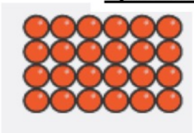
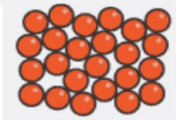
Knowledge Organiser: GCSE – C3 Chemistry; Structure and Bonding

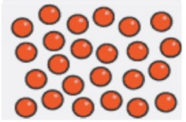
Episode 1 - States of matter



Solid - Particles vibrate and have a regular arrangement



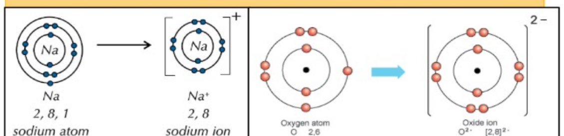
Liquid - Particles can slide past each other, random arrangement



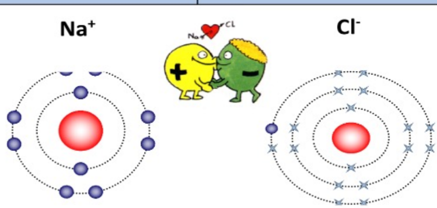
Gas - Particles are far apart and have high energy, so they move in all directions

Episode 2 - Ions and Ionic Bonding

Ionic bonding is the **transfer** of electrons from a metal to a non-metal. The oppositely charged ions are electrostatically attracted to each other creating an **IONIC BOND**.



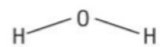
Metals lose electrons = positive ion	Non-metals gain electrons = negative ion



Na loses 1 electron, chlorine gains this 1 electron to fill their outer shells. The oppositely charged ions then attract.

Episode 3 - Covalent Bonding

In covalent bonding, non-metal atoms **share** electrons so all the atoms in the molecule have full outer shells. Covalent molecules can be *simple* or *giant molecular structures.*

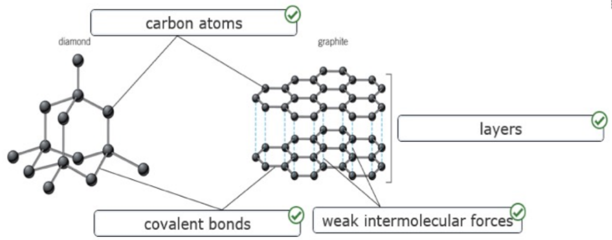


Simple: small molecules with strong covalent bonds

Giant molecular: huge networks of atoms with strong covalent bonds

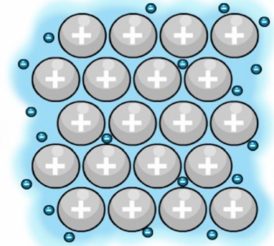
Graphite is made up of layers that can slide, each carbon forms 3 strong covalent bonds with other carbon atoms. It can also conduct electricity

Diamond is very hard due to the rigid covalent structure.

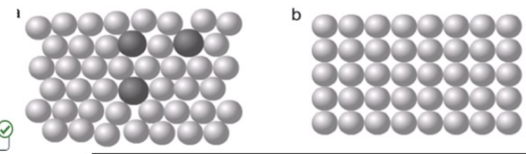


Ionic	Covalent	Metallic
High melting point– due to strong electrostatic attractions between ions	Simple molecules: Low melting and boiling points (mainly liquids and gases at room temp), no overall charge, weak intermolecular forces between molecules	High melting points – strong attractions between delocalised electrons and metal ions.
Can conduct electricity when dissolved or molten – ions are free to move to carry charge	Giant molecular: High melting and boiling point, due to lots of strong covalent bonds	Good conductors of electricity and heat because the delocalised electrons can move freely through the lattice structure.

Episode 4 - Metallic Bonding A 'sea' of free-moving delocalised electrons surrounds the positive metal ions.



Alloy	Pure metal
Different sized atoms Irregular arrangement Particles unable to slide = harder	Made up of one type of atom Giant lattice structure. Layers can slide when force applied



Key definitions to remember!

Ion: A charged particle.

Alloy: A mixture of metals.

Intermolecular force: A **weak** force between molecules.

Polymer: A plastic made up from small monomers.

Delocalised: Does not belong to any atom and are free moving.

Ionic bond: transfer of electrons

Covalent bond: shared pair of electrons

Leave blank to allow students to glue.

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Term	Topic/s	Year group
1	C3	10

Tier 2 'unlocking' language	Tier 3 subject relevant language
Metallic	Electrostatic
Bonds	Lone Pair
Alloy	Intermolecular Forces
Properties	Covalent
Giant	Ionic
Molecule	Allotrope
Chemical	Graphite
Diamond	Fullerenes

Knowledge Organiser: GCSE – C4 Chemistry; Chemical Calculations

Conservation of Mass

No atoms can be created or made during a chemical reaction, so the mass of the reactants will equal the mass of the product.

Reactions can be shown as a word or symbol equation.

magnesium + oxygen → magnesium oxide

Mg + O → MgO

Symbol equations should also be balanced; they should have the same number of atoms on each side.

$2Mg + O_2 \rightarrow 2MgO$

The Mole

The Avogadro constant, 6.02×10^{23}, is the number of molecules of a substance that make up one mole of that substance.

Iron has an A_r of 56, so 1 mole of iron has a mass of 56g.

Oxygen (O_2) gas has an M_r of 32, so 1 mole of oxygen has a mass of 32g.

Ammonia (NH_3) has an M_r of 17, so 1 mole of ammonia has a mass of 17g.

$$\text{number of moles} = \frac{\text{mass in g (of an element or compound)}}{M_r \text{ (of the element or compound)}}$$

Moles and Equations

Write a balanced symbol equation for the reaction in which 5.6g of iron reacts with 10.65g of chlorine to form iron chloride.

Work out the M_r of all the substances.

A_r of Fe = 56 and A_r of Cl = 35.5

Divide the mass of each substance by its M_r to calculate how many moles of each substance reacted or produced.

moles Fe = 5.6/56 = 0.1

moles Cl = 10.65/35.5 = 0.3

Divide by the smallest number of moles

$Fe = \frac{0.1}{0.1} = 1$ $\quad Cl = \frac{0.3}{0.1} = 3$

Write down the balanced symbol equation.

Fe + 3Cl

Chlorine exists as Cl_2 so the whole thing must be multiplied by 2.

$2Fe + 3Cl_2 \rightarrow 2FeCl_3$

Relative Formula Mass

The relative formula mass (M_r) is the sum of all the relative atomic masses (A_r) of the atoms in the formula.

Examples:

HCl

A_r of H = 1

A_r of Cl = 35.5

M_r of HCl = 1 + 35.5 = 36.5

H_2SO_4

A_r of H = 1

A_r of S = 32

A_r of O = 16

M_r of H_2SO_4 = (1 × 2) + 32 + (16 × 4)

M_r of H_2SO_4 = 2 + 32 + 64

M_r of H_2SO_4 = 98

Calculating Percentage Mass of an Element in a Compound

percentage mass of an element in a compound =

$$A_r \times \frac{\text{number of atoms of that element}}{M_r \text{ of the compound}}$$

Find the percentage mass of oxygen in magnesium oxide.

A_r of magnesium = 24 $\quad A_r$ of oxygen = 16

M_r of MgO = 24 + 16

= 40

$\%\ \text{mass} = \frac{A_r}{M_r} = \frac{16}{40} = 0.4 \quad 0.4 \times 100 = 40\%$

Conservation of Mass

Show that mass is conserved in a reaction.

$2Mg + O_2 \rightarrow 2MgO$

(2 × 24) + (2 × 16) → 2(24 + 16)

48 + 32 → 2 × 40

80 → 80

Total M_r on the left-hand side of the equation is the same as the M_r on the right-hand side.

Calculate the mass of the product.

6g of magnesium reacts with 4g of oxygen:

6 + 4 = 10g of magnesium oxide

During a reaction the mass can change. If one of the reactants is a gas, the mass can go up.

E.g.

magnesium + oxygen → magnesium oxide

Oxygen from the air is added to the magnesium (making the product) which will be heavier in mass.

If one of the products is a gas, the mass can go down.

E.g.

sodium carbonate → sodium oxide + carbon dioxide

When sodium carbonate is thermally decomposed, carbon dioxide gas is produced and released into the atmosphere.

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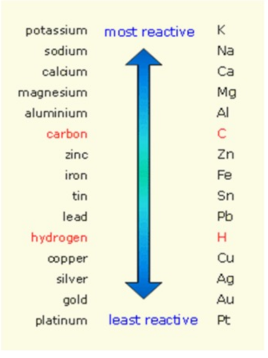
Term	Topic/s	Year group
2	C4	10

Tier 2 'unlocking' language	Tier 3 subject relevant language
Mass	Relative Formula Mass
Balanced	Conservation
Equation	Concentration
Concentration	Limiting Reactants
Calculate	Composition
Solution	Mole
Percentage	Avagadro
Element	Solute

Knowledge Organiser: GCSE – C5 Chemistry; Chemical Changes



Reactivity depends on tendency to form metal ion

A and C are Cations (Positive Ions)
B and D are Anions (Negative Ions)

Double Displacement Reaction

HT: OILRIG
Oxidation **I**s **L**oss of electrons
Reduction **I**s **G**ain of electrons

Metal + Oxygen → Metal Oxide

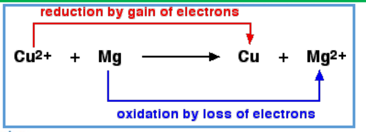
Metal + Water → Metal Hydroxide + hydroge

Metal + acid → Metal salt + Hydrogen

Acid+metal → salt + hydrogen
Acid + alkali → salt + water
Acid + insoluble base → salt + water
Acid + carbonate → salt + water + carbon dioxide

HT: OILRIG
e.g. $2HCl + Mg \rightarrow MgCl_2 + H_2$
Magnesium is oxidised
$Mg \rightarrow Mg^{2+} + 2e^-$

Hydrochloric Acid → Chlorides
HCl
Nitric Acid → Nitrates
HNO_3
Sulphuric Acid → Sulphates
H_2SO_4



Key Terms	Definitions
Oxidation	The loss of electrons from an atom OR when an atom gains an oxygen atom
Reduction	The opposite to oxidation, when an atom gains electrons OR when an atom loses an oxygen atom
REDOX Reaction	A reaction where one atom is oxidised and another atom is reduced

Other methods of extraction
The amount of some metals is running out, this means people are finding new ways to extract metals like copper.
Phytomining uses plants to absorb copper from the soil, the plants are then burnt and the copper extracted.
Bioleaching involves using bacteria to make a **leachate** that contains metal compounds.
Scrap iron can also be used to **displace copper** from a solution.

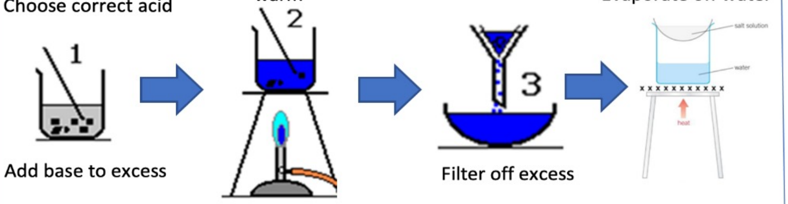
Oxidation Reactions
When working out whether a reaction is oxidation or reduction: in terms of electrons, remember OILRIG. This stands for oxidation is loss and reduction is gain.

HT - Oxidation Reactions of Acids
When an acid reacts with a metal a salt and hydrogen are produced. For example the symbol the symbol equation for an acid reacting with lithium is:

$$2Li + 2HCl \rightarrow 2LiCl + H_2$$

In this reaction, lithium has been oxidised because it has lost an electron to form a **+1 ion** and hydrogen has been reduced from a +1 ion to a **hydrogen molecule.**

RP: Preparation of a dry sample of a soluble salt

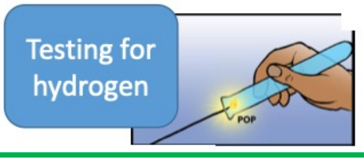


Reactions of Metals
When a metal reacts with water it produces a metal hydroxide and **hydrogen gas.**
The more reactive the metal is, the more vigorous the reaction. For example:
Lithium + Water → Lithium Hydroxide + Hydrogen
You see a similar pattern for the reaction between metals and acids however the products in these reactions are different, in this case you will make a salt and water, the salt will depend on the type of acid that you have used.
Lithium + Hydrochloric Acid → Lithium Chloride + Water
If sulphuric acid is used the salt made will be a sulphate, if nitric acid is used the salt will be a nitrate.
Metals also react with oxygen to form metal oxides; in this reaction the metal donates electrons to the oxygen. This means the metal is **oxidised as it has lost electrons. The oxygen is reduced as it has gained electrons.**

Extraction of Metals
A metal ore is a compound found in rock, dug out of the ground, that contains enough metal that it is **economical** to extract it. For example, magnesium oxide. In order for us to use the magnesium we need to **extract** it from the oxide.
Metals more reactive than carbon are extracted from their ore using **electrolysis**.
Metals which are less reactive than carbon are extracted from their ore using **reduction** (by adding carbon). Reduction is the removal of oxygen as seen in the example.
Example: Iron Oxide + Carbon → Iron + Carbon Dioxide

The least reactive metals such as gold and silver are found on their own—they do not form a compound. This means they do not need to be extracted from their ore.

Reactivity series	An arrangement of metals in order of reactivity
Displacement reaction	Reaction where a more reactive element takes the place of a less reactive element in a compound
Oxidation	A reaction in which a substance loses electrons (gains oxygen)
Reduction	Reaction in which a substance gains electrons (loses oxygen)
Ore	A rock from which a metal can be extracted for profit
Acid	Solution with a pH less than 7; produces H^+ ions in water
Alkali	Solution with a pH more than 7; produces OH^- ions in water
Aqueous	Dissolved in water



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2	C5	10

Tier 2 'unlocking' language	Tier 3 subject relevant language
Electrons	Oxidation
Equation	Stoichiometry
Concentration	Displacement
Formula	Neutralisation
Reactivity	Alkali
Extraction	pH
Excess	Dissociation
(In)Soluble	Ionise

Knowledge Organiser: GCSE – C6 Chemistry; Electrolysis

Electrolysis means splitting up of a compound using electricity.

If you pass electric current through an ionic substance that is molten or dissolved in water, it breaks down into its substituent elements.

The liquid will then conduct electricity as it contains freely moving ions.

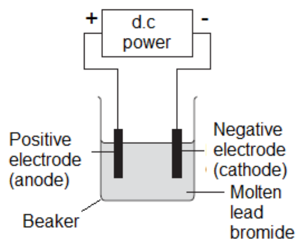
The liquid that conducts electricity is known as the **electrolyte**.

The **positive electrode** is called the **anode**.

The **negative electrode** is called the **cathode**.

At the anode, negative ions are attracted. At the cathode, positive ions are attracted.

Electrolysis always involves oxidation and reduction. **Oxidation** (loss of electrons) occurs at the **anode**, **reduction** (gain of electrons) occurs at the **cathode**.



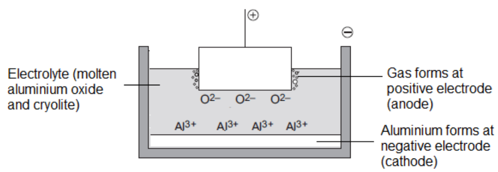
In the electrolysis of **molten lead bromide** (diagram above):
Lead metal is produced at the cathode $Pb^{2+} + 2e^- \rightarrow Pb$
Bromine is produced at the anode $2Br^- \rightarrow Br_2 + 2e^-$

Metals that are **more reactive than carbon** are extracted **by electrolysis**

Aluminium is extracted from its aluminium oxide ore (called Bauxite) by electrolysis.

Aluminium oxide Al_2O_3 has a high melting point (>2000°C) because it has ionic bonding. So molten cryolite is added to dissolve the aluminium oxide, lowering its melting point to 900°C.

The **electrodes** are made from **graphite** (carbon) as graphite can conduct electricity (due to it having delocalised electrons between it's layers.



Aluminium forms at negative electrode, oxygen at positive electrode.
$Al^{3+} + 3e^- \rightarrow Al$ (Reduction)
$2O^{2-} \rightarrow O_2 + 4e^-$ (Oxidation)

The oxygen produced at the positive electrode reacts with the carbon graphite electrode forming carbon dioxide. Hence the electrode has to be replaced after a while.

Using molten cryolite to reduce the melting point of aluminium oxide saves energy and hence costs.

Electrolysis knowledge organiser

Reactivity affects products formed by electrolysis in **aqueous** solutions.

Hydrogen can be included in the reactivity series. It slots in between lead and copper.

Reactivity increases ↑

Reactivity series
Potassium
Sodium
Lithium
Calcium
Magnesium
Aluminium
Carbon
Zinc
Iron
Tin
Lead
Hydrogen
Copper
Silver
gold
platinum

Aqueous means dissolved in water (solution).

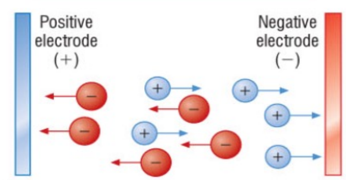


Figure 1 An ion always moves towards the oppositely charged electrode

In electrolysis of aqueous solutions, there will be some H^+ ions and OH^- ions present

At the negative electrode, if metal ions and H^+ ions are present, the metal ions will stay in solution if the metal is more reactive than hydrogen. Hence hydrogen gas would be produced. If the metal is less reactive than hydrogen then the metal will form.

At the positive electrode, if OH^- ions and halide ions (Cl^-, Br^- or I^-) are present, then halogen molecules (Cl_2, Br_2 or I_2) are formed. If no halide ions present then oxygen forms.

Solution being electrolysed	Negative electrode (Cathode)	Positive electrode (Anode)
$CuBr_2$	Copper	Bromine
NaCl	Hydrogen	Chlorine
KI	Hydrogen	Iodine
Na_2SO_4	Hydrogen	Oxygen

Sodium chloride NaCl solution is known as brine.

In the electrolysis of sodium chloride NaCl solution, three products are formed, hydrogen, chlorine and sodium hydroxide

At the negative electrode hydrogen gas forms
$2H^+ + 2e^- \rightarrow H_2$ (reduction)

At the positive electrode, chlorine gas forms
$2Cl^- \rightarrow Cl_2 + 2e^-$ (Oxidation)

Sodium ions stay in solution (as sodium is more reactive than hydrogen) and combine with hydroxide ions to form sodium hydroxide. $Na^+ + OH^- \rightarrow NaOH$

Electrolysis of solutions

The following ions are also present along with the substance being electrolysed:

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

OILRIG

Oxidation **I**s **L**oss **R**eduction **I**s **G**ain (of electrons)

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3	C6	10

Tier 2 'unlocking' language	Tier 3 subject relevant language
Ions	Electrolysis
Ionic	Half Equation
Extracting	Electrode
Positive	Electrolyte
Negative	Anode
Aqueous	Cathode
Reactivity	Oxidation
Solution	Reduction

Knowledge Organiser: GCSE – C7 Chemistry; Energy Changes

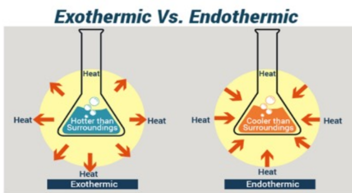
Episode 1 - Exothermic vs Exothermic

Exothermic

In some reactions more energy comes OUT than goes in

The reactants have more energy than the products.

e.g. combustion, oxidation, neutralisation.



Endothermic

In some reactions more energy goes IN than comes out.

The products have more energy than the reactants.

e.g. thermal decomposition

Episode 2 - Uses

Exothermic

Self heating cans, hand warmers

Chemicals react in an exothermic reaction and give OUT heat energy.

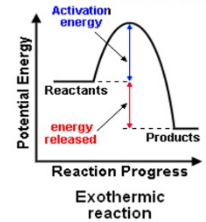
Endothermic

Cool packs for sports injuries

Chemicals react in an Endothermic reaction and take IN heat energy – therefore cooling the surroundings.

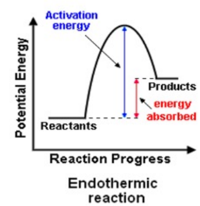
Episode 3 - Reaction Profiles

Exothermic



Products at LOWER energy than reactants

Endothermic



Products at HIGHER energy than reactants

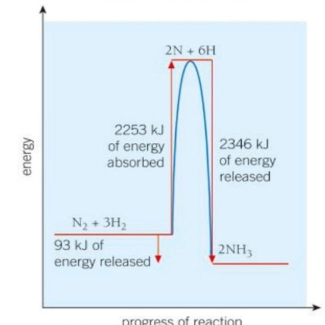
Activation Energy is the energy needed to start a reaction.

Episode 4 - Bond energy Calculations

BINMIX
Bond Breaking Is eNdothermic
Bond Making Is eXothermic

Exothermic

More energy comes OUT making bonds



Endothermic

More energy goes IN breaking bonds

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Term	Topic/s	Year group
1	C7	10

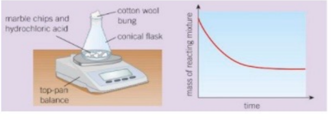
Tier 2 'unlocking' language	Tier 3 subject relevant language
Temperature	Exothermic
Thermal	Endothermic
Reactants	Activation energy
Combustion	Catalyst
Absorbed	Enthalpy Change
Energy	Thermal Decomposition
Positive	Bond Energy
Negative	Neutralisation

Knowledge Organiser: GCSE – C8 Chemistry; Rates and Equilibrium

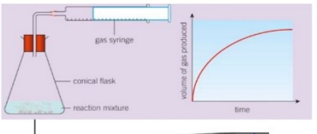
Episode 1 - Measuring Rate

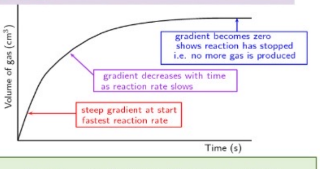
To measure the rate of a reaction you can:
- **Measure how fast the reactants are used up**
- **Measure how fast the products are made**

e.g. Measure mass lost due to gas formed



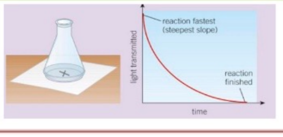
e.g. Measure volume of gas made





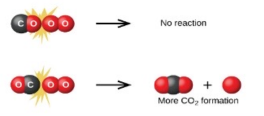
Rate = volume of gas ÷ time
cm^3/s

e.g. Measure time for insoluble product to form



Episode 2 – Collision theory

For a reaction to happen reactants must: **collide** with **enough energy** (activation energy)



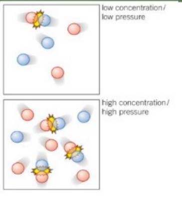
A successful collision is one that leads to a reaction

So to increase the rate of a reaction you must either
- **Increase the frequency of collisions**
- **Increase the energy of the collisions**
- **Decrease the energy needed for a collision to be successful**

Episode 3 - Factors affecting rate

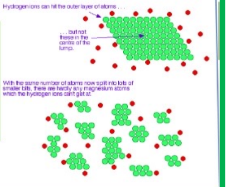
Concentration and Pressure

More particles in the same space. **More frequent collisions**



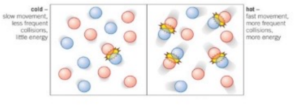
Surface area

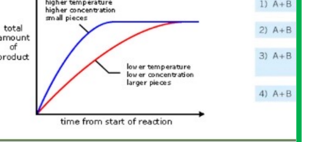
More particles available to react. **More frequent collisions**



Temperature

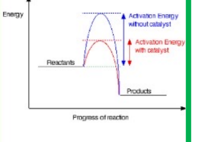
Particles **move faster**.
So they **collide more frequently**.
Particles collide **with more energy**.
So more of the collisions are **successful**.





Catalysts

Lower the energy needed for successful collisions. (Activation energy)
Not used up.
Biological catalysts are called **enzymes**



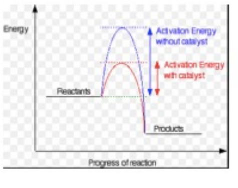
Collision Theory- in more detail Concentration

If the concentration of a solution is increased then there are more particles in a given volume, therefore collisions are **more frequent** and the chemical reaction is faster. Concentration **is directly proportional** to rate of reaction (if you double the concentration you double the rate

Collision Theory in more detail Catalysts

A catalyst is a substance which speeds up a chemical reaction without being used up. It speeds up a reaction because it lowers the activation energy by providing an alternative pathway and this means that there are more **successful collisions and a faster reaction.**

The effect of a catalyst is shown on the reaction profile below:



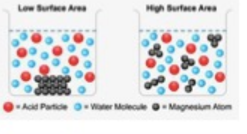
Catalysts are not included in a chemical equation as they are not used up in a chemical reaction.

Collision Theory in more detail Temperature

When you increase the temperature of something the particles will move around faster, this increases the **frequency of the collisions.** As well as that, as the particles are moving faster the particles collide with more energy making it more likely that collisions exceed the **activation energy.**

Collision Theory in more detail Surface Area

When you increase the surface area of a solid (you cannot increase the surface area of a liquid or gas). You increase the number of particles that are available for collision, therefore increasing the frequency of collisions therefore increase the rate of reaction.



Collision Theory- in more detail gas pressure

If the reaction is carried out in the gaseous state, then increasing the pressure will increase the rate of reaction. If there are more particles in a given volume of gas, then collisions will be more frequent and therefore the reaction will be faster.

Enzymes

Enzymes **are biological catalysts**, they speed up chemical reactions in biological systems for example in digestion in animals. Unlike catalysts enzymes have an optimum temperature where they work best, this is usually around 37

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How do we use Knowledge Organisers in Chemistry

How can you use knowledge organisers at home to help us?

- **Retrieval Practice:** Read over a section of the knowledge organiser, cover it up and then write down everything you can remember. Repeat until you remember everything.
- **Flash Cards:** Using the Knowledge Organisers to help on one side of a piece of paper write a question, on the other side write an answer. Ask someone to test you by asking a question and seeing if you know the answer.
- **Mind Maps:** Turn the information from the knowledge organiser into a mind map. Then reread the mind map and on a piece of paper half the size try and recreate the key phrases of the mind map from memory.
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Term	Topic/s	Year group
3	C8	10

Tier 2 'unlocking' language	Tier 3 subject relevant language
Frequency	Le Chatelier's Principle
Collisions	Catalyst
Volume	Equilibrium
Concentration	Neutralisation
Temperature	pH
Pressure	Ions
Energy	Activation energy
Rate	Reaction Profile

Knowledge Organiser: GCSE – C10 Chemistry; Chemical Analysis

Key Points	
Pure substance	A pure substance is a single **element** or **compound**, **not mixed** with anything else.
Formulation	**Useful mixtures** that have a precise purpose. The quantity of each component in a formulation has been measured carefully. Formulations include **fuels**, **cleaning agents**, **paints**, **medicines**, **alloys**, **fertilisers** & **foods**.
Melting point	The **temperature** at which a substance changes state from a solid to a liquid.
Boiling point	The **temperature** at which a substance changes state from a liquid to a gas.
Chromatography	An analytical method used to **separate substances** in a **mixture**.
Mixture	A mixture is not a pure substance. It consists of two or more elements/compounds not chemically combined.

Pure substances and mixtures

You can use melting points and boiling points to identify pure substances. For example, the **test for pure water** is that it melts at exactly 0°C and boils at exactly 100°C.

A **mixture** does not have a sharp melting point or boiling point, it changes state over a range of temperatures.

Impurities will **lower the melting point** of a substance and **increase its boiling point**. The purer the compound is, the narrower the melting point range.

Formulations

Formulations are made by mixing components in **carefully measured quantities** to ensure that the product has the **required properties**.

Depending on the product's intended function, the amount and type of chemicals used will be changed to make sure it is right for the job. E.g. Pigment of paint.

Testing for gases

Gas	Method	Positive test
Hydrogen	Hold a **lighted splint** at the end of a test tube producing the hydrogen gas.	The lighted splint gives a squeaky **"pop"**.
Oxygen	Hold a **glowing splint** in a test tube of the oxygen gas.	The glowing splint **"relights"**.
Carbon dioxide	Bubble carbon dioxide gas through a solution of **limewater**.	The limewater turns **"milky or cloudy"**.
Chlorine	When damp litmus paper is put into test tube containing chlorine gas	The litmus paper is **"bleached"** and **turns white**.

Paper Chromatography

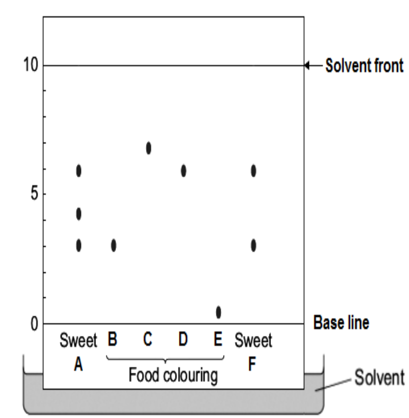
Chromatography always involves two phases, a **mobile** phase and a **stationary** phase.

In **paper chromatography**, the **mobile phase** is the **solvent**, the **stationary phase** is the **paper**.

During chromatography, the substances in the sample constantly move between the mobile and the stationary phase forming an equilibrium.

Different dyes have different solubilities in solvent and different attractions for the paper and hence are carried different distances. An unknown substance can be identified by calculating its R_f value.

$$R_f = \frac{\text{distance moved by substance}}{\text{distance moved by solvent}}$$



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