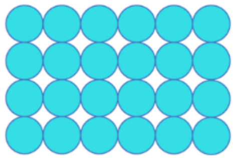
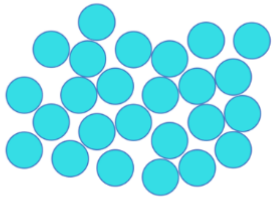
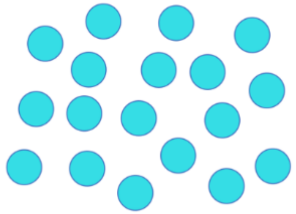
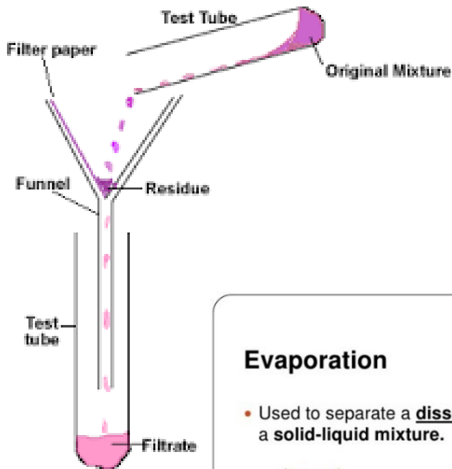
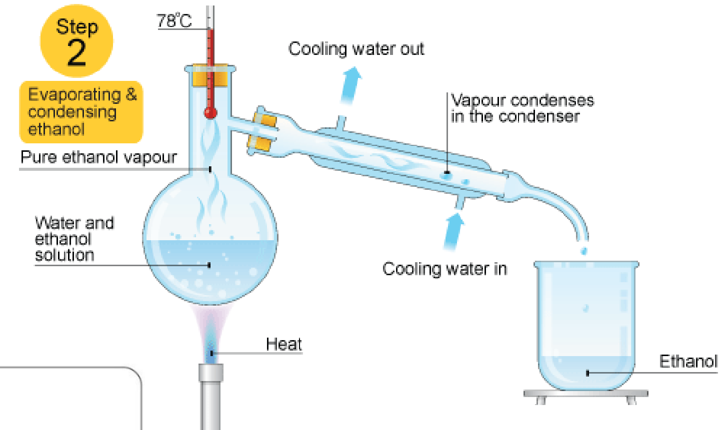
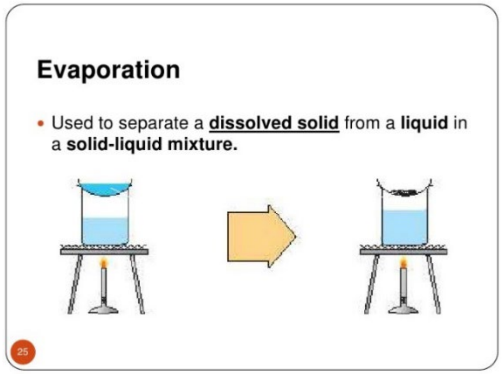
	Solid	Liquid	Gas
Arrangement of Particles	Regular pattern Close together	Irregular pattern Close together	Irregular pattern Far apart
Movement of Particles	Vibrate around their fixed positions	Move past each other in random directions	Move quickly in random directions
Diagram			

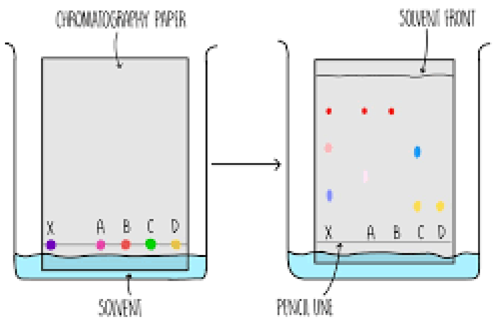
Particle: A very tiny object such as an atom or molecule, too small to be seen with a microscope.
Particle Model: A way to think about how substances behave in terms of small, moving particles.
Diffusion: The process by which particles in liquids or gases spread out through random movement from a region where there are many particles to one where there are fewer.
Gas pressure: Caused by collisions of particles with the walls of a container.
Density: How much matter there is in a particular volume, or how close the particles are.
Evaporate: Change from liquid to gas at the surface of a liquid, at any temperature.
Boil: Change from liquid to a gas of all the liquid when the temperature reaches boiling point.
Condense: Change of state from gas to liquid when the temperature drops to the boiling point.
Melt: Change from solid to liquid when the temperature rises to the melting point.
Freeze: Change from liquid to a solid when the temperature drops to the melting point.

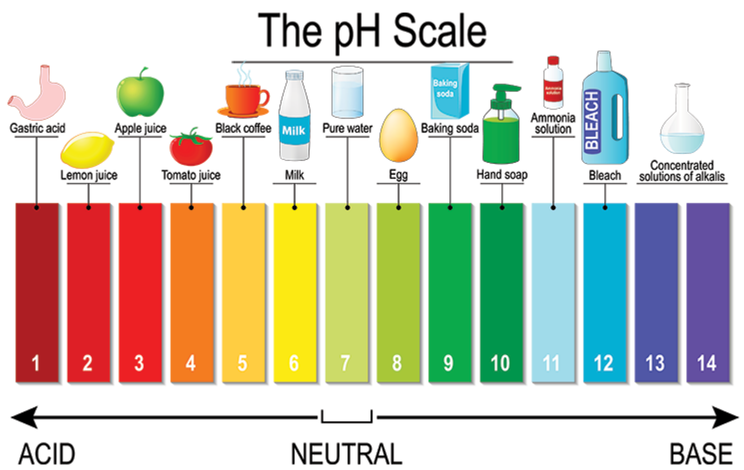
Solvent: A substance, normally a liquid, that dissolves another substance.
Solute: A substance that can dissolve in a liquid.
Dissolve: When a solute mixes completely with a solvent.
Solution: Mixture formed when a solvent dissolves a solute.
Soluble (insoluble): Property of a substance that will (will not) dissolve in a liquid.
Solubility: Maximum mass of solute that dissolves in a certain volume of solvent.
Pure substance: Single type of material with nothing mixed in.
Mixture: Two or more pure substances mixed together, whose properties are different to the individual substances.
Filtration: Separating substances using a filter to produce a filtrate (solution) and residue.
Distillation: Separating substances by boiling and condensing liquids.
Evaporation: A way to separate a solid dissolved in a liquid by the liquid turning into a gas.
Chromatography: Used to separate different coloured substances.











Scientific enquiries: Different ways to investigate including observation over time, fair test and pattern seeking.
Variable: A factor that can be changed, measured and controlled.
Independent variable: What you change in an investigation to see how it affects the dependent variable.
Dependent variable: What you measure or observe in an investigation.
Correlation: A relationship between variables where one increases or decreases as the other increases.

Metals Key Words

Metals: Shiny, good conductors of electricity and heat, malleable and ductile, and usually solid at room temperature.
Non-metals: Dull, poor conductors of electricity and heat, brittle and usually solid or gaseous at room temperature.
Displacement: Reaction where a more reactive metal takes the place of a less reactive metal in a compound.
Oxidation: Reaction in which a substance combines with oxygen.
Reactivity: The tendency of a substance to undergo a chemical reaction.
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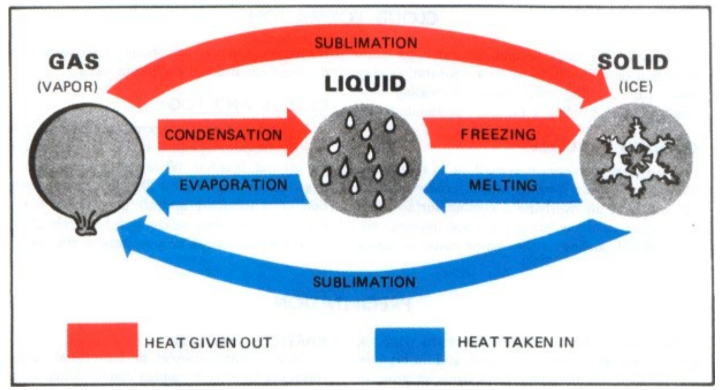
Acid Key Words

- **pH:** Scale of acidity and alkalinity from 0 to 14.
- **Indicators:** Substances used to identify whether unknown solutions are acidic or alkaline.
- **Base:** A substance that neutralises an acid - those that dissolve in water are called alkalis.
- **Concentration:** A measure of the number of particles in a given volume.
- **Neutralisation:** When an alkali or base is added to an acid (or vice-versa) until the pH changes to 7.
- **Neutral:** A solution with a pH of 7.
- **Corrosive:** A substance which can burn or destroy living material
- **Irritant:** A substance which can cause reddening or itching when it comes into contact with the skin

potassium — most reactive
sodium
calcium
magnesium
aluminium
carbon
zinc
iron
tin
lead
hydrogen
copper
silver
gold
platinum — least reactive

Hydrogen test –
lighted splint
Squeaky pop!



Representing neutralisation reactions

Word equations: Acid + Alkali → Salt + Water
eg: Hydrochloric acid + sodium hydroxide → sodium chloride + water
Symbol equation: $HCl\,(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O\,(l)$

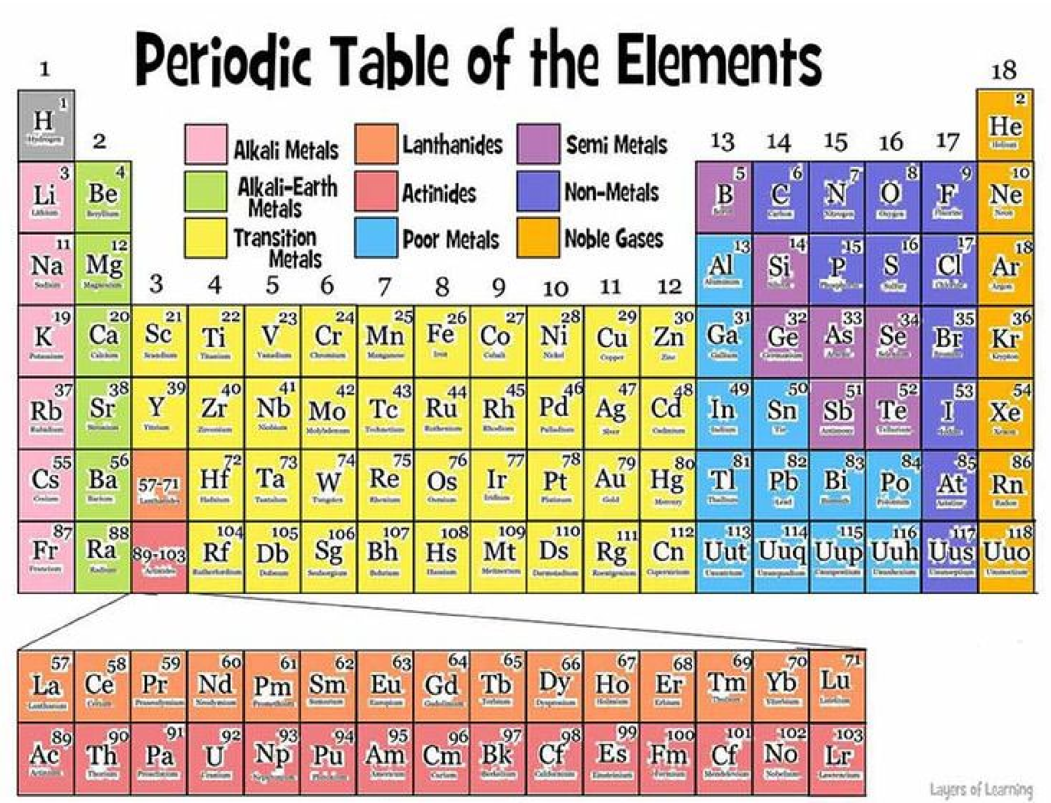
The **Group 1** elements all react vigorously with water, becoming more reactive as you down the group. An alkali is left behind in the solution which is why these elements are often called '**The Alkali Metals**'.

Sodium + water → Sodium hydroxide + hydrogen

All the **Group 7** (17) elements are molecules containing two atoms. (They are diatomic)

Melting Points and boiling points increase as the molecules get bigger and they become more reactive down the group. They are called the **Halogens.**

Group 0 (18) are known as the **Noble gases.** They are unreactive gases used in balloons and light bulbs.



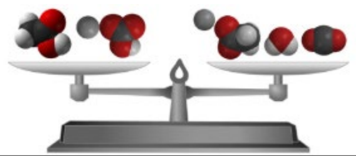
Total mass of reactants = total mass of products

This is known as the *Law of Conservation of Mass*

Physical properties of metals and nonmetals

property	metal	nonmetal
hardness	hard	soft
density	high	low
luster	shiny	dull
ductile (can be stretched into a wire)	yes	no
malleable (can be beaten into sheets)	yes	no
thermal conductivity	good conductor	poor conductor
electrical conductivity	good conductor	poor conductor
sonorous (rings when struck with hammer)	yes	no

Thermal decomposition reactions appear to lose mass as gases are released. Combustion may lose mass as gases are released.



Mixtures are, as the name indicates, ***mixed*** rather than reacted together.

Elements: What all substances are made up of, and which contain only one type of atom.
Atom: The smallest particle of an element that can exist.
Molecules: Two to thousands of atoms joined together. Most non-metals exist either as small or giant molecules.
Compound: Pure substances made up of two or more elements strongly joined together.
Chemical formula: Shows the elements present in a compound and their relative proportions.
Polymer: A molecule made of thousands of smaller molecules in a repeating pattern. Plastics are man-made polymers (polythene, polyester, polystyrene), starch is a natural polymer.

Reactions Key words

Chemical reaction a change in which a new substance is made – or bonds are broken in the reacting particles and new bond form in the product particles. The particles themselves have changed.
Physical change one that changes the physical properties but no new substance is formed – or the particles are rearranged but the particles themselves have not changed.
Fuel stores energy in a chemical store which can be released as heat
Reactants substances that react together, shown before the arrow in an equation.
Products substances that are made, shown after the arrow.
Conserved when the quantity of something doesn't change
Combustion a substance reacting with oxygen, releasing heat and light.
Thermal decomposition a single substance is broken down by heating

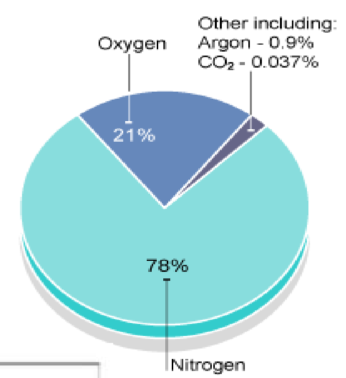
Energy Key words

Chemical bond a force holding two atoms together
Endothermic a reaction that takes in energy, the temperature drops.
Exothermic a reaction that releases energy so the temperature increases
Hazard a situation that prevents a threat to people.
Risk how likely something is to be harmful
Control measure an action taken to remove the hazard or reduce it.

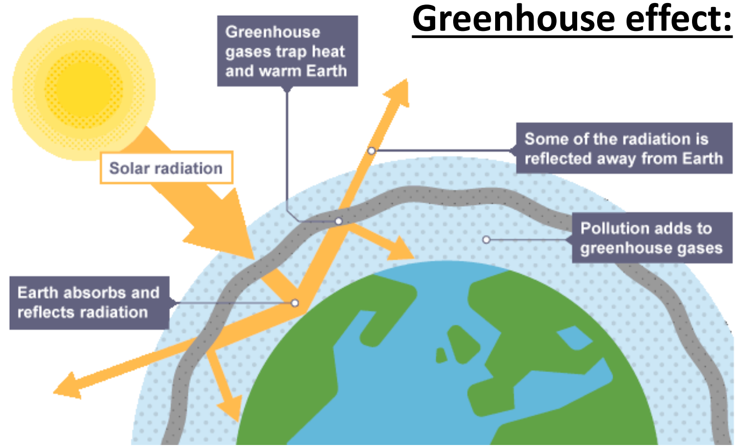
Climate Keywords:

Global warming: The gradual increase in surface temperature of Earth.
Fossil fuels: Remains of dead organisms that are burned as fuels, releasing carbon dioxide.
Greenhouse effect: When energy from the sun is transferred to the thermal energy store of gases in Earth's atmosphere.
Natural resources: Materials from the Earth which act as raw materials for making a variety of products.
Mineral: Naturally occurring metal or metal compound.
Ore: Naturally occurring rock containing sufficient minerals for extraction.
Recycling: Processing a material so that it can be used again.

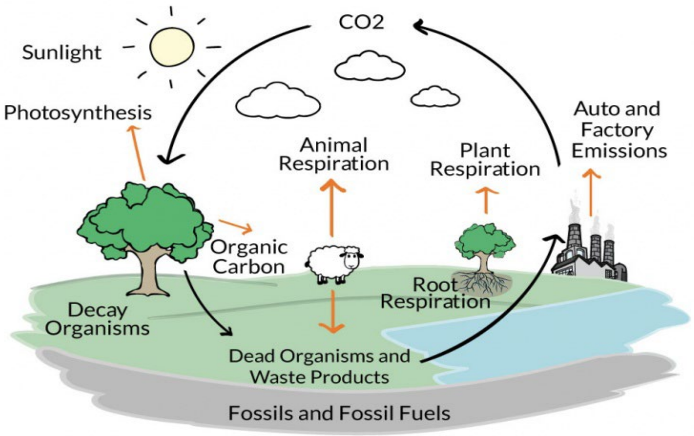
Composition of air:

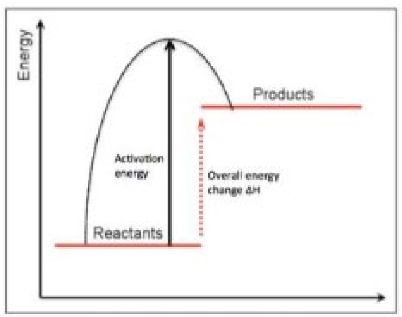


Greenhouse effect:

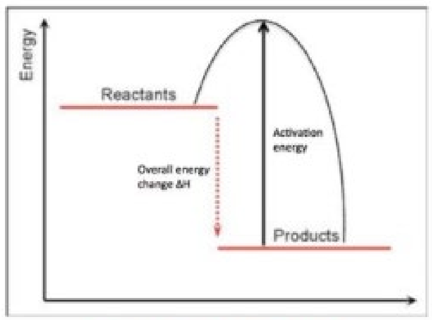


Carbon Cycle

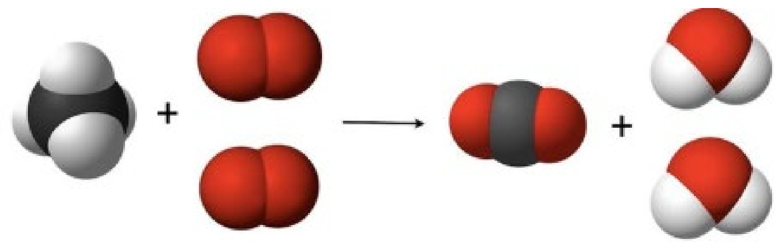




Endothermic reaction



Exothermic reaction

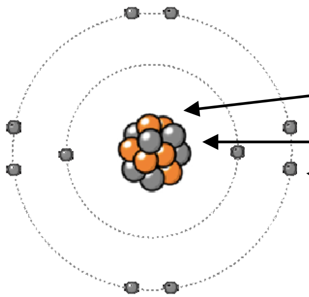


$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

AQA GCSE Atomic structure and periodic table

7
Li
3

Mass number	*The sum of the protons and neutrons in the nucleus*	
Atomic number	*The number of protons in the atom*	Number of electrons = number of protons

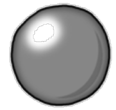
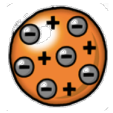
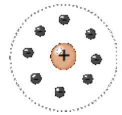
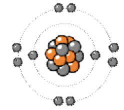


Name of Particle	Relative Charge	Relative Mass
Proton	+1	1
Neutron	0	1
Electron	-1	Very small

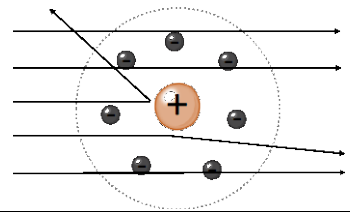
Electronic structures

Isotope	*Atoms of the same element with the same number of protons and different numbers of neutrons*	**^{35}Cl (75%) and ^{37}Cl (25%)** Relative abundance = (% isotope 1 x mass isotope 1) + (% isotope 2 x mass isotope 2) ÷ 100 **e.g. (25 x 37) + (75x 35) ÷ 100 = 35.5**

The development of the model of the atom

Pre 1900		*Tiny solid spheres that could not be divided*	Before the discovery of the electron, John Dalton said the solid sphere made up the different elements.
1897 'plum pudding'		*A ball of positive charge with negative electrons embedded in it*	JJ Thompson 's experiments showed that showed that an atom must contain small negative charges (discovery of electrons).
1909 nuclear model		*Positively charge nucleus at the centre surrounded negative electrons*	Ernest Rutherford's alpha particle scattering experiment showed that the mass was concentrated at the centre of the atom.
1913 Bohr model		*Electrons orbit the nucleus at specific distances*	Niels Bohr proposed that electrons orbited in fixed shells; this was supported by experimental observations.

James Chadwick	*Provided the evidence to show the existence of neutrons within the nucleus*

Rutherford's scattering experiment	*A beam of alpha particles are directed at a very thin gold foil* 	Most of the alpha particles passed right through. A few (+) alpha particles were deflected by the positive nucleus. A tiny number of particles reflected back from the nucleus.

The Periodic table

Elements arranged in order of atomic number	*Elements with similar properties are in columns called groups*	Elements in the same group have the same number of outer shell electrons and elements in the same period (row) have the same number of electron shells.

Before discovery of protons, neutrons and electrons	*Elements arranged in order of atomic weight*	Early periodic tables were incomplete, some elements were placed in inappropriate groups if the strict order atomic weights was followed.
Mendeleev	*Left gaps for elements that hadn't been discovered yet*	Elements with properties predicted by Mendeleev were discovered and filled in the gaps. Knowledge of isotopes explained why order based on atomic weights was not always correct.

Alkali metals **Transition metals** **Halogens** **Noble gases**

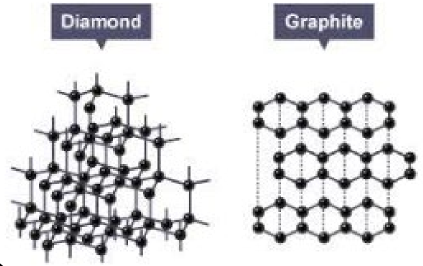
1	2											3	4	5	6	7	0
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	?	?	?						

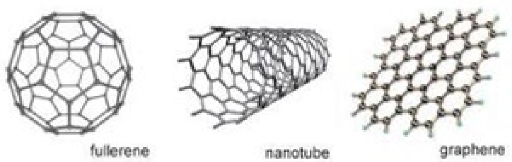
Metals to the left of this line, non metals to the right

AQA BONDING, STRUCTURE AND THE PROPERTIES OF MATTER

Giant covalent structures

Name of structure	Diamond	Graphite	Graphene + Fullerene
Number of bonds	4	3	3
Any delocalised electrons?	no	yes	Yes
Hardness	Very hard	soft	Flexible and strong
Conduct electricity	No	yes	Yes
Melting point	Very high	High	High
Uses	• Gems • Drill bits	• Electrodes • Pencils	• Electronics • Nanotubes



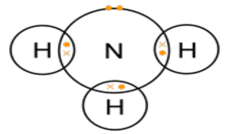


Covalent bonding

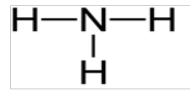
Usually gases or liquids			
	Covalent bonds in the molecule are strong but forces between molecules (intermolecular) are weak	Low melting and boiling points.	Due to having weak intermolecular forces that easily broken.
		Do not conduct electricity.	Due to them molecules not having an overall electrical charge.
		Larger molecules have higher melting and boiling points.	Intermolecular forces increase with the size of the molecules.

Atoms share pairs of electrons

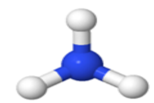
Can be small molecules e.g. ammonia



Dot and cross :
+ Show which atom the electrons in the bonds come from
- All electrons are identical

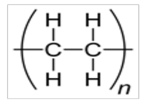


2D with bonds:
+ Show which atoms are bonded together
- It shows the H-C-H bond incorrectly at 90°

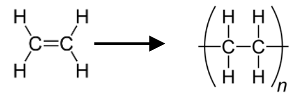


3D ball and stick model:
+ Attempts to show the H-C-H bond angle is 109.5°

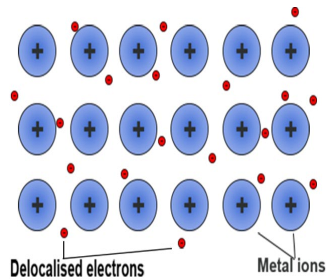
Can be giant covalent structures e.g. polymers



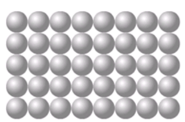
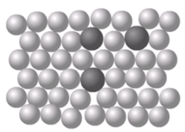
Polymers

Very large molecules	*Solids at room temperature*	Atoms are linked by strong covalent bonds.	

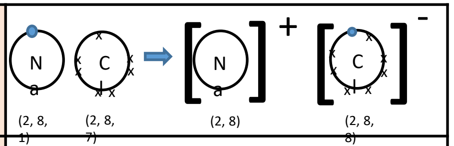
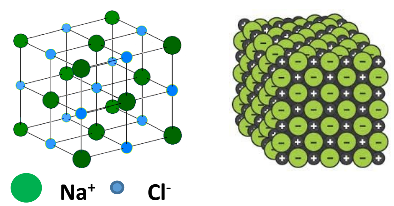
Metallic bonding

Giant structure of atoms arranged in a regular pattern		Electrons in the outer shell of metal atoms are delocalised and free to move through the whole structure. This sharing of electrons leads to strong metallic bonds.

Alloys	*Mixture of two or more elements at least one of which is a metal*	Harder than pure metals because atoms of different sizes disrupt the layers so they cannot slide over each other.

Pure metal  Alloy 

Ionic bonding

Dot and cross diagram	
Giant structure	

Structure	*Held together by strong electrostatic forces of attraction between positive metal ions and negative non metal ions* *Forces act in all directions in the lattice* *High Mp and Bp* *Only conduct when aqueous or molton when ions can move*

AQA GCSE QUANTITATIVE CHEMISTRY - Foundation

Limiting reactants

The reactant that is completely used up	*Limits the amount of product that is made*	Less moles of product are made.

Relative formula mass (M_r)

M_r	*The sum of the relative atomic masses of the atoms in the numbers shown in the formula*	The sum of the M_r of the reactants in the quantities shown equals the sum of the M_r of the products in the quantities shown.	$2Mg + O_2 \rightarrow 2MgO$ 48g + 32g = 80g 80g = 80g

Mass changes when a reactant or product is a gas

Concentration of solutions

Measured in mass per given volume of solution (g/dm^3)	*Conc. = mass (g) / volume (dm^3)*	Greater mass = higher concentration. Greater volume = lower concentration.

Chemical measurements

Whenever a measurement is taken, there is always some uncertainty about the result obtained	*Can determine whether the mean value falls within the range of uncertainty of the result*	1. Calculate the mean 2. Calculate the range of the results 3. Estimate of uncertainty in mean would be half the range

Example:

1. Mean value is 46.5s
2. Range of results is 44s to 49s = 5s
3. Time taken was 46.5s $\pm$2.5s

AQA GCSE QUANTITATIVE CHEMISTRY - Higher

Relative formula mass (M_r)

M_r	*The sum of the relative atomic masses of the atoms in the numbers shown in the formula*	The sum of the M_r of the reactants in the quantities shown equals the sum of the M_r of the products in the quantities shown.	$2Mg + O_2 \rightarrow 2MgO$ 48g + 32g = 80g 80g = 80g

Limiting reactants

The reactant that is completely used up	*Limits the amount of product that is made*	Less moles of product are made.

Mass changes when a reactant or product is a gas

Concentration of solutions

Measured in mass per given volume of solution (g/dm^3)	*Conc. = mass (g) / volume (dm^3)*	Greater mass = higher concentration. Greater volume = lower concentration.

Chemical measurements

Whenever a measurement is taken, there is always some uncertainty about the result obtained	*Can determine whether the mean value falls within the range of uncertainty of the result*	1. Calculate the mean 2. Calculate the range of the results 3. Estimate of uncertainty in mean would be half the range

Example:
1. Mean value is 46.5s
2. Range of results is 44s to 49s = 5s
3. Time taken was 46.5s $\pm$2.5s

Moles (HT only)

Chemical amounts are measured in moles (mol)	*Mass of one mole of a substance in grams = relative formula mass*	One mole of H_2O = 18g (1 + 1 + 16) One mole of Mg = 24g

Avogadro constant	*One mole of any substance will contain the same number of particles, atoms, molecules or ions.*	6.02×10^{23} per mole One mole of H_2O will contain 6.02×10^{23} molecules One mole of NaCl will contain 6.02×10^{23} Na^+ ions

Number of moles = mass (g) / A_r or mass (g) / M_r	How many moles of sulfuric acid molecules are there in 4.7g of sulfuric acid (H_2SO_4)? Give your answer to 1 significant figure. $\frac{4.7}{98}$ = 0.05 mol 98 ← (M_r of H_2SO_4)

Amounts of substances in equations (HT only)

Chemical equations show the number of moles reacting and the number of moles made	*$Mg + 2HCl \rightarrow MgCl_2 + H_2$* *One mole of magnesium reacts with two moles of hydrochloric acid to make one mole of magnesium chloride and one mole of hydrogen*	If you have a 60g of Mg, what mass of HCl do you need to convert it to $MgCl_2$? A_r : Mg =24 so mass of 1 mole of Mg = 24g M_r : HCl (1 + 35.5) so mass of 1 mole of HCl = 36.5g So 60g of Mg is 60/24 = 2.5 moles Balanced symbol equation tells us that for every one mole of Mg, you need two moles of HCl to react with it. So you need 2.5x2 = 5 moles of HCl You will need 5 x 36.5g of HCl= 182.5g

AQA QUANTITATIVE CHEMISTRY Part 2 (Separates only)

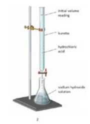
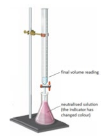
Atom economy

A measure of the amount of starting materials that end up as useful products	Atom economy = $\frac{\text{Relative formula mass of desired product from equation}}{\text{Sum of relative formula mass of all reactants from equation}}$ x 100	High atom economy is important or sustainable development and economic reasons

Using concentrations of solutions in mol/dm³ (HT only)

Concentration of a solution is the amount of solute per volume of solution	*Concentration (mol/dm³) = amount (mol) / volume (dm³)*	What is the concentration of a solution that has 35.0g of solute in 0.5dm³ of solution? 35/0.5 = 70 g/dm³

Titrations

	1. Use the pipette to add 25 cm³ of alkali to a conical flask and add a few drops of indicator.
	2. Fill the burette with acid and note the starting volume. Slowly add the acid from the burette to the alkali in the conical flask, swirling to mix.
	3. Stop adding the acid when the end-point is reached (the appropriate colour change in the indicator happens). Note the final volume reading. Repeat steps 1 to 3 until you get consistent readings.

Titrations are used to work out the precise volumes of acid and alkali solutions that react with each other.

Calculating the chemical quantities in titrations involving concentrations in mol/dm³ and in g/dm³ (HT ONLY): **2NaOH(aq) + H_2SO_4(aq)→ Na_2SO_4(aq) + 2H_2O(l)** It takes 12.20cm³ of sulfuric acid to neutralise 24.00cm³ of sodium hydroxide solution, which has a concentration of 0.50mol/dm³. *Calculate the concentration of the sulfuric acid in g/dm³* 0.5 mol/dm³ x (24/1000) dm³ = 0.012 mol of NaOH	The equation shows that 2 mol of NaOH reacts with 1 mol of H_2SO_4, so the number of moles in 12.20cm³ of sulfuric acid is (0.012/2) = 0.006 mol of sulfuric acid *Calculate the concentration of sulfuric acid in mol/ dm³* 0.006 mol x (1000/12.2) dm³ =0.49mol/dm³ *Calculate the concentration of sulfuric acid in g/ dm³* H_2SO_4 = (2x1) + 32 + (4x16) = 98g 0.49 x 98g = 48.2g/dm³

Percentage yield

HT only:
200g of calcium carbonate is heated. It decomposes to make calcium oxide and carbon dioxide. *Calculate the theoretical mass of calcium oxide made.*

$CaCO_3$ → CaO + CO_2
M_r of $CaCO_3$ = 40 + 12 + (16x3) = 100
M_r of CaO = 40 + 16 = 56
100g of $CaCO_3$ would make 56 g of CaO
So 200g would make 112g

Yield is the amount of product obtained	*It is not always possible to obtain the calculated amount of a product*	The reaction may not go to completion because it is reversible.
		Some of the product may be lost when it is separated from the reaction mixture.
		Some of the reactants may react in ways different to the expected reaction.

Percentage yield is comparing the amount of product obtained as a percentage of the maximum theoretical amount	*% Yield = $\frac{\text{Mass of product made}}{\text{Max. theoretical mass}}$ x 100*	A piece of sodium metal is heated in chlorine gas. A maximum theoretical mass of 10g for sodium chloride was calculated, but the actual yield was only 8g. *Calculate the percentage yield.* Percentage yield = 8/10 x 100 =80%

Use of amount of substance in relation to volumes of gases (HT only)

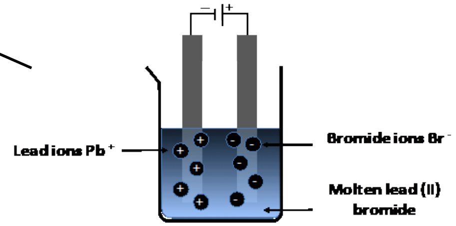
Equal amounts of moles or gases occupy the same volume under the same conditions of temperature and pressure	*The volume of one mole of any gas at room temperature and pressure (20°C and 1 atmospheric pressure) is 24 dm³*	No. of moles of gas = $\frac{\text{vol of gas (dm}^3\text{)}}{24\text{dm}^3}$

OILRIG - Oxidation Is Loss (of electrons) Reduction Is Gain (of electrons)

AQA Chemical Changes - Foundation

Electrolysis

Process of electrolysis	*Splitting up using electricity*	When an ionic compound is melted or dissolved in water, the ions are free to move. These are then able to conduct electricity and are called electrolytes. Passing an electric current though electrolytes causes the ions to move to the electrodes.
Electrode	*Anode* *Cathode*	The positive electrode is called the anode and attracts negative cations. The negative electrode is called the cathode and attracts positive anions.



Extracting metals using electrolysis	
	Metals can be extracted from molten compounds using electrolysis.
	This process is used when the metal is too reactive to be extracted by reduction with carbon.
	The process is expensive due to large amounts of energy needed to produce the electrical current. Example: aluminium is extracted in this way.

Electrolysis of aqueous solutions

At the negative electrode	Metal will be produced on the electrode if it is less reactive than hydrogen. Hydrogen will be produced if the metal is more reactive than hydrogen.
At the positive electrode	Oxygen is formed at positive electrode. If you have a halide ion (Cl^-, I^-, Br^-) then you will get chlorine, bromine or iodine formed at that electrode.

Reactions of acids

Soluble salts

Soluble salts	*Soluble salts can be made from reacting acids with solid insoluble substances (e.g. metals, metal oxides, hydroxides and carbonates).*
Production of soluble salts	*Add the solid to the acid until no more dissolves. Filter off excess solid and then crystallise to produce solid salts.*

The pH scale and neutralisation

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

In neutralisation reactions, hydrogen ions react with hydroxide ions to produce water:

$H^+ + OH^- \rightarrow H_2O$

Reactions of acids and metals

Acids react with some metals to produce salts and hydrogen.

Reactions with acids	*metal + acid → metal salt + hydrogen*	**magnesium + hydrochloric acid → magnesium chloride + hydrogen** **zinc + sulfuric acid → zinc sulfate + hydrogen**

Neutralisation of acids and salt production

Acid name	Salt name
Hydrochloric acid	Chloride
Sulfuric acid	Sulfate
Nitric acid	Nitrate

sodium hydroxide + hydrochloric acid → sodium chloride + water

calcium carbonate + sulfuric acid → calcium sulfate, + carbon dioxide + water

Metal oxides

Metals and oxygen	*Metals react with oxygen to form metal oxides*	**magnesium + oxygen → magnesium oxide** *$2Mg + O_2 \rightarrow 2MgO$*

Extraction of metals and reduction

Unreactive metals, such as gold, are found in the Earth as the metal itself. They can be mined from the ground.

Extraction using carbon	
Metals less reactive than carbon can be extracted from their oxides by reduction – removing oxygen	For example: **zinc oxide + carbon → zinc + carbon dioxide**

OILRIG - Oxidation Is Loss (of electrons) Reduction Is Gain (of electrons)

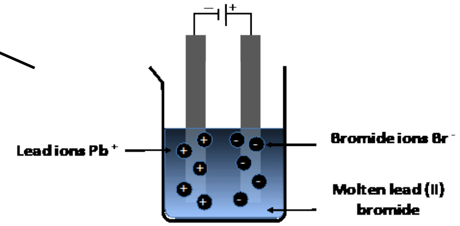
AQA Chemical Changes - Higher

Electrolysis

Process of electrolysis	*Splitting up using electricity*	When an ionic compound is melted or dissolved in water, the ions are free to move. These are then able to conduct electricity and are called electrolytes. Passing an electric current though electrolytes causes the ions to move to the electrodes.
Electrode	*Anode Cathode*	The positive electrode is called the anode and attracts negative cations. The negative electrode is called the cathode and attracts positive anions.

Extracting metals using electrolysis

Metals can be extracted from molten compounds using electrolysis.
This process is used when the metal is too reactive to be extracted by reduction with carbon.
The process is expensive due to large amounts of energy needed to produce the electrical current. Example: aluminium is extracted in this way.



Higher tier: You can display what is happening at each electrode using ionic half-equations:

At the cathode: $Pb^{2+} + 2e^- \rightarrow Pb$

At the anode: $2Br^- \rightarrow Br_2 + 2e^-$

Electrolysis of aqueous solutions

At the negative electrode	Metal will be produced on the electrode if it is less reactive than hydrogen. Hydrogen will be produced if the metal is more reactive than hydrogen.
At the positive electrode	Oxygen is formed at positive electrode. If you have a halide ion (Cl^-, I^-, Br^-) then you will get chlorine, bromine or iodine formed at that electrode.

Reactions of acids

Strong and Weak acids

Strong acids	*Completely ionised in aqueous solutions e.g. hydrochloric, nitric and sulfuric acids.*
Weak acids	*Only partially ionised in aqueous solutions e.g. ethanoic acid, citric acid.*
Hydrogen ion concentration	*As the pH decreases by one unit (becoming a stronger acid), the hydrogen ion concentration increases by a factor of 10.*

Soluble salts

Soluble salts	*Soluble salts can be made from reacting acids with solid insoluble substances (e.g. metals, metal oxides, hydroxides and carbonates).*
Production of soluble salts	*Add the solid to the acid until no more dissolves. Filter off excess solid and then crystallise to produce solid salts.*

The pH scale and neutralisation

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

In neutralisation reactions, hydrogen ions react with hydroxide ions to produce water:

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Nitric acid	Nitrate

sodium hydroxide + hydrochloric acid → sodium chloride + water

calcium carbonate + sulfuric acid → calcium sulfate, + carbon dioxide + water

Extraction of metals and reduction

Unreactive metals, such as gold, are found in the Earth as the metal itself. They can be mined from the ground.

Extraction using carbon	
Metals less reactive than carbon can be extracted from their oxides by reduction – removing oxygen	For example: **zinc oxide + carbon → zinc + carbon dioxide**

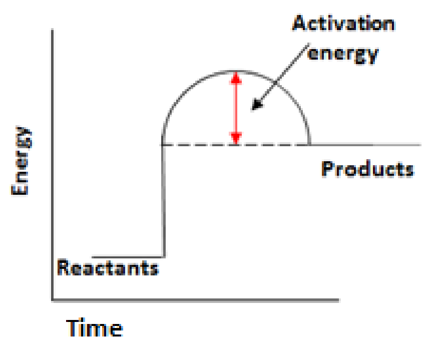
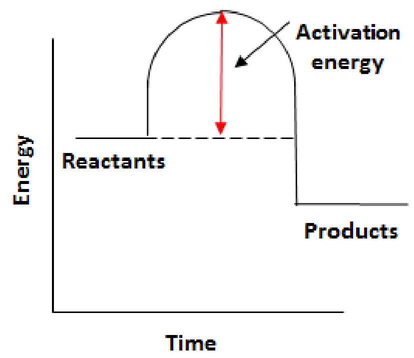
Metal oxides

Metals and oxygen	*Metals react with oxygen to form metal oxides*	**magnesium + oxygen → magnesium oxide** $2Mg + O_2 \rightarrow 2MgO$

AQA GCSE Energy changes - Foundation

Reaction profiles

Activation energy		
	Chemical reactions only happen when particles collide with sufficient energy	The minimum amount of energy that colliding particles must have in order to react is called the activation energy.

Endothermic		Products are at a higher energy level than the reactants. As the reactants form products, energy is transferred from the surroundings to the reaction mixture. The temperature of the surroundings decreases because energy is taken in during the reaction.
Exothermic		Products are at a lower energy level than the reactants. When the reactants form products, energy is transferred to the surroundings. The temperature of the surroundings increases because energy is released during the reaction.

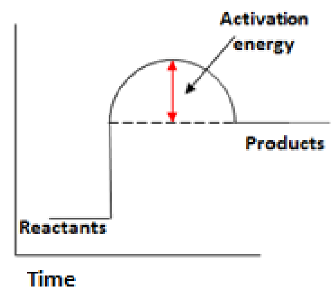
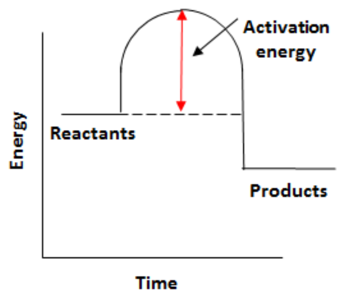
Breaking bonds in reactants	*Endothermic process*
Making bonds in products	*Exothermic process*

Overall energy change of a reaction		
	Exothermic	Energy released making new bonds is greater than the energy taken in breaking existing bonds.
	Endothermic	Energy needed to break existing bonds is greater than the energy released making new bonds.

AQA GCSE Energy changes

Reaction profiles

Activation energy		
Activation energy	*Chemical reactions only happen when particles collide with sufficient energy*	The minimum amount of energy that colliding particles must have in order to react is called the activation energy.

Endothermic		Products are at a higher energy level than the reactants. As the reactants form products, energy is transferred from the surroundings to the reaction mixture. The temperature of the surroundings decreases because energy is taken in during the reaction.
Exothermic		Products are at a lower energy level than the reactants. When the reactants form products, energy is transferred to the surroundings. The temperature of the surroundings increases because energy is released during the reaction.

The energy change of reactions

Breaking bonds in reactants	*Endothermic process*
Making bonds in products	*Exothermic process*

Overall energy change of a reaction		
Overall energy change of a reaction	*Exothermic*	Energy released making new bonds is greater than the energy taken in breaking existing bonds.
	Endothermic	Energy needed to break existing bonds is greater than the energy released making new bonds.

Bond energy calculation

Calculate the overall energy change for the forward reaction

$N_2 + 3H_2 \rightleftharpoons 2NH_3$

Bond energies (in kJ/mol): H-H 436, H-N 391, N≡N 945

Bond breaking: 945 + (3 x 436) = 945 + 1308 = 2253 kJ/mol

Bond making: 6 x 391 = 2346 kJ/mol

Overall energy change = 2253 - 2346 = -93kJ/mol

Therefore reaction is exothermic overall.

AQA GCSE Energy changes (Separates)

The energy change of reactions (HT only)

Breaking bonds in reactants	*Endothermic process*
Making bonds in products	*Exothermic process*

Overall energy change of a reaction		
	Exothermic	Energy released making new bonds is greater than the energy taken in breaking existing bonds.
	Endothermic	Energy needed to break existing bonds is greater than the energy released making new bonds.

Bond energy calculation	
	Calculate the overall energy change for the forward reaction $N_2 + 3H_2 \rightleftharpoons 2NH_3$ Bond energies (in kJ/mol): H-H 436, H-N 391, N≡N 945
	Bond breaking: 945 + (3 x 436) = 945 + 1308 = 2253 kJ/mol Bond making: 6 x 391 = 2346 kJ/mol Overall energy change = 2253 - 2346 = -93kJ/mol Therefore reaction is exothermic overall.

Cells and battertes

Simple cell	*Make a simple cell by connecting two different metals in contact with an electrolyte*	Increase the voltage by increasing the reactivity difference between the two metals.
Batteries	*Consist of two or more cells connected together in series to provide a greater voltage.*	

Non-rechargeable cells	*Stop when one of the reactants has been used up*	Alkaline batteries
Rechargeable cells	*Can be recharged because the chemical reactions are reversed when an external electrical current is supplied*	Rechargeable batteries

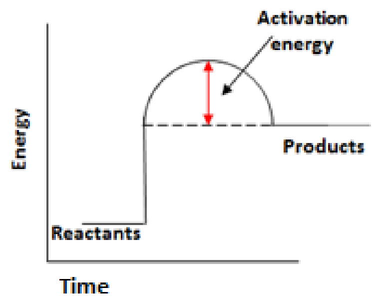
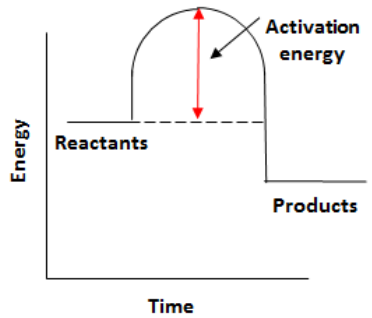
Fuel cells

Ionic half equations	Negative electrode: $2H_2\,(g) + 4OH^-\,(aq) \rightarrow 4H_2O\,(l) + 4e^-$	Positive electrode: $O_2\,(g) + 2H_2O\,(l) + 4e^- \rightarrow 4OH^-\,(aq)$

Hydrogen fuel cells	*Word equation:* *hydrogen + oxygen → water*	Symbol equation: $2H_2 + O_2 \rightarrow 2H_2O$
	Advantages: • No pollutants produced • Can be a range of sizes	Disadvantages: • Hydrogen is highly flammable • Hydrogen is difficult to store

Reaction profiles

Activation energy	*Chemical reactions only happen when particles collide with sufficient energy*	The minimum amount of energy that colliding particles must have in order to react is called the activation energy.

Endothermic		Products are at a higher energy level than the reactants. As the reactants form products, energy is transferred from the surroundings to the reaction mixture. The temperature of the surroundings decreases because energy is taken in during the reaction.
Exothermic		Products are at a lower energy level than the reactants. When the reactants form products, energy is transferred to the surroundings. The temperature of the surroundings increases because energy is released during the reaction.

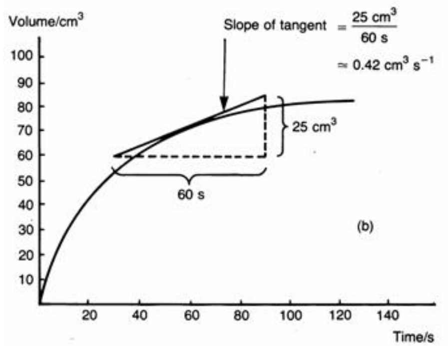
AQA GCSE The rate and extent of chemical change - Foundation

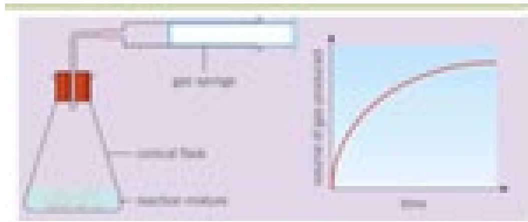
Rate of reaction

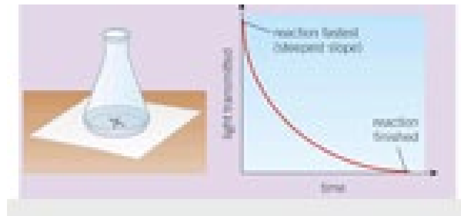
Calculating rates of reactions

Rate = $\frac{\text{quantity of reactant used}}{\text{time taken}}$

Rate = $\frac{\text{quantity of product formed}}{\text{time taken}}$

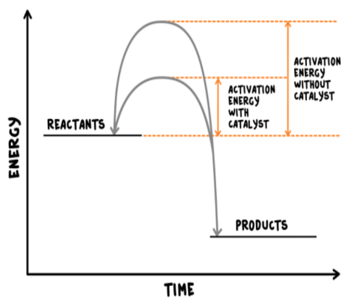






Catalysts

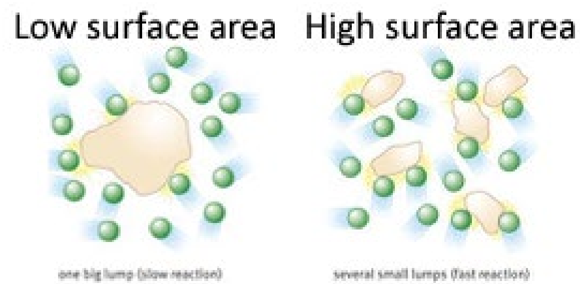
Catalyst	A catalyst changes the rate of a chemical reaction but is not used in the reaction.
Enzymes	These are biological catalysts.
How do they work?	Catalysts provide a different reaction pathway where reactants do not require as much energy to react when they collide.

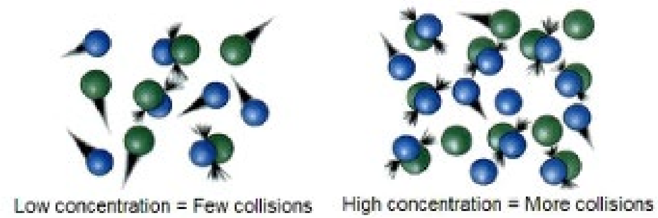


If a catalyst is used in a reaction, it is not shown in the word equation.

Collision theory and rates

Collision theory	*Chemical reactions can only occur when reacting particles collide with each other with sufficient energy (activation energy).*	Increasing the temperature increases the frequency of collisions and makes the collisions more energetic, therefore increasing the rate of reaction. Increasing the concentration, pressure (gases) and surface area (solids) of reactions increases the frequency of collisions, therefore increasing the rate of reaction.





Reversible reactions and dynamic equilibrium

Reversible reactions

Reversible reactions	In some chemical reactions, the products can react again to re-form the reactants.
Representing reversible reactions	A + B $\rightleftharpoons$ C + D
The direction	The direction of reversible reactions can be changed by changing conditions: A + B $\underset{\text{cool}}{\overset{\text{heat}}{\rightleftharpoons}}$ C + D

Energy changes and reversible reactions

If one direction of a reversible reaction is exothermic, the opposite direction is endothermic. The same amount of energy is transferred in each case.

For example:
Hydrated copper sulfate $\underset{\text{exothermic}}{\overset{\text{endothermic}}{\rightleftharpoons}}$ Anhydrous copper sulfate + Water

Equilibrium

Equilibrium in reversible reactions	When a reversible reaction occurs in apparatus which prevents the escape of reactants and products, equilibrium is reached when the forward and reverse reactions occur exactly at the same rate.

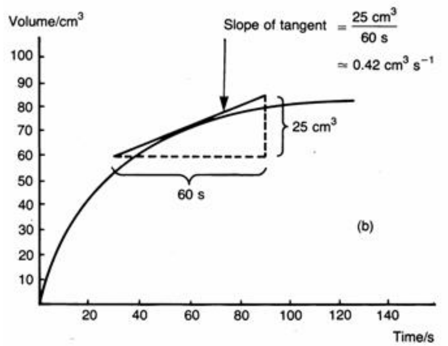
AQA GCSE The rate and extent of chemical change - Higher

Rate of reaction

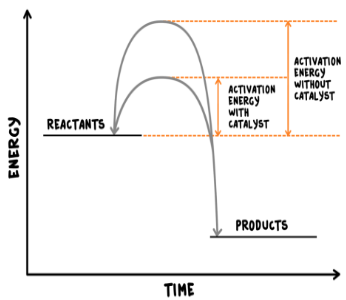
Calculating rates of reactions

Rate = $\frac{\text{quantity of reactant used}}{\text{time taken}}$

Rate = $\frac{\text{quantity of product formed}}{\text{time taken}}$



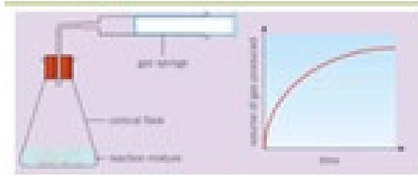
Catalysts

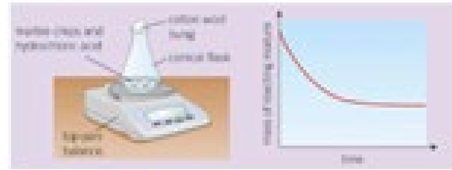


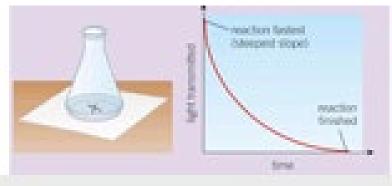
Catalyst	A catalyst changes the rate of a chemical reaction but is not used in the reaction.
Enzymes	These are biological catalysts.
How do they work?	Catalysts provide a different reaction pathway where reactants do not require as much energy to react when they collide.

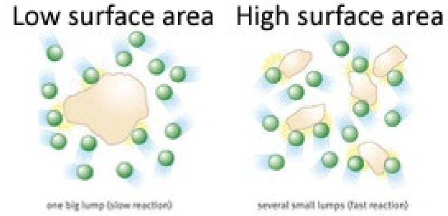
If a catalyst is used in a reaction, it is not shown in the word equation.

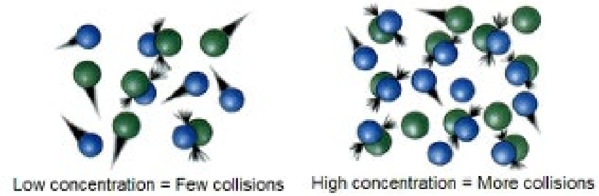
Collision theory and rates











Collision theory	*Chemical reactions can only occur when reacting particles collide with each other with sufficient energy (activation energy).*	Increasing the temperature increases the frequency of collisions and makes the collisions more energetic, therefore increasing the rate of reaction. Increasing the concentration, pressure (gases) and surface area (solids) of reactions increases the frequency of collisions, therefore increasing the rate of reaction.

Reversible reactions and dynamic equilibrium

Reversible reactions

Reversible reactions	In some chemical reactions, the products can react again to re-form the reactants.
Representing reversible reactions	A + B $\rightleftharpoons$ C + D
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Energy changes and reversible reactions

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For example: Hydrated copper sulfate $\underset{\text{exothermic}}{\overset{\text{endothermic}}{\rightleftharpoons}}$ Anhydrous copper sulfate + Water

Equilibrium

Equilibrium in reversible reactions	When a reversible reaction occurs in apparatus which prevents the escape of reactants and products, equilibrium is reached when the forward and reverse reactions occur exactly at the same rate.

Changing conditions and equilibrium

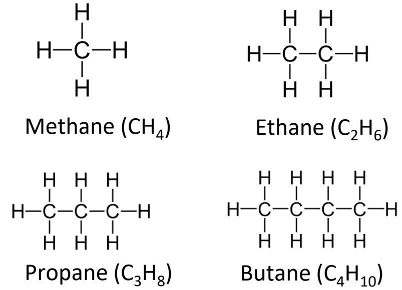
Le Chatelier's Principles	States that when a system experiences a disturbance (change in condition), it will respond to restore a new equilibrium state.
Changing concentration	If the concentration of a reactant is increased, more products will be formed . If the concentration of a product is decreased, more reactants will react.
Changing temperature	If the temperature of a system at equilibrium is increased: - Exothermic reaction = products decrease - Endothermic reaction = products increase
Changing pressure (gaseous reactions)	For a gaseous system at equilibrium: - Pressure increase = equilibrium position shifts to side of equation with smaller number of molecules. - Pressure decrease = equilibrium position shifts to side of equation with larger number of molecules.

AQA GCSE Organic Chemistry

Carbon compounds as fuels and feedstock

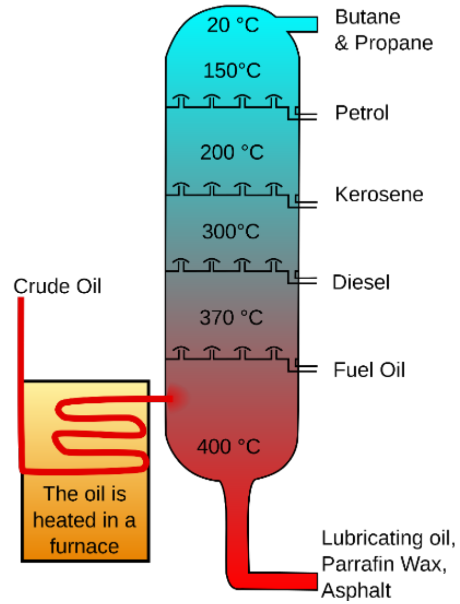
Crude oil, hydrocarbons and alkanes

Crude oil	*A finite resource*	Consisting mainly of plankton that was buried in the mud, crude oil is the remains of ancient biomass.
Hydrocarbons	*These make up the majority of the compounds in crude oil*	Most of these hydrocarbons are called alkanes (saturated).
General formula for alkanes	C_nH_{2n+2}	For example: C_2H_6 C_6H_{14}



Fractional distillation and petrochemicals

Hydrocarbon chains		
	In oil	Hydrocarbon chains in crude oil come in lots of different lengths.
	Boiling points	The boiling point of the chain depends on its length. During fractional distillation, they boil and separate at different temperatures due to this.



Carbon compounds as fuels and feedstock

Properties of hydrocarbons

Complete combustion of methane:
Methane + oxygen → carbon dioxide + water + energy
$CH_4 (g) + 2O_2 (g) \rightarrow CO_2 (g) + 2 H_2O (l)$

Boiling point (temperature at which liquid boils)	*As the hydrocarbon chain length increases, boiling point increases.*
Viscosity (how easily it flows)	*As the hydrocarbon chain length increases, viscosity increases.*
Flammability (how easily it burns)	*As the hydrocarbon chain length increases, flammability decreases.*

Cracking and alkenes

Alkenes	*Alkenes are hydrocarbons with a double bond (unsaturated - some are formed during the cracking process).*
Properties of alkenes	*Alkenes are more reactive that alkanes and react with bromine water. Bromine water changes from orange to colourless in the presence of alkenes.*

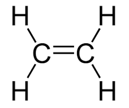
Cracking	*The breaking down of long chain hydrocarbons into smaller chains (and an alkene)*	The smaller chains are more useful and make polymers. Cracking can be done by various methods including catalytic cracking and steam cracking.
Catalytic cracking	*The heavy fraction is heated until vaporised*	After vaporisation, the vapour is passed over a hot catalyst forming smaller, more useful hydrocarbons.
Steam cracking	*The heavy fraction is heated until vaporised*	After vaporisation, the vapour is mixed with steam and heated to a very high temperature forming smaller, more useful hydrocarbons.

Decane → pentane + propene + ethane

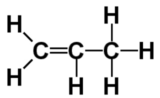
$C_{10}H_{22} \rightarrow C_5H_{12} + C_3H_6 + C_2H_4$

AQA GCSE Organic Chemistry 2 (Separates only)

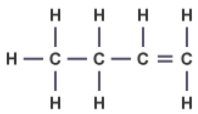
Reactions of alkenes and alcohols



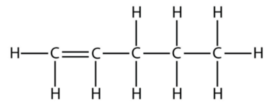
Ethene C_2H_4



Propene C_3H_6



Butene C_4H_8

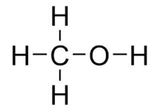


Pentene C_5H_{10}

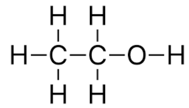
Reactions of alkenes

Alkene reactions C_nH_{2n}	*Alkenes react with oxygen in the same way as other hydrocarbons, just with a smoky flame due to incomplete combustion.*	Alkenes also react with hydrogen, water and the halogens. The C=C bond allows for the addition of other atoms.

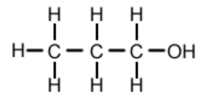
Alcohols



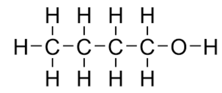
Methanol



Ethanol



Propanol



Butanol

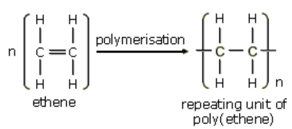
Functional group	*-OH* *For example: CH_3CH_2OH*	Methanol, ethanol, propanol and butanol are the first four of the homologous series.
Alcohol reactions	*Alcohols react with sodium, air and water.*	Alcohols and sodium: bubbling, hydrogen gas given off and salt formed. Alcohols and air: alcohols burn in air releasing carbon dioxide and water. Alcohols and water: alcohols dissolve in water to form a neutral solution.
Fermentation	*Ethanol is produced from fermentation.*	When sugar solutions are fermented using yeast, aqueous solutions of ethanol are produced. The conditions needed for this process include a moderate temperature (25 – 50°C), water (from sugar solution) and an absence of oxygen.

Carboxylic acids

Functional group	*-COOH* *For example: CH_3COOH*	Methanoic acid, ethanoic acid, propanoic acid and butanoic acid are the first four of the homologous series.
Carboxylic acid reactions	*Carboxylic acids react with carbonates, water and alcohols.*	Carboxylic acids and carbonates: These acids are neutralised by carbonates Carboxylic acids and water: These acids dissolve in water. Carboxylic acids and alcohols: The acids react with alcohols to form esters.
Strength (HT only)	*Carboxylic acids are weak acids*	Carboxylic acids only partially ionise in water. An aqueous solution of a weak acid with have a high pH (but still below 7).

Synthetic and naturally occurring polymers

Addition polymerisation

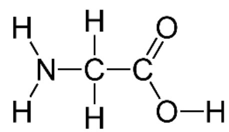
Polymers	*In addition polymers, the repeating unit has the same atoms as the monomer (small molecules that joined to make it).*	It can be displayed like this: 

Condensation polymerisation

Condensation polymerisation	*Condensation polymerisation involves monomers with two functional groups*	When these types of monomers react they join together and usually lose small molecules, such as water. This is why they are called condensation reactions.

Amino acids

Amino acids have two functional groups in a molecule. They react by condensation polymerisation to produce peptides.



Glycine

DNA and naturally occurring polymers

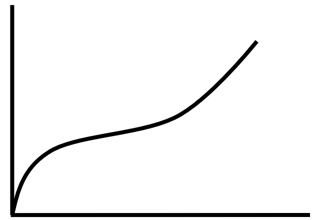
DNA	*Deoxyribonucleic acid is a large molecule essential for life. DNA gives the genetic instructions to ensure development and functioning of living organisms and viruses.*
DNA structure	*Most DNA molecules are two polymer chains made from four different monomers, called nucleotides. They are in the double helix formation.*
Natural polymers	*Other naturally occurring polymers include proteins, starch and cellulose and are all important for life.*

AQA Chemical analysis

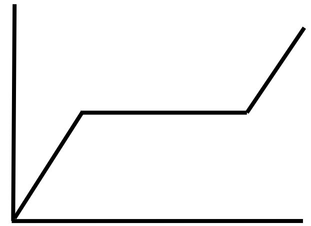
Purity, formulations and chromatography

Pure substances

Pure substances	***A pure substances is a single element or compound, not mixed with any other substance.***	Pure substances melt and boil at specific temperatures. Heating graphs can be used to distinguish pure substances from impure.



Melting point of an impure substance



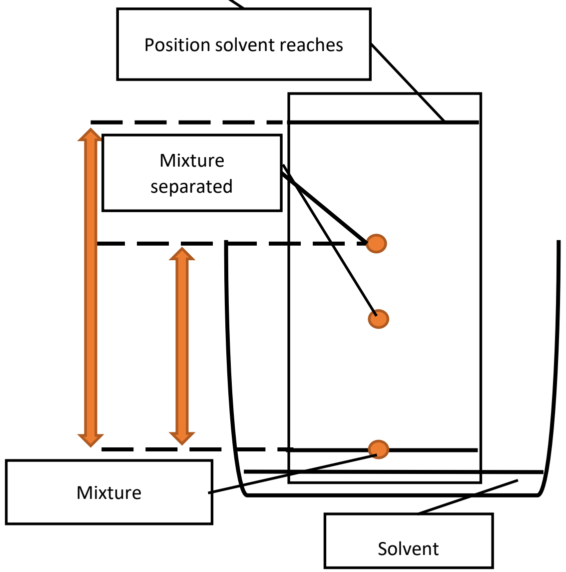
Melting point of a pure substance

Formulations

Formulation	***A formulation is a mixture that has been designed as a useful product.***
How are formulations made?	***By mixing chemicals that have a particular purpose in careful quantities.***
Examples of formulations.	***Fuels, cleaning agents, paints, medicines and fertilisers.***

Chromatography

Chromatography	***Can be used to separate mixtures and help identify substances.***	Involves a mobile phase (e.g. water or ethanol) and a stationary phase (e.g. chromatography paper).
R_f Values	***The ratio of the distance moved by a compound to the distance moved by solvent.***	$R_f = \frac{\text{distance moved by substance}}{\text{distance moved by solvent}}$
Pure substances	***The compounds in a mixture separate into different spots.***	This depends on the solvent used. A pure substance will produce a single spot in all solvents whereas an impure substance will produce multiple spots.



Identification of common gases

Gas	Test	Positive result
Hydrogen	***Burning splint***	'Pop' sound.
Oxygen	***Glowing splint***	Re-lights the splint.
Chlorine	***Litmus paper (damp)***	Bleaches the paper white.
Carbon dioxide	***Limewater***	Goes cloudy (as a solid calcium carbonate forms).

AQA Chemical analysis (Separates)

Purity, formulations and chromatography

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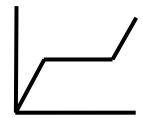
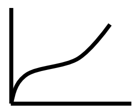


Melting point of a pure substance



Melting point of an impure substance

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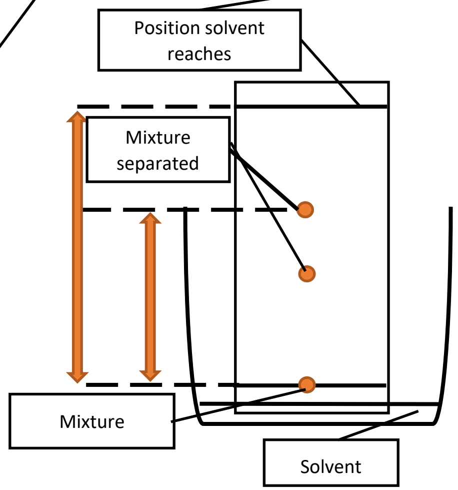

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Carbon dioxide	*Limewater*	Goes cloudy (as a solid calcium carbonate forms).

Identification of ions

Flame tests

Element	Colour flames
Lithium	*Crimson*
Sodium	*Yellow*
Potassium	*Lilac*
Calcium	*Orange-red*
Copper	*Green*

Metal hydroxides

Sodium hydroxide	*Is added to solutions to identify metal ions.*
White precipitates	*Aluminium, calcium and magnesium ions form this with sodium hydroxide solution.*
Coloured precipitates	*Copper (II) = blue* *Iron (II) = green* *Iron (III) = brown*

Carbonates, halides and sulfates

Carbonates	*React with dilute acids to form carbon dioxide.*
Halide ions	*When in a solution, they produce precipitates with silver nitrate solution in the presence of nitric acid.*
Sulfate ions	*When in a solutions they produce a white precipitate with barium chloride solutions in the presence of hydrochloric acid.*

Instrumental methods

Instrumental methods	*Methods that rely on machines*	Can be used to identify elements and compounds. These methods are accurate, sensitive and rapid.

Flame emission spectroscopy

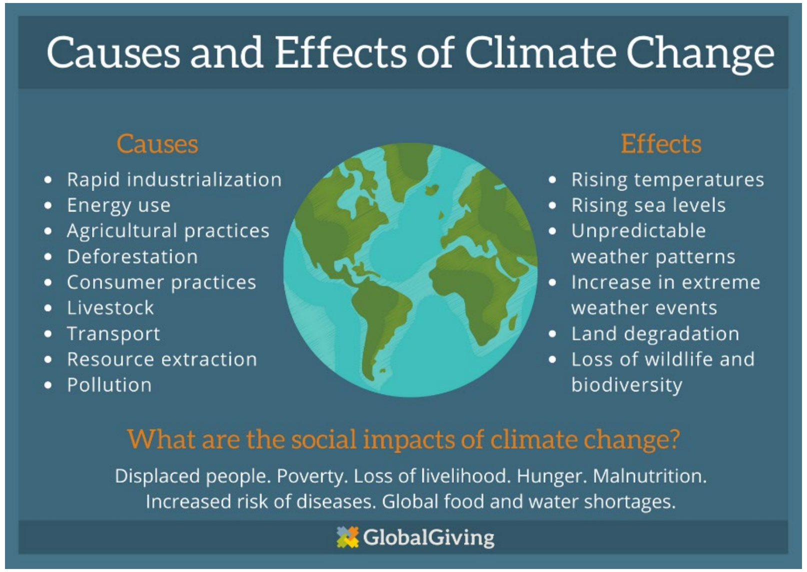
Flame emission spectroscopy	*An instrumental method used to analyse metal ions.*	The sample solution is put into a flame and the light that is given out is put through a spectroscope. The output line spectrum, can be analysed to identify the metal ions in the solution. It can also be used to measure concentrations.

AQA GCSE Chemistry of the atmosphere

1. Composition of the earths atmosphere now	
79%	Nitrogen
20%	Oxygen
1%	Other gases including CO_2

2. Evolution of the atmosphere		
Time	Atmosphere	reason
4 billion years a go	Nitrogen, Carbon dioxide and water vapour (like mars)	Volcanic erruptions
	Nitrogen, Carbon dioxide decreases	Earth cools and water vapour condenses. Carbon dioxide dissolves into the oceans
2.7 billion years ago	Increasing oxygen decreasing carbon dioxide	Photosynthesising organisms evolved
	Reducing oxygen to modern levels	Animals evolved and began respiring the oxygen

Algae and plants	***These produced the oxygen that is now in the atmosphere, through photosynthesis.***	carbon dioxide + water → glucose + oxygen $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$
Oxygen in the atmosphere	***First produced by algae 2.7 billion years ago.***	Over the next billion years plants evolved to gradually produce more oxygen. This gradually increased to a level that enabled animals to evolve.



3. Climate change	
Greenhouse gases	Gases which increase the temperature of the atmosphere Eg Carbon dioxide, methane, water vapour
Greenhouse effect	When excess greenhouse gases absorb and radiate IR radiation back to the earth warming it
Man-made climate change	The leading theory that human activities are causing an increase in global temperature
Carbon footprint	Total amount of carbon dioxide emitted over the life of a product, service or event
Global dimming	Particulates block the light from the sun slightly, reducing global temperature
Acid rain	Gases dissolve in rain causing damage to buildings, statues, lakes and trees

4. Atmospheric pollutants from combustion		
Pollutant	Source	Effect
Carbon dioxide	All combustion	Global warming
Carbon monoxide	Incomplete combustion	Toxic, breathing problems
Carbon particle (Soot)	Incomplete combustion	Breathing problems, global dimming
Sulfur dioxide	Burning sulphur, impurities in fossil fuels	Acid rain
Oxides of nitrogen	Vehicle engines	Acid rain

AQA GCSE Using Resources - Foundation

Life cycle assessment

LCAS	***Life cycle assessments are carried out to assess the environmental impact of products***	They are assessed at these stages: - Extraction and processing raw materials - Manufacturing and packaging - Use and operation during lifetime - Disposal

Potable water

Potable water	***Water of an appropriate quality is essential for life***	Human drinking water should have low levels of dissolved salts and microbes. This is called potable water.
UK water	***Rain provides water with low levels of dissolved substances***	This water collects in the ground/lakes/rivers. To make potable water an appropriate source is chosen, which is then passed through filter beds and then sterilized using chlorine, ozone or UV light.
Desalination	***Needs to occur is fresh water is limited and salty/sea water is needed for drinking***	This can be achieved by distillation or by using large membranes e.g. reverse osmosis. These processes require large amounts of energy.

Waste water treatment

Waste water	***Produced from urban lifestyles and industrial processes***	These require treatment before used in the environment. Sewage needs the organic matter and harmful microbes removed.
Sewage treatment	***Includes many stages***	- Screening and grit removal - Sedimentation to produce sludge and effluent (liquid waste or sewage). - Anaerobic digestion of sludge - Aerobic biological treatment of effluent.

Ways of reducing the use of resources

Reduce, reuse and recycle	***This strategy reduces the use of limited resources***	This, therefore, reduces energy sources being used, reduces waste (landfill) and reduces environmental impacts.
Limited raw materials	***Used for metals, glass, building materials, plastics and clay ceramics***	Most of the energy required for these processes comes from limited resources. Obtaining raw materials from the Earth by quarrying and mining causes environmental impacts.
Reusing and recycling	***Metals can be recycled by melting and recasting/reforming***	Glass bottles can be reused. They are crushed and melted to make different glass products. Products that cannot be reused are recycled.

AQA GCSE Using Resources - Higher

Life cycle assessment

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Alternative methods of extracting metals

Metals ores	***These resources are limited***	Copper ores especially are becoming sparse. New ways of extracting copper from low-grade ores are being developed.
Phytomining	***Plants absorb metal compounds***	These plants are then harvested and burned; their ash contains the metal compounds.
Bioleaching	***Bacteria is used to produce leachate solutions that contain metal compounds***	The metal compounds can be processed to obtain the metal from it e.g. copper can be obtained from its compounds by displacement or electrolysis.

Ways of reducing the use of resources

Reduce, reuse and recycle	***This strategy reduces the use of limited resources***	This, therefore, reduces energy sources being used, reduces waste (landfill) and reduces environmental impacts.
Limited raw materials	***Used for metals, glass, building materials, plastics and clay ceramics***	Most of the energy required for these processes comes from limited resources. Obtaining raw materials from the Earth by quarrying and mining causes environmental impacts.
Reusing and recycling	***Metals can be recycled by melting and recasting/reforming***	Glass bottles can be reused. They are crushed and melted to make different glass products. Products that cannot be reused are recycled.

AQA GCSE Using Resources Part 2 (Separates only)

Using materials

Corrosion and its prevention

Corrosion	*The destruction of materials by chemical reactions with substances in the environment*	An example of this is iron rusting; iron reacts with oxygen from the air to form iron oxide (rust) water needs to be present for iron to rust.
Preventing corrosion	*Coatings can be added to metals to act as a barrier*	Examples of this are greasing, painting and electroplating. Aluminium has an oxide coating that protects the metal from further corrosion.
Sacrificial corrosion	*When a more reactive metal is used to coat a less reactive metal*	This means that the coating will react with the air and not the underlying metal. An example of this is zinc used to galvanise iron.

Alloys are useful materials

Alloys	*A mixture of two elements, one of which must be a metal e.g. Bronze is an alloy of copper and tin and Brass is an alloy of copper and zinc.*
Gold carats	*Gold jewellery is usually an alloy with silver, copper and zinc. The carat of the jewellery is a measure of the amount of gold in it e.g. 18 carat is 75% gold, 24 carat is 100% gold.*
Steels	*Alloys of iron, carbon and other metals.*
	High carbon steel is strong but brittle.
	Low carbon steel is softer and easily shaped.
	Steel containing chromium and nickel (stainless) are hard and corrosion resistant.
	Aluminium alloys are low density.

Ceramics, polymers and composites

Polymers	*Thermosetting*	polymers that do not melt when they are heated.
	Thermosoftening	polymers that melt when they are heated.

Composite materials	*A mixture of materials put together for a specific purpose e.g. strength*	Soda-lime glass, made by heating sand, sodium carbonate and limestone.
		Borosilicate glass, made from sand and boron trioxide, melts at higher temperatures than soda-lime glass.
		MDF wood (woodchips, shavings, sawdust and resin)
		Concrete (cement, sand and gravel)
Ceramic materials	*Made from clay*	Made by shaping wet clay and then heating in a furnace, common examples include pottery and bricks.
Polymers	*Many monomers can make polymers*	These factors affect the properties of the polymer. Low density (LD) polymers and high density (HD) polymers are produced from ethene. These are formed under different conditions.

The Haber process and the use of NPK fertilisers

Production and uses of NPK fertilisers

NPK fertilisers	*These contain nitrogen, phosphorous and potassium*	Formulations of various salts containing appropriate percentages of the elements.
Fertiliser examples	*Potassium chloride, potassium sulfate and phosphate rock are obtained by mining*	Phosphate rock needs to be treated with an acid to produce a soluble salt which is then used as a fertiliser. Ammonia can be used to manufacture ammonium salts and nitric acid.

The Haber process

The Haber process	*Used to manufacture ammonia*	***Ammonia is used to produce fertilisers*** Nitrogen + hydrogen $\rightleftharpoons$ ammonia
Raw materials	*Nitrogen from the air while hydrogen from natural gas*	Both of these gases are purified before being passed over an iron catalyst. This is completed under high temperature (about $450^{\circ}C$) and pressure (about 200 atmospheres).
Catalyst	*Iron*	The catalyst speeds up **both** directions of the reaction, therefore not actually increasing the amount of valuable product.

The Haber process – conditions and equilibrium	
Pressure	*The reactants side of the equation has more molecules of gas. This means that if pressure is increased, equilibrium shifts towards the production of ammonia (Le Chatelier's principle). The pressure needs to be as high as possible.*
Temperature	*The forward reaction is exothermic. Decreasing temperature increases ammonia production at equilibrium. The exothermic reaction that occurs releases energy to surrounding, opposing the temperature decreases. Too low though and collisions would be too infrequent to be financially viable.*