

AQA GCSE Chemistry (Combined Science) Unit 5.3: Quantitative Chemistry Knowledge Organiser - Foundation

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

$\text{Mg} + \text{O} \rightarrow \text{MgO}$

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

$2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}$

Relative Formula Mass

The relative formula mass is the sum of all the relative atomic masses of the atoms in the formula.

Examples:

HCl

A_r of H = 1

A_r of Cl = 35.5

$1 + 35.5 = 36.5$

H₂SO₄

A_r of H = 1

A_r of S = 32

A_r of O = 16

$(1 \times 2) + 32 + (16 \times 4)$

$2 + 32 + 64 = 98$

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 magnesium in magnesium oxide.

A_r of magnesium = 24

A_r of oxygen = 16

M_r of MgO = $24 + 16$

= 40

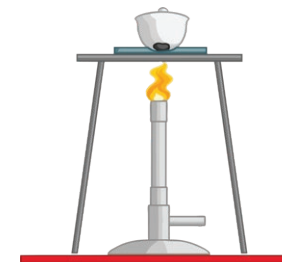
$$\% \text{ mass} = \frac{A_r}{M_r} = \frac{24}{40} = 0.6 \quad 0.6 \times 100 = 60\%$$

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.

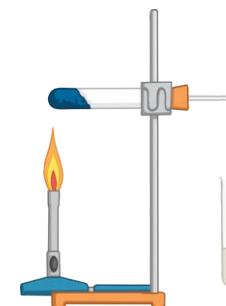


If one of the products is a gas, the mass can go down.

E.g.

sodium carbonate → sodium oxide + carbon dioxide

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



Concentration of Solutions

Concentration is the amount of a substance in a specific volume of a solution. The more substance that is dissolved, then the more concentrated the solution is.

It is possible to calculate the concentration of a solution with the following equation:

concentration (g/dm³) = mass (g) ÷ volume of solvent (dm³)

The equation can be rearranged to find the mass of the dissolved substance:

mass (g) = concentration (g/dm³) × volume (dm³)

Conservation of Mass

Show that mass is conserved in a reaction.

$2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}$

$(2 \times 24) + (2 \times 16) \rightarrow 2(24 + 16)$

$48 + 32 \rightarrow 2 \times 40$

$80 \rightarrow 80$

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.

8g of magnesium reacts with 6g of oxygen:

$8 + 6 = 14\text{g}$ of magnesium oxide



Science

visit [twinkl.com](https://www.twinkl.com)



AQA GCSE Chemistry (Combined Science) Unit 6: The Rate and Extent of Chemical Change

Calculating Rates of Reactions

Reactions happen at **varying rates**. For example, a firework exploding is a fast reaction whereas a piece of iron rusting would take place over a longer period of time.

The **rate of a chemical reaction** tells us how quickly a **product is formed** or how quickly a **reactant is used up**.

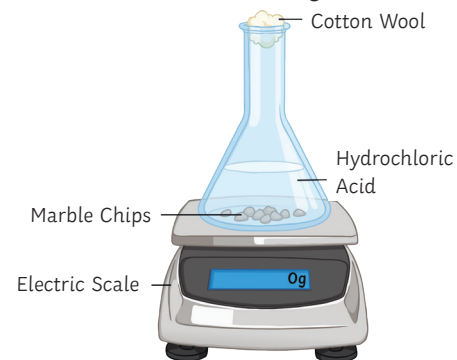
For a chemical reaction to occur, the reactant particles must collide with enough energy. Those collisions that produce a chemical reaction are called successful collisions.

$$\text{mean rate of reaction} = \frac{\text{quantity of reactant used}}{\text{time taken}}$$

$$\text{mean rate of reaction} = \frac{\text{quantity of product formed}}{\text{time taken}}$$

Measuring the Mass of a Reaction Mixture

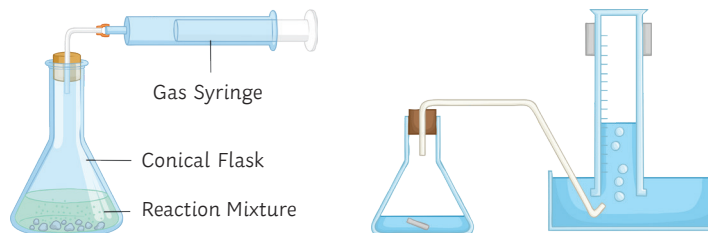
The changing mass of a reaction mixture can be measured during a reaction. This method is particularly useful when gases, such as carbon dioxide, are given off. **Gas escapes during the reaction and the mass of the reaction mixture decreases.** The mass can be measured at regular time intervals.



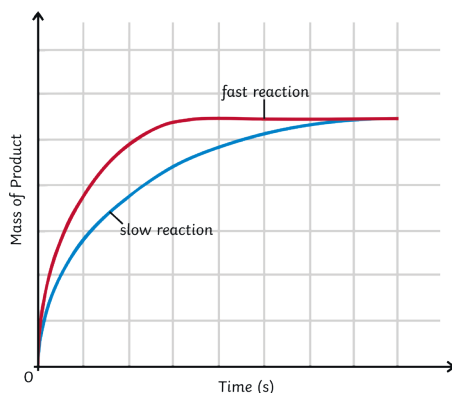
units = g/s or g/min

Measuring the Volume of a Reaction Mixture

The changing volume of a reaction mixture can be measured during a reaction. This method is particularly useful when gases, such as carbon dioxide, are given off. The gas can be collected and its volume measured at regular time intervals. Different types of measuring equipment can be used to collect the gas such as a gas syringe, measuring cylinder or upside-down burette.



units = cm³/s or cm³/min



Graphs are a useful way to **analyse** the results from a rate of reaction investigation. The graph above shows two lines, one red and one blue.

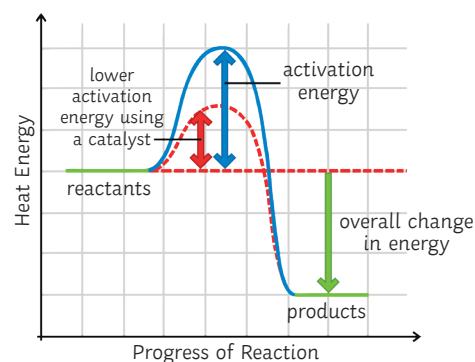
The red line represents a fast reaction and the blue line a slow reaction. We know the fast reaction occurs at a much faster rate as the line is steep. The fast reaction finishes before the slow reaction as the line plateaus sooner.

Factors Affecting the Rate of a Chemical Reaction

- concentration and pressure
- catalyst
- surface area
- temperature

The rate of a chemical reaction will be increased if there are more frequent successful collisions between reactant particles.

Catalyst



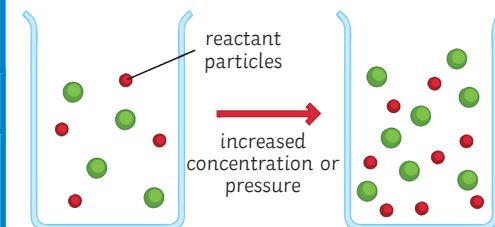
A catalyst is a **substance** that speeds up a chemical reaction without getting used up itself. Catalysts are able to offer an **alternative pathway** at a **lower activation energy**.

Biological catalysts are called **enzymes**.

When a catalyst is used in a chemical reaction (not all reactions have a catalyst that is suitable to use), the **frequency of collisions** is **unchanged**. More **particles** are able to react. The particles have **energy greater** than that of the **activation energy**. Consequently, there is an **increase** in the **rate successful of collisions**.

Concentration and Pressure

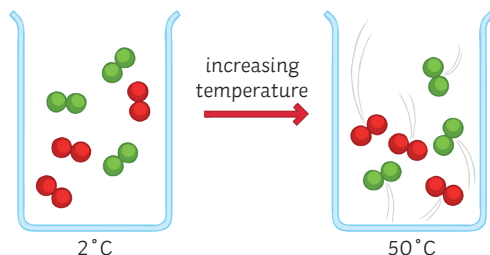
If the **number of reactant particles** in a given space is **doubled**, there will be **more frequent successful collisions** between reactant particles, therefore, **increasing the rate of reaction**.



AQA GCSE Chemistry (Combined Science) Unit 6: The Rate and Extent of Chemical Change

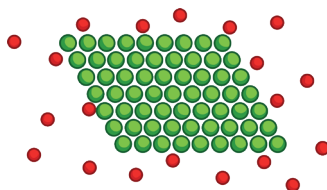
Temperature

When the temperature of the reaction mixture is increased, the reactant particles **gain kinetic energy** and move much more quickly. This results in **more frequent successful collisions** between the reactant particles, therefore, **increasing the rate of the reaction**.



Surface Area

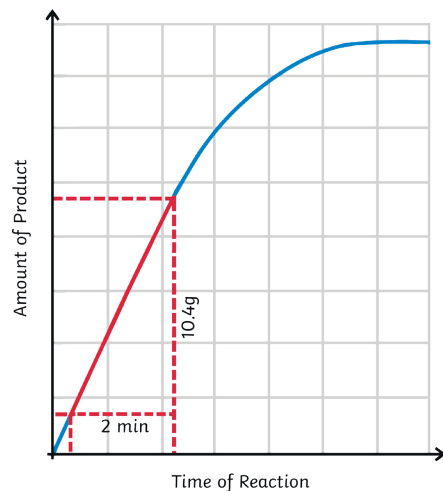
Large lumps of a solid have a **small surface area to volume ratio**. If the solid is broken up into smaller lumps or crushed into a powder, this will increase the surface area to volume ratio.



A larger area of the solid is now exposed to other reactant particles. This increases the frequency of successful collisions thus increasing the rate of reaction.

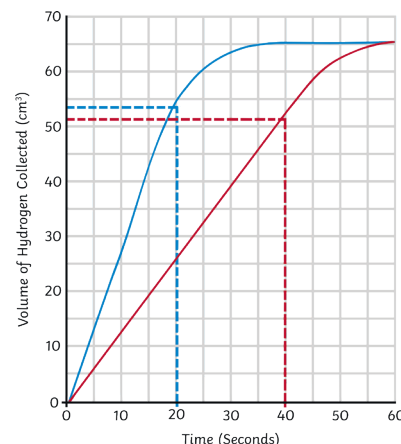
Calculating Gradient (Higher Tier Only) $\text{gradient} = \frac{y}{x}$

On the graph, draw construction lines on the part of the graph that has a straight line. Measure the values of x and y.



In the graph below, the gradient of the first line is much steeper than the second line. This indicates that a faster reaction is taking place. Remember, the steeper the line, the faster the reaction.

To calculate the reaction rate at a specific time period, construction lines must first be drawn on the straightest part of the graph.



For the first line, what is the rate of reaction at 20 seconds?

$$54 \div 20 = 2.7 \text{ cm}^3/\text{s}$$

For the second line, what is the rate of reaction at 40 seconds?

$$52 \div 40 = 1.3 \text{ cm}^3/\text{s}$$

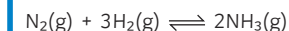
Dynamic Equilibrium

In a **closed system** (this means nothing can get in or out), a reversible reaction can reach **dynamic equilibrium**. This is where the **forward** and **reverse reactions** are occurring at the **same rate** and the **concentrations** of all the substances that are reacting remain constant.

Changing Conditions and the Effect on the Position of Equilibrium (Higher Tier Only)

The reaction between nitrogen and hydrogen to make ammonia is an industrial process called the Haber process. It requires a high temperature, high pressure and an iron catalyst.

The symbol equation for the reaction is as follows:



According to **Le Chatelier's Principle**, the position of equilibrium can be altered by changing the conditions of the reaction i.e. the pressure, concentration and/or the temperature. The **position** of the **equilibrium** will shift to **counteract** any changes made.

Increasing the **temperature** of the reaction in the forward direction (exothermic) will result in the equilibrium shifting in favour of the reverse direction (endothermic) to reduce the temperature.

From the equation, it is clear that on the **left-hand side**, there are **four molecules** and on the **right-hand side**, there are **two molecules**. If the **pressure** in the system were **increased**, the equilibrium **position would shift to the right** as there are fewer molecules. If the pressure in the system were **decreased**, the equilibrium **position would shift to the left** as there are a larger number of molecules.

If the **concentration** of one of the **reactants** were **increased**, then the equilibrium position would move in **favour of the products**. This would result in more product being produced. If the concentration of the **products** were **decreased**, equilibrium would shift to **favour the products**. More reactants would react until equilibrium is reached.



AQA GCSE Chemistry (Combined Science) Unit 6: The Rate and Extent of Chemical Change

Reversible Reactions

A reversible reaction is one in which the **reactants form products**. The products are then able to react together to **reform the reactants**.

For example:

A reacts with B to form C and D.

C and D are able to react to form A and B.

The equation would be as follows (where the **double arrow symbol** represents a **reversible reaction** is taking place):

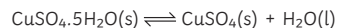


The **forward reaction** goes to the **left** and the **backwards reaction** goes to the **right**. For example, if the forward reaction is exothermic then the backward reaction will be endothermic. The amount of energy that is transferred is the same for both the forward and reverse reaction.

Hydrated copper sulfate is a blue substance. We say that the copper sulfate is hydrated as it **contains water**. The copper sulfate is heated and the water evaporates leaving a white substance known as **anhydrous** copper sulfate. Anhydrous meaning **no water**.

The word equation for the reaction is as follows:

hydrated copper sulfate $\rightleftharpoons$ anhydrous copper sulfate + water



The reaction can be reversed when water is added to the anhydrous copper sulfate.

Required Practical 5: Measuring the Production of a Gas

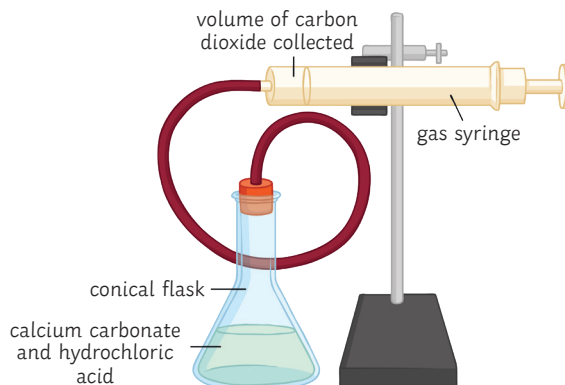
This method outlines one way to carry out an investigation to collect a gas from a chemical reaction.

The practical involves changing the concentration of hydrochloric acid and measuring the volume of carbon dioxide gas produced when the acid reacts with calcium carbonate.

The word equation for the reaction is as follows:

calcium carbonate + hydrochloric acid $\rightarrow$ calcium chloride + water + carbon dioxide

The symbol equation for the reaction is:



Method

Step 1 – Clamp a gas syringe to a retort stand using a boss and clamp. Ensure the syringe is a quarter of the way from the top of the stand. Place the delivery tube to the end of the gas syringe.

Step 2 – Measure out 50ml of hydrochloric acid using a measuring cylinder and pour into a conical flask.

Step 3 – Using a top pan balance, measure out 0.5g of powdered calcium carbonate and place in the conical flask.

Step 4 – Immediately connect the bung and delivery tube to the conical flask. Start the stopwatch.

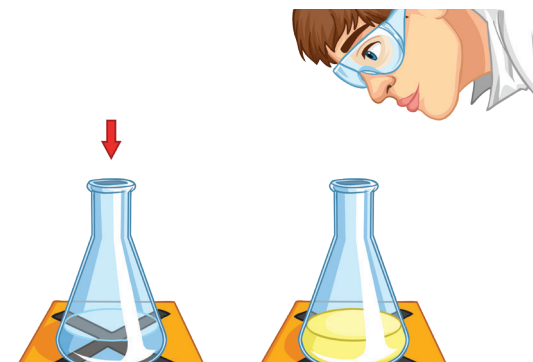
Step 5 – Record the volume of carbon dioxide gas produced every 10 seconds.

Step 6 – When the reaction has finished and there are no more bubbles of gas being produced, clean the equipment and repeat using four other different concentrations of hydrochloric acid.

When analysing the results from the practical investigation, plot a graph of Time (s) against Volume of Gas Produced (cm^3). Draw a curve of best fit through the points. A graph should be plotted for each concentration of acid.

Calculate the mean rate of reaction (cm^3/s) for each concentration of acid used. This can be calculated by dividing the total mass of gas produced (cm^3) by the reaction time (s).

Required Practical 5: Investigating a Change in Colour



This method outlines one way to carry out an investigation into the effect of increased temperature on the rate of a reaction.

The word equation for this reaction is as follows:

sodium thiosulfate + hydrochloric acid $\rightarrow$ sodium chloride + water + sulfur dioxide + sulfur

The symbol equation for this reaction is:



The reaction between sodium thiosulfate and hydrochloric acid produces a **precipitate**. **Sulfur** is responsible for the formation of the precipitate. A precipitate is a **solid** that is formed in a solution. It is the formation of this precipitate that causes the reaction mixture to become **cloudy**; the cloudiness is a way to measure the **reaction time**.



AQA GCSE Chemistry (Combined Science) Unit 6: The Rate and Extent of Chemical Change

Method

Sodium thiosulfate from three different temperatures may be used, for example, ice cold, room temperature and hot.

Step 1 – Place a black cross on a white tile.

Step 2 – Using the first temperature, measure out 35cm^3 of sodium thiosulfate using a measuring cylinder. Place the liquid in a conical flask and position over the black cross on the white tile.

Step 3 – Measure out 5cm^3 of water and 10cm^3 of hydrochloric acid in separate measuring cylinders.

Step 4 – Pour the water and acid into the conical flask.

Step 5 – Pour the measured amount of sodium thiosulfate into the conical flask and immediately start the stopwatch.

Step 6 – Look down through the conical flask to the black cross below. When the black cross is no longer visible, stop the stopwatch and record the results in a table.

Step 7 – Repeat the steps with the remaining temperatures of sodium thiosulfate.



AQA GCSE Chemistry (Combined Science) Unit 7: Organic Chemistry Knowledge Organiser

Crude Oil

Hydrocarbons are compounds that are made up of the elements **hydrogen** and **carbon** only.

Crude oil is a **non-renewable resource**, a **fossil fuel**. Crude oil is made up of a mixture of compounds, most of which are long- and short-chain hydrocarbons.

Most of the compounds in crude oil are hydrocarbons called **alkanes**. The alkanes form a **homologous series**. This is a family of hydrocarbons that all share the **same general formula** and have **chemical properties** that are **similar**.

Alkanes are held together by **single bonds**.

The general formula for an alkane is C_nH_{2n+2} .

They differ from the neighbouring alkane with the addition of a CH_2 .

Alkanes are **saturated hydrocarbons**. This means that all their bonds are taken up and they cannot bond to any more atoms.

Alkanes have **similar chemical properties** but have **different physical properties** due to differences in chain length. The longer the chain, the higher the boiling point of the hydrocarbon.

The first four alkanes are: methane, ethane, propane and butane.

A mnemonic to help you remember the order of the alkanes: **mice eat paper bags**.



Fractional Distillation

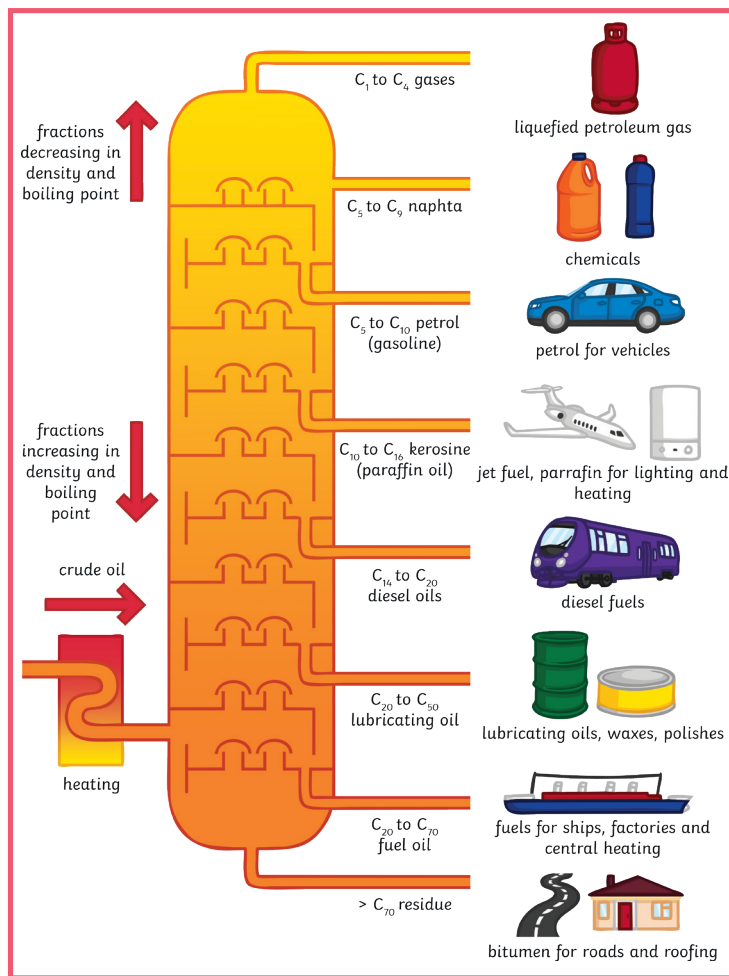
Fractional distillation is used to **separate** a mixture of long-chain hydrocarbons in crude oil into smaller, more useful fractions.

Hydrocarbons have different boiling points depending on their chain length. **Each fraction contains hydrocarbons of a similar chain length**. These fractions will boil at different temperatures due to the difference in sizes of the molecules. The different parts of crude oil are called fractions because they are a small part of the original mixture.

Crude oil is heated and enters at all column called a **fractioning column**. The column is **hot at the bottom** and decreases in temperature toward the top. As the crude oil is heated, it begins to evaporate and its vapours begin to rise up through the column. These vapours condense at the different fractions.

Short-chain hydrocarbons are found at the **top** of the column. This is because shorter chain molecules are held together by **weak intermolecular forces** resulting in low boiling points. These shorter chain hydrocarbons leave the column as gas.

Long-chain hydrocarbons are found at the bottom of the column and are held together by **strong intermolecular forces**, resulting in high boiling points.

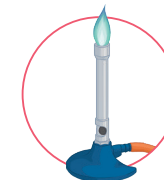


Name of Alkane	Structural Formula	Molecular Formula
methane	$\begin{array}{c} H \\ \\ H-C-H \\ \\ H \end{array}$	CH_4
ethane	$\begin{array}{c} H & H \\ & \\ H-C & -C-H \\ & \\ H & H \end{array}$	C_2H_6
propane	$\begin{array}{c} H & H & H \\ & & \\ H-C & -C & -C-H \\ & & \\ H & H & H \end{array}$	C_3H_8
butane	$\begin{array}{c} H & H & H & H \\ & & & \\ H-C & -C & -C & -C-H \\ & & & \\ H & H & H & H \end{array}$	C_4H_{10}

Combustion

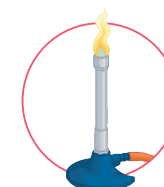
Complete combustion

occurs when there is **enough oxygen** for a fuel to burn. A hydrocarbon will react with oxygen to produce carbon dioxide and water.



Incomplete combustion

occurs when there **isn't enough oxygen** for a fuel to burn. The products in this reaction are water and poisonous **carbon monoxide**.



AQA GCSE Chemistry (Combined Science) Unit 7: Organic Chemistry Knowledge Organiser

Cracking

Cracking is an example of a **thermal decomposition reaction**. **Long-chain** hydrocarbons can be **broken** down into **shorter**, more useful hydrocarbon chains.

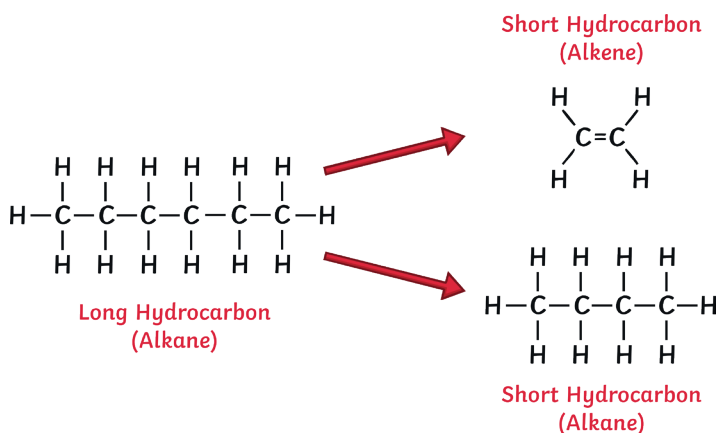
Cracking can be carried out with a catalyst in **catalytic cracking** or with steam in **steam cracking**.

Catalytic cracking involves heating a hydrocarbon to a high temperature (550°C) and passing over a hot catalyst.

Cracking of a long-chain hydrocarbon **produces** a **short-chain alkane** and an **alkene**.

Alkenes are another type of hydrocarbon that is double bonded. The general formula for an alkene is C_nH_{2n} .

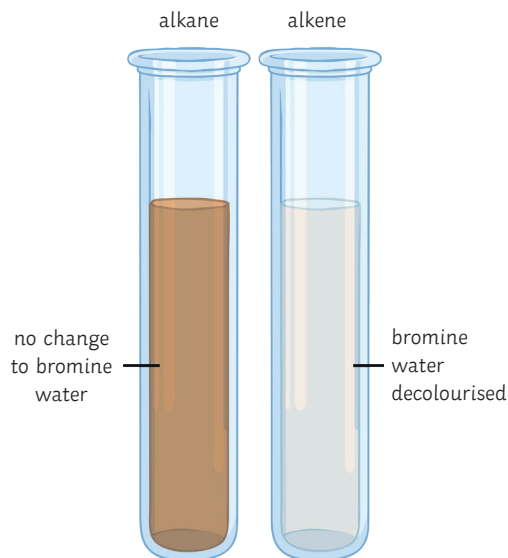
Alkenes are **unsaturated hydrocarbons**. In a chemical reaction, the double bond of the alkenes can break. This allows other atoms to bond to it.



Test for Alkanes

Bromine, when added to an **alkane**, will **remain brown/orange**. Alkanes are saturated hydrocarbons, they have no double bonds which could be broken to accept the bromine molecule and so remain orange.

Bromine, when added to an **alkene**, will **change from brown/orange to colourless**. This is because alkenes are unsaturated hydrocarbons. The double bond breaks and the bromine molecule is accepted.



Making Polymers

The fractional distillation of crude oil and cracking produces an array of hydrocarbons that are key to our everyday lives.

Alkenes are used to produce plastics such as poly(ethene) which is used to make plastic bags, drinks bottles and dustbins. Poly(propene), another polymer, forms very strong, tough plastic.

Short-Chain Molecules



thin



Increasing Chain Length



As chain length increases, the **boiling point** of the hydrocarbon chains also increases.



Long-Chain Molecules



thick



Viscosity describes how easily a substance can flow e.g. treacle is very viscous; it is thick.



Flammability is a measure of how easily a substance burns.



AQA GCSE Chemistry (Combined Science) Unit 8: Chemical Analysis

Pure Substances

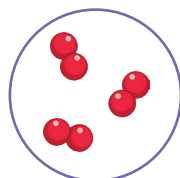
Pure substances, in chemistry, only contain **one type of element** or **one type of compound**. For example, pure water will just contain water (a compound).

In our everyday language, we use the word 'pure' differently to how it is used in chemistry. Pure can mean a **substance** that has had **nothing else added to it** and is in its natural state. An example of this is pure orange juice. This means that the bottle will just contain orange juice and no other substances.

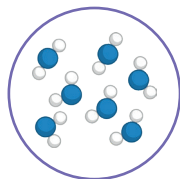
Elements are made up of **one type of atom**.

For example, oxygen is made up of oxygen atoms.

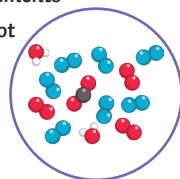
Carbon is made up of carbon atoms.



Compounds are **two or more elements** that are **chemically joined** together. For example, NaCl which is sodium chloride.



Mixtures are **two or more elements or compounds** that are **not chemically joined** together. An example of this is a standard cup of coffee. Coffee contains water, milk, coffee and possibly sugar. The components of the cup of coffee are not bonded together.



Pure Substances have a **sharp melting point** compared to **impure substances** which **melt over a range** of temperatures.

Formulations

Formulations are **mixtures of compounds or substances** that **do not react together**. They **do produce a useful product** with desirable characteristics or properties to suit a particular function.

There are examples of formulations all around us such as medicines, cleaning products, deodorants, hair colouring, cosmetics and sun cream.

Chromatography

Paper chromatography is a separation technique that is used to **separate** mixtures of **soluble substances**. How soluble a substance is determines how far it will travel across the paper.

In chromatography, there are **two phases**: the **mobile** and **stationary** phase.

The **mobile phase** **moves** through the stationary phase.

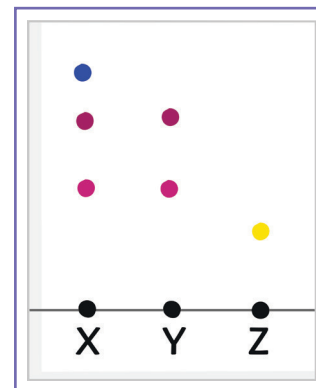
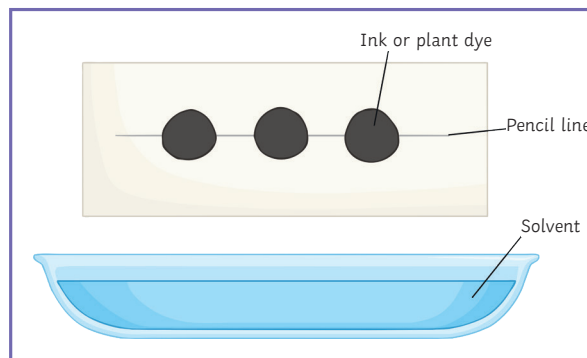
The **solvent** is the **mobile phase**. It moves through the paper carrying the different substances with it.

The **stationary phase** in paper chromatography is the **absorbent paper**.

Separation of the dissolved substances produces what is called a **chromatogram**. In paper chromatography, this can be used to **distinguish** between those substances that are **pure** and those that are **impure**.

Pure substances have **one spot** on a chromatogram as they are made from a single substance. **Impure substances** produce **two or more spots** as they contain multiple substances.

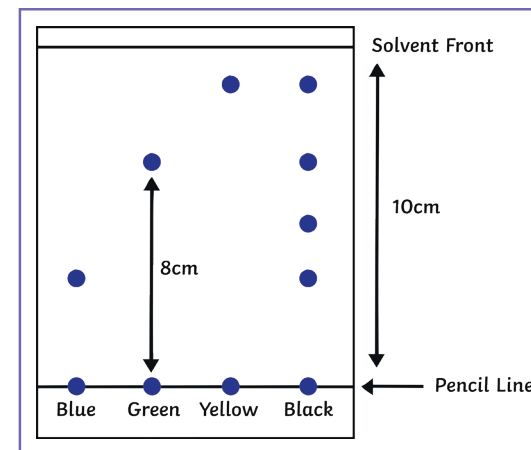
By calculating the **R_f values** for each of the spots, it is possible to identify the unknown substances. Similarly, if an unknown substance produces the **same number and colour of spots**, it is possible to match it to a known substance.



R Value

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

Different compounds have different R_f values in different solvents. The R_f values of known compounds can be used to help identify unknown compounds.



Required Practical – Paper Chromatography

Investigate how paper chromatography can be used to separate and distinguish between coloured substances.

Step 1 – Using a ruler, measure 1cm from the bottom of the chromatography paper and mark with a small dot using a pencil. Rule a line across the bottom of the chromatography paper with a pencil, going through the dot you have just made.

Step 2 – Using a pipette, drop small spots of each of the inks onto the pencil line. Leave a sufficient gap between each ink spot so that they do not merge.

Step 3 – Pour a suitable solvent into the bottom of a container such as a beaker. The solvent should just touch the chromatography paper. The solvent line must not go over the ink spots as this will cause the inks to run into each other.

Step 4 – Place the chromatography paper into the container and allow the solvent to move up through the paper.

Step 5 – Just before the solvent line reaches the top of the paper, remove the chromatogram from the container and allow to dry.

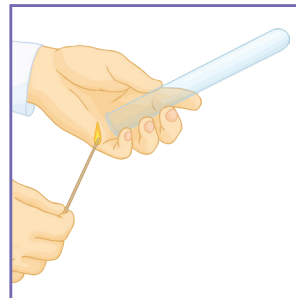
Step 6 – Once the chromatogram has dried, measure the distance travelled by the solvent.

Step 7 – Measure the distance travelled by each ink spot.

Step 8 – Calculate the R_f value. Compare the R_f values for each of the spots of ink.

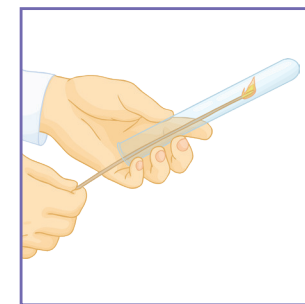
$$R_f = \frac{\text{distance travelled by substance}}{\text{distance travelled by solvent}}$$

Identification of the Common Gases



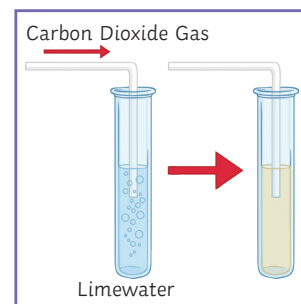
The Test for Hydrogen

Place a burning splint at the opening of a test tube. If hydrogen gas is present, it will burn rapidly with a **squeaky-pop** sound.



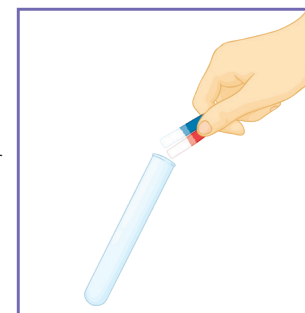
The Test for Oxygen

Place a glowing splint inside a test tube. The **splint will relight** in the presence of oxygen.



The Test for Carbon Dioxide

Calcium hydroxide (lime water) is used to test for the presence of carbon dioxide. When carbon dioxide is bubbled through or shaken with limewater, the limewater turns **cloudy**.



The Test for Chlorine

Damp litmus paper is used to test for chlorine gas. The litmus paper becomes **bleached and turns white**.

