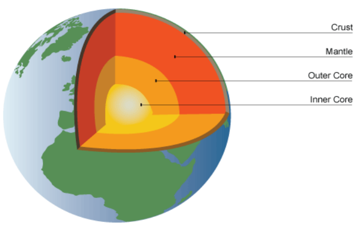
Thermal decomposition

Breakdown of a substance using heat. Carbon dioxide is produced. This turns limewater cloudy.

Calcium carbonate $\xrightarrow{\text{heat}}$ Carbon dioxide + calcium oxide



Structure of the Earth



Plates

Continental plates

carry the continents

Continental plates

underneath the oceans

Volcanoes

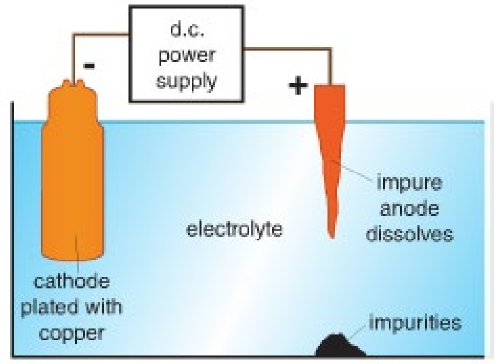
- Igneous rock is volcanic rock e.g. basalt and granite
- Hard rock that contains crystals
- Cooled slowly – large crystals
- Cooled quickly – small crystals
- People live near volcanoes as the land is fertile

Magma – molten rock inside the volcano

Lava – molten rock that has erupted and is on the outside of the volcano.

Electrolysis – splitting of a compound using electricity.

- Pure copper is extracted using electrolysis



Recycling copper - saves resources

Positive
Anode
Negative
Is
Cathode

Cation – positive ion

Anion – negative ion

Electrolyte – liquid that conducts electricity.

Alloys

Mixture of a metal and another element – improves it.

- bronze
- brass
- solder
- steel
- amalgam

Solder

- contains lead and tin
- It has a low melting point and can be used to join metals together

Rust

Iron + Oxygen + water → Hydrated iron (III) oxide
(Rust)

Iron and oxygen are needed to make iron rust.

Cars near the sea rust quicker. Salt increases the rate of rusting.

Cars

Similarities - Both steel and aluminium conduct electricity and are malleable (can be shaped.

Differences:

	Steel	**Aluminium**
Advantages	Cheaper, stronger and harder than aluminium	Lighter than aluminium – better fuel economy, doesn't corrode as easily as steel
Disadvantages	Rusts	More expensive

Haber Process – makes Ammonia.
Ammonia can be used to make fertilisers

Uses Nitrogen from the air and hydrogen cracking oil/ natural gas.

Nitrogen + Hydrogen $\rightleftharpoons$ Ammonia

$\rightleftharpoons$ Means reversible

Conditions needed are:

- high temperature (450°C) High pressure
- Iron catalyst (speeds up the reaction)

Costs involved (in any manufacturing industry)

- building the plant/ factory
- labour costs
- cost of chemicals/ resources
- energy

A problem of using high pressure is the high cost. It is also dangerous.	

pH scale

1	2	3	4	5	6	7	8	9	10	11	12	13	14

Strong acid **Weak acid** **neutral** **Weak alkali** **Strong alkali**

If you have an acid and you add an alkali the pH increases (becomes more alkali)
If you have an alkali and you add an acid the pH decreases (becomes more acid)

<u>Neutralisation</u>

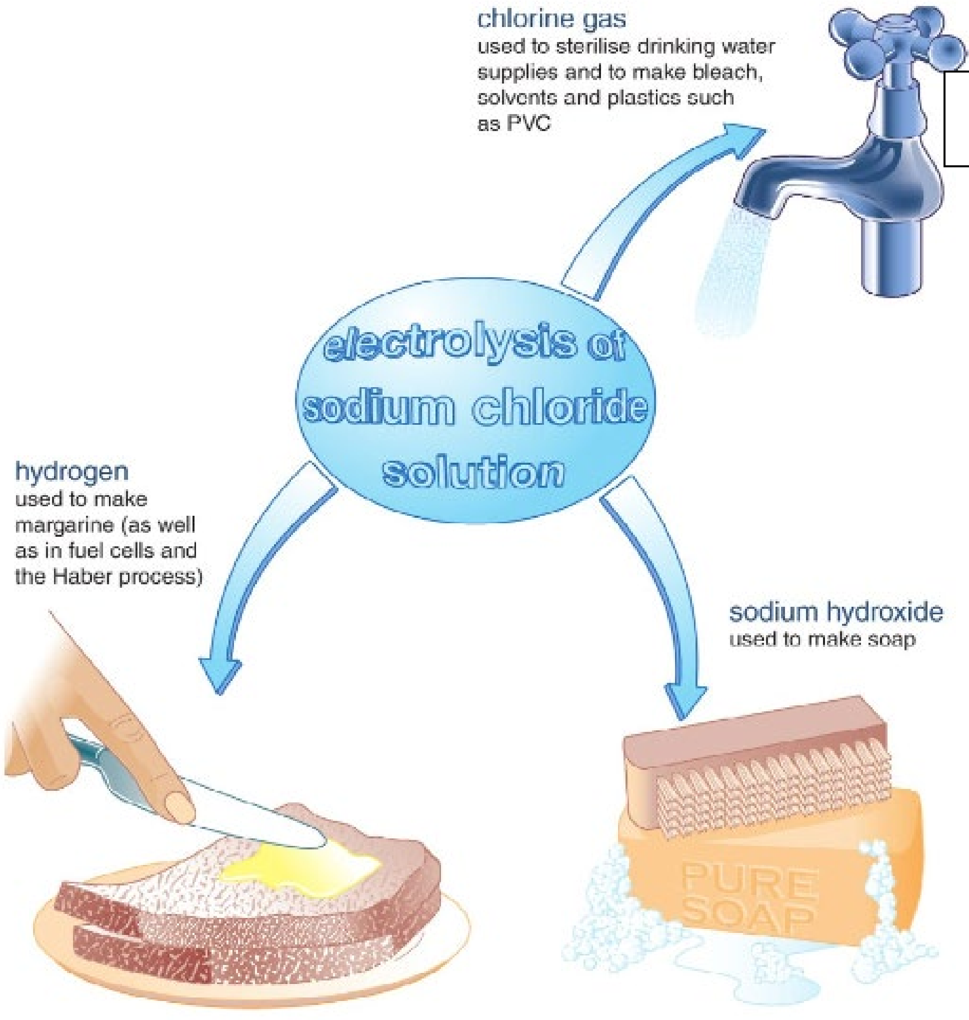
If **Hydrochloric acid** is used – a **chloride** is produced e.g.
Sodium Hydroxide + **Hydrochloric acid** → Sodium **chloride** + water

If **Sulphuric acid** is used – a **sulphate** is produced e.g.
Sodium Hydroxide + **Sulphuric acid** → **Sodium Sulphate** + water

If **Nitric acid** is used – a **nitrate** is produced e.g.
Sodium Hydroxide + **Nitric acid** → Sodium **Nitrate** + water

<u>Fertilisers –</u> increase crop yield. They help the crops grow bigger and faster.
NPK – contain nitrogen, phosphorus and potassium.

<u>Salt</u> – used as a preservative, flavouring and put onto roads in winter.



Test for chlorine gas – litmus paper goes white.

Rates of reaction e.g during a reaction a large amount of gas could be produced.	
Increasing temperature Particles move faster as the temperature increases. The reacting particles have more kinetic (movement) energy and so the number of collision increases.	**Increasing surface area** The reaction rate is faster if you use powdered reactants rather than a lump. The particles in the solution will have more area to work on.
Increasing concentration A higher concentration means that there are more reacting particles. More particles means that there are more collisions	**Catalysts** Using a catalyst speed up the reaction. It is not used up in the reaction. Some catalysts work by giving the particles a surface to stick to.

Examples of questions.

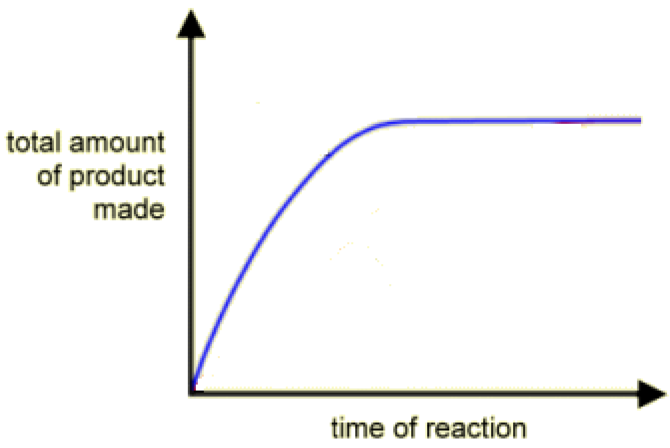
1. Phil and Anne investigate the reaction between Zinc and hydrochloric acid. Zinc chloride and hydrogen gas is made. Write a word equation for the reaction.

Zinc + Hydrochloric acid → Zinc chloride + Hydrogen

2. Make sure you know the reactants (what is reacting) and the products (what is produced/made)

Magnesium + Hydrochloric acid → Magnesium chloride + Hydrogen

3. If there are any reactants left at the end of the reaction it is because one of the reactants has been used up.



Reacting masses	**Relative formula Mass**
12	e.g. CO_2 1 Carbon = 12 2 Oxygen = 2 x 16 = 32

C

6

Mass number is always the largest number – Carbon is 12

32 + 12 = 44

Calculating percentage yield

The percentage yield is calculated using this formula:

Percentage yield = $^{\text{actual yield}}/_{\text{predicted yield}} \times 100$

For example, if the predicted yield is 20 g but the actual yield is 15 g:

Percentage yield = $^{15}/_{20} \times 100 = 75\%$

Losing product

A 100% yield means that no product has been lost, while a 0 per cent yield means that no product has been made. There are several reasons why the percentage yield of a product might be less than 100 per cent, including loss when:

Filtering

Evaporating

Transferring liquids

Not all reactants react to make product

Exothermic – give out heat to their surroundings. (Temperature increases) e.g. respiration and combustion.

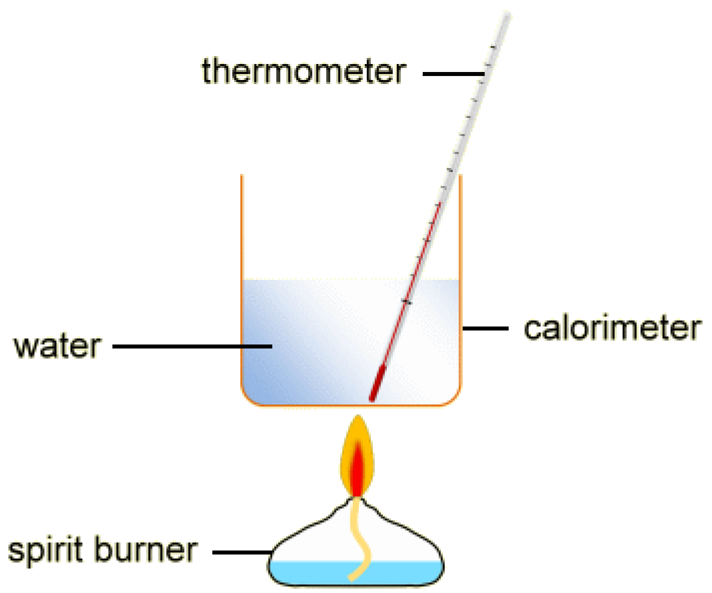
Bonds are made.

Endothermic – take in energy from their surroundings.
(Temperature decreases) e.g. photosynthesis.

Bonds are broken.

Calorimetry

Measuring heat transfers is called **calorimetry**. The diagram shows a simple calorimetry experiment to measure the heat energy released from burning fuel. You should be able to recognise and label apparatus like this:



Calorimetry

In a typical calorimetry experiment:

1. Cold water is measured into a copper calorimeter - a small metal can

2. The starting temperature of the water is recorded
3. The water is heated using the flame from the burning fuel
4. The final temperature of the water is recorded

The spirit burner containing the fuel is usually weighed before and after the experiment. In this way, the mass of the fuel burned can be found.

Fair testing

When comparing different fuels, it is important to carry out a fair test. Several variables should be kept constant, including:

- The mass - or volume - of water used
- The starting temperature of the water
- The temperature increase
- The distance of the flame from the calorimeter

More reliable results can be obtained by repeating the experiment many times. The biggest source of error in calorimetry is usually unwanted heat loss to the surroundings. This can be reduced by insulating the sides of the calorimeter and adding a lid.

Calculating energy transfers

The amount of energy transferred from the burning fuel to the water in the calorimeter can be calculated if you know:

- The mass of water heated
- The temperature rise

This is the equation you need:

Energy transferred (joules, J) = mass of water heated (grams, g) × 4.2 × temperature rise (ºC)

For a given amount of water heated up, the greater the temperature rise, the greater the amount of heat energy transferred to the water. For example, twice as much energy is transferred to the water to achieve a temperature increase of 20ºC compared with 10ºC.

Comparing fuels

You can compare fuels by measuring the mass of fuel burned in the experiment. The best fuel is likely to release the most energy per gram of fuel. This is worked out using:

energy released (J/g of fuel) = energy transferred to water (J) ÷ mass of fuel burned (g)

Medicines

Costs include:

- labour
- research and testing
- marketing and legal costs
- energy costs
- time for development

Sometimes the materials for a medicine are **extracted** from plants
Other medicines are made in the **laboratory**, they are **synthetic**.

To extract materials from plants:

- **crush/grind** the plant material
- **dissolve** in a **solvent**
- separate the compound needed using **<u>chromatography</u>**.

Batch process	**Continuous process**
Is when something is needed in small amounts e.g. medicine. When supplies run low, more are made	Is when something is needed in large amounts e.g. ammonia. Factory can run 24hrs a day.

<u>Allotropes of carbon</u>

Allotrope	Properties	Used for
Diamond	Transparent, high melting point, hard, don't conduct electricity	Jewellery and cutting tools
Graphite	Conducts electricity,	Lubricant
Buckminster Fullerene	60 carbon atoms. The nanotubes conduct electricity	Catalysts. Could be used to carry drugs around the body.

Nanotubes – used for semiconductors, industrial catalysts and tennis rackets

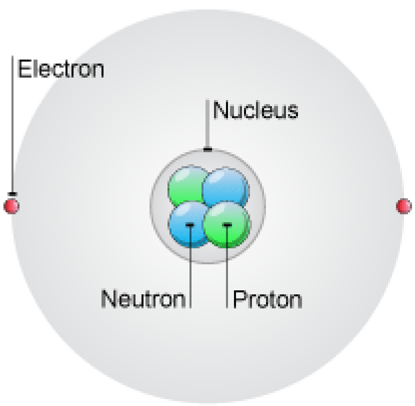
<u>Atomic structure</u>

<u>All substances are made of atoms.</u> Each atom is made of a nucleus - containing protons and neutrons - surrounded by electrons.

The **atomic number** is the number of protons in an atom.

The **mass number** of an atom is the total of protons plus neutrons.

There are **just over one hundred different types of atom, called elements.**



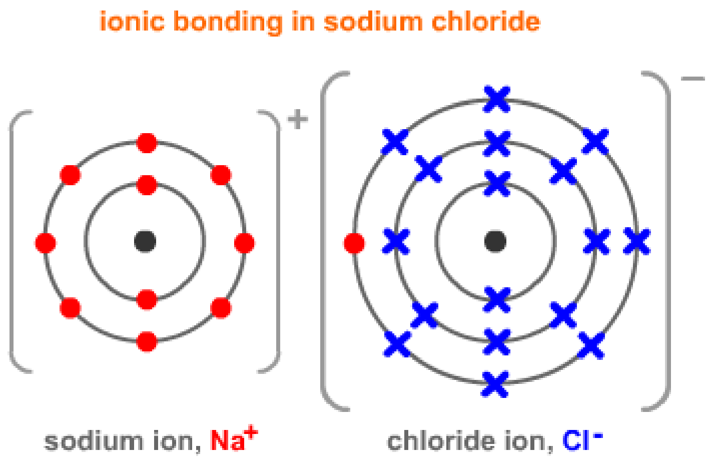
<u>P</u>roton – <u>p</u>ositive charge

<u>E</u>lectron – negative charge

<u>N</u>eutron – <u>neu</u>tral/ <u>n</u>o charge

Ionic bonding

Bonding between a **metal** and a **non-metal.** **Ions** (charged particles are formed). Transfer of electrons.



Ionic compounds like magnesium oxide and sodium chloride have **high melting points** and do not conduct electricity when **solid**. They do conduct electricity when **molten**. Sodium chloride is soluble in water and the **solution** conducts electricity.

Covalent bonding

Non-metals combine together by **sharing electrons**. The shared pair of electrons holds the two atoms together. It's called a **covalent bond**. The group of atoms bonded together in this way is called a **molecule**.

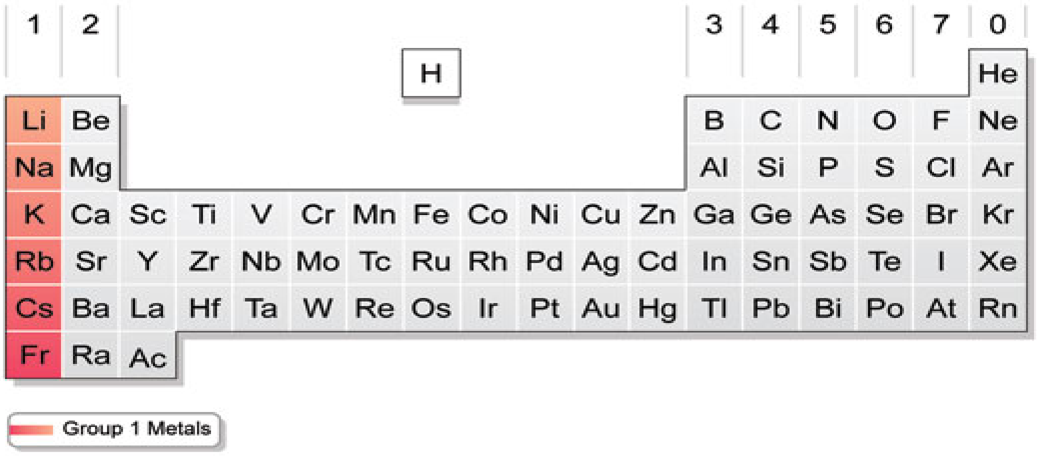
Carbon dioxide (learn a property of carbon dioxide)

Carbon dioxide is a gas with a boiling point of -44°C (**low melting point**). It **doesn't conduct electricity.**

Remember on the periodic table **groups go down** and **periods go across**. Remember a woman is **cross** when she has her **period.**

The Group 1 Alkali metals

The Group 1 elements, which include lithium (Li), sodium (Na) and potassium (K) are also known as the **alkali metals**. They all have **one electron** in the outer shell and so they have **similar properties**.



Group 1 of the periodic table

Reaction with air and water

Potassium reacts with a lilac flame

Lithium, sodium and potassium all **react** vigorously with water. **Hydrogen gas bubbles off** and, in the case of potassium, this burns with a lilac flame. The metal hydroxide is formed which is a strong alkali.

Alkali metals need to be stored under oil to prevent them reacting with the oxygen and water vapour in the air.

The reactivity of the alkali metals **increases** down the group. Potassium reacts **more** vigorously than sodium and lithium.

Flame tests

A cleaned, moistened flame test wire is dipped into a solid sample of the compound and then put into a blue Bunsen flame. The **flame colour** indicates which alkali metal ion is present in the compound.

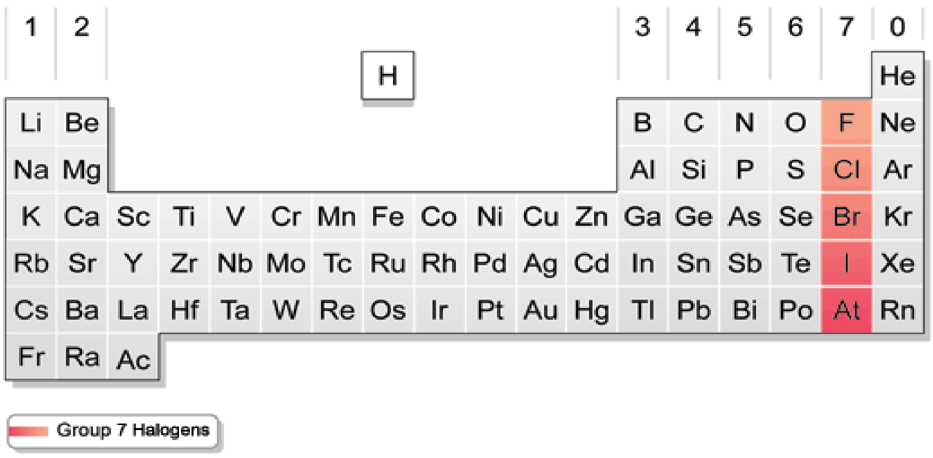
Flame colours and the alkali metal ion they represent

Flame colour	Ion present
red	lithium
orange	sodium
lilac	potassium

The Halogens

The Group 7 elements are also known as the halogens. They include **fluorine, chlorine, bromine and iodine**, which all have seven electrons in their outer shell.

In a displacement reaction a less reactive element is removed and replaced by a more reactive element.



Chlorine is used to sterilise the **drinking water** supply and in the manufacture of many important **chemicals** such as pesticides and plastics. Iodine can be used to sterilise **wounds**.

An important compound of chlorine is **sodium chloride** or common **salt**. It's used to preserve food, as flavouring and to manufacture chlorine.

The properties of the halogens

The halogens have **similar properties** because they all have **seven electrons** in the outer shell. They all react very vigorously with alkali metals.

Halogen	Appearance	Reaction with sodium	Reactivity
Chlorine	pale green gas	sodium + chlorine → sodium chloride	extremely reactive
Bromine	orange liquid	sodium + bromine → sodium bromide	very reactive
Iodine	grey solid	sodium + iodine → sodium iodide	reactive

Displacement and reactivity

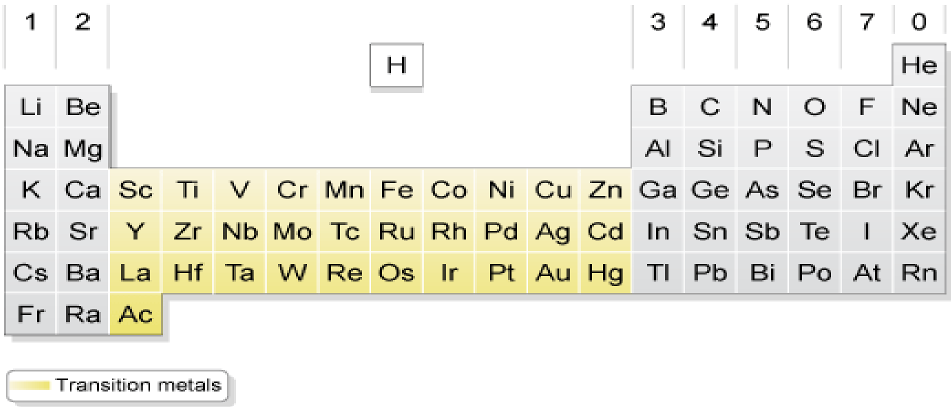
If a reactive element comes into contact with the compound of a less reactive element a **chemical reaction** may take place. The less reactive element is **removed** from the compound and **replaced** by the more reactive element.

Examples of displacement reactions

Halogen	Metal halide	The most reactive halogen	Reaction
chlorine	sodium bromide	chlorine	chlorine + sodium bromide → sodium chloride + bromine
bromine	sodium chloride	chlorine	no reaction

Halogen	Metal halide	The most reactive halogen	Reaction
bromine	sodium iodide	bromine	bromine + sodium iodide → sodium bromide + iodine

Transition elements



The transition elements are those in the **middle section** of the Periodic Table.

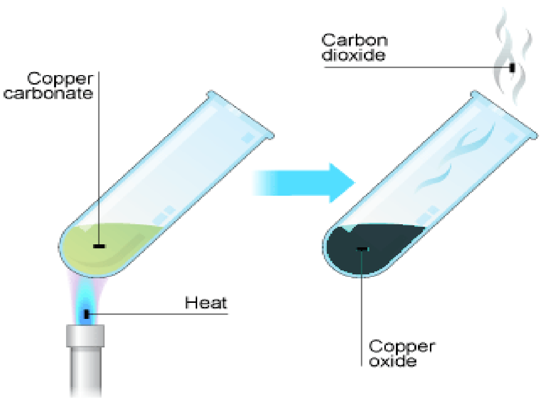
All the transition elements are metals and so they have typical metallic properties - they conduct heat and electricity, they are malleable and ductile and they form positive ions when they react with non-metals.

The compounds of transition metals are often coloured.

- Copper compounds are blue
- Iron(II) compounds are light green
- Iron(III) compounds are orange/brown

Thermal decomposition: Make sure you know that limewater is used to test for Carbon dioxide. If Carbon dioxide is present limewater turns cloudy.

A reaction in which a substance is broken down into at least two other substances by heat is called **thermal decomposition**.



If limewater is shaken with a sample of the gas produced, the limewater turns milky. This shows that the gas is carbon dioxide. Notice that the solid in the test tube changes colour as the copper carbonate breaks down to copper oxide and carbon dioxide.

Examples

iron carbonate → iron oxide + carbon dioxide

manganese carbonate → manganese dioxide + carbon dioxide

zinc carbonate → zinc oxide and carbon dioxide

The physical properties of metals

Metal	Property	Use
Aluminium	Heat conductor	Make saucepans
Copper	Electrical conductor	Make electric wiring
Gold	Lustrous (shiny)	Make jewellery

Superconductors (usually comes up – definition and an advantage)

At very low temperatures some metals conduct electricity very easily indeed. They have little or no resistance and **so enormous currents can be produced without using large amounts of energy**. They're called **superconductors**.

Water tests (and the way to remember it courtesy of Katie Hills)

Chlorides – **w**hite precipitate	**C**hange in **w**eather
Bromides – **c**ream precipitate	**b**rings **c**raziness
Iodides – (**p**ale) **y**ellow precipitate	**i**ncluding **p**eople **y**elling
Sulphates – **w**hite	**s**tupid **w**ords