Y10 GCSE Triple Science

Cycle 2

Science Y10 Triple

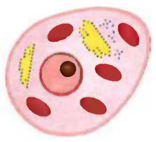
Cycle 2

Exam Board AQA

Y10 TRIPLE SCIENCE				
		Biology	**Chemistry**	**Physics**
Weeks	**Date**	**4 ppf**	**4 ppf**	**4 ppf**
1&2	**8th Dec**	B2 Organisation	C2 Bonding, Structure, and The Properties of Matter	P2 Electricity
3&4	**5th Jan**	B2 Organisation	C2 Bonding, Structure, and The Properties of Matter	P2 Electricity
5&6	**19th Jan**	B2 Organisation	C3 Quantitative Chemistry	P2 Electricity
7&8	**2nd Feb**	B2 Organisation	C3 Quantitative Chemistry	P2 Electricity
9&10	**23rd Feb**	B2 Organisation & Assessment	C3 Quantitative Chemistry & Assessment	P3 Particle Model of Matter & Assessment
11&12	**9th Mar**	B2 Organisation & Feedback	C3 Quantitative Chemistry & Feedback	P3 Particle Model of Matter & Feedback

AQA Organisation Knowledge Organiser

Principles of Organisation

				
cell	**tissue**	**organ**	**organ system**	**organism**
Cells are the basic building blocks of all living things.	A group of cells with a similar structure and function is called a tissue.	An organ is a combination of tissues carrying out a specific function.	Organs work together within an organ system.	Organ systems work together to form whole living organisms.

Food Tests (Required Practical)

What are you testing for?	Which indicator do you use?	What does a positive result look like?
sugar	Benedict's reagent	Once heated, the solution will change from blue-green to yellow-red.
starch	iodine	Blue-black colour indicates starch is present.
protein	biuret	The solution will change from blue to pink-purple.
lipid	sudan III	The lipids will separate and the top layer will turn bright red.

Effect of pH on the Rate of Reaction of Amylase (Required Practical)

Iodine is used to test for the presence of **starch**. If starch is present, the colour will change to blue-black.

The **independent variable** in the investigation is the pH of the buffer solution.

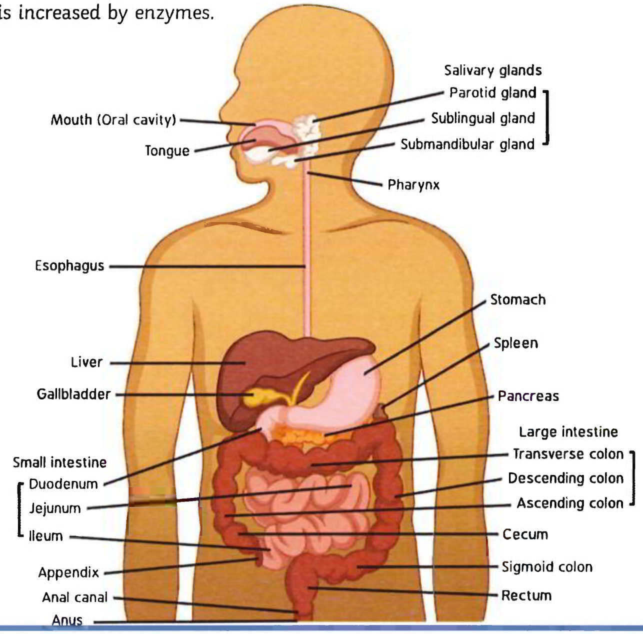
The **dependent variable** in the investigation is the time taken for the reaction to complete (how long it takes for all the starch to be digested by the amylase).

Method:

1. Use the marker pen to label a test tube with the first value of pH buffer solution (pH 4) and stand it in the test tube rack.
2. Into each well of the spotting tiles, place a drop of iodine.
3. Using a measuring cylinder, measure 2cm³ of amylase and pour into the test tube.
4. Using a syringe, measure 1cm³ of the buffer solution and pour into the test tube.
5. Leave this to stand for five minutes and then use the thermometer to measure the temperature. Make a note of the temperature.
6. Add 2cm³ of starch solution into the test tube, using a different measuring cylinder to measure, and begin a timer (leave the timer to run continuously).
7. After 10 seconds, use a pipette to extract some of the amylase/starch solution, and place one drop into the first well of the spotting tile. Squirt the remaining solution back into the test tube.
8. Continue to place one drop into the next well of the spotting tile, every 10 seconds, until the iodine remains orange.
9. Record the time taken for the starch to be completely digested by the amylase by counting the wells that were tested positive for starch (indicated by the blue/black colour change of the iodine). Each well represents 10 seconds of time.
10. Repeat steps 1 to 8 for pH values 7 and 10.

The Digestive System

The purpose of the digestive system is to break down large molecules into smaller, soluble molecules, which are then absorbed into the bloodstream. The rate of these reactions is increased by enzymes.



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Enzymes

An enzyme is a biological **catalyst**; enzymes speed up chemical reactions without being changed or used up.
This happens because the enzyme lowers the **activation energy** required for the reaction to occur. Enzymes are made up of chains of amino acids folded into a globular shape.

Enzymes have an **active site** which the **substrate** (reactants) fits into. Enzymes are very specific and will only catalyse one specific reaction. If the reactants are not the complimentary shape, the enzyme will not work for that reaction.
Enzymes also work optimally at specific conditions of pH and temperature. In extremes of pH or temperature, the enzyme will **denature**. This means that the bonds holding together the 3D shape of the active site will break and the active shape will deform. The substrate will not be able to fit into the active site anymore and the enzyme cannot function.

Enzyme	Reactant	Product
amylase	starch	sugars (glucose)
protease	protein	amino acids
lipase	lipid	glycerol and fatty acids

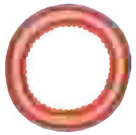
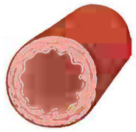
The products of digestion are used to build new carbohydrates and proteins and some of the glucose is used for respiration.

Bile is produced in the **liver** and stored in the gall bladder. It is an **alkaline** substance which **neutralises** the hydrochloric acid in the stomach. It also works to **emulsify** fats into small droplets. The fat droplets have a higher **surface area** and so the rate of their digestion by lipase is increased.

The Heart and Blood Vessels

The **heart** is a large muscular organ which **pumps blood** carrying oxygen or waste products around the body. The **lungs** are the site of **gas exchange** where oxygen from the air is exchanged for waste carbon dioxide in the blood. Oxygen is used in the **respiration** reaction to release energy for the cells and carbon dioxide is made as a waste product during the reaction.

glucose + oxygen ⟶ carbon dioxide + water + [energy]

		
vein	artery	capillary

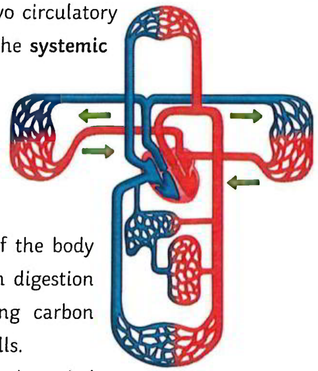
The three types of blood vessels, shown above, are each adapted to carry out their specific function.

Capillaries are narrow vessels which form networks to closely supply cells and organs between the veins and arteries. The walls of the capillaries are only **one cell thick**, which provides a short **diffusion pathway** to increase the rate at which substances are transferred.

The table below compares the structure and function of arteries and veins:

	Artery	Vein
direction of blood flow	away from the heart	towards the heart
oxygenated or deoxygenated blood?	oxygenated (except the pulmonary artery)	deoxygenated (except the pulmonary vein)
pressure	high	low (negative)
wall structure	thick, elastic, muscular, connective tissue for strength	thin, less muscular, less connective tissue
lumen (channel inside the vessel)	narrow	wide (with valves)

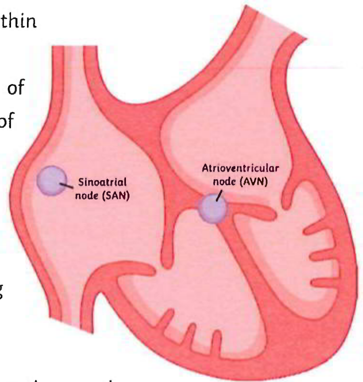
The Heart as a Double Pump



The heart works as a **double pump** for two circulatory systems; the **pulmonary** circulation and the **systemic** circulation.
The pulmonary circulation serves the lungs and bring deoxygenated blood to exchange waste carbon dioxide gas for oxygen at the **alveoli**.
The systemic circulation serves the rest of the body and transports oxygen and nutrients from digestion to the cells of the body, whilst carrying carbon dioxide and other waste away from the cells.
The systemic circulation flows through the whole body. This means the blood is flowing at a much higher pressure than in the pulmonary circuit.

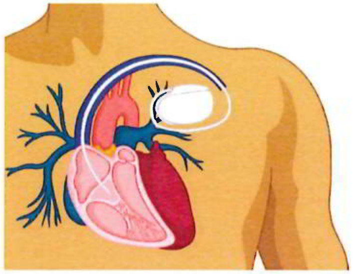
The Heart as Pacemaker

The rate of the heart beating is very carefully, and automatically, controlled within the heart itself.
Located in the muscular walls of the heart are small groups of cells which act as pacemakers. They produce electrical impulses which stimulate the surrounding muscle to contract, squeezing the chambers of the heart and pumping the blood.



The **sino-atrial node (SAN)** is located near the right atrium and it stimulates the atria to contract.
The **atrio-ventricular node (AVN)** is located in between the ventricles and stimulates them to contract.

Artificial pacemakers can be surgically implanted into a person if their heart nodes are not functioning correctly.



Coronary Heart Disease

Coronary heart disease is a condition resulting from **blockages** in the **coronary arteries**. These are the main arteries which supply blood to the heart itself and they can become blocked by build-up of **fatty deposits**.

In the UK and around the world, coronary heart disease is a major cause of many **deaths**.

The main symptoms can include **chest pain**, **heart attack** or **heart failure**. Yet, not all people suffer the same symptoms, if any at all.
Lifestyle factors can increase the risk of a person developing coronary heart disease.

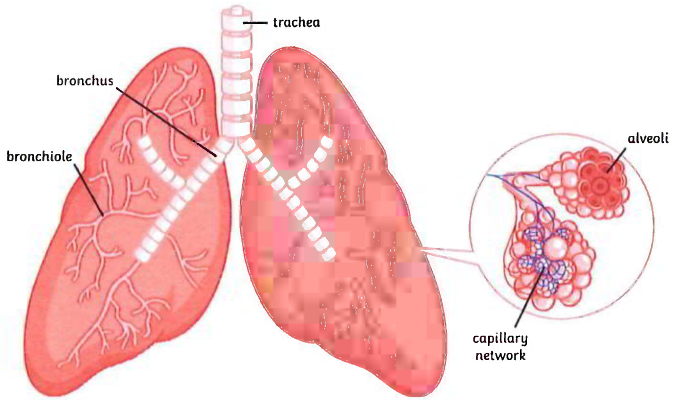
Diet – a high-fat diet (containing lots of saturated fat) can lead to higher cholesterol levels and this cholesterol forms the fatty deposits which damage and block the arteries.

Smoking – chemicals in cigarette smoke, including nicotine and carbon monoxide, increase the risk of heart disease. Carbon monoxide reduces the amount of oxygen which can be transported by the red blood cells and nicotine causes an increased heart rate. The lack of oxygen to the heart and increased pressure can lead to heart attacks.

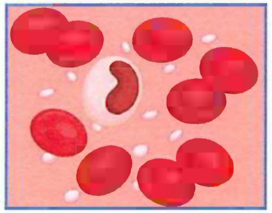
Stress – prolonged exposure to stress or stressful situations (such as high pressure jobs) can lead to high blood pressure and an increased risk of heart disease.

Drugs – illegal drugs (e.g. ecstasy and cannabis) can lead to increased heart rate and blood pressure, increasing the risk of heart disease.

Alcohol – regularly exceeding unit guidelines for alcohol can lead to increased blood pressure and risk of heart disease.



Blood



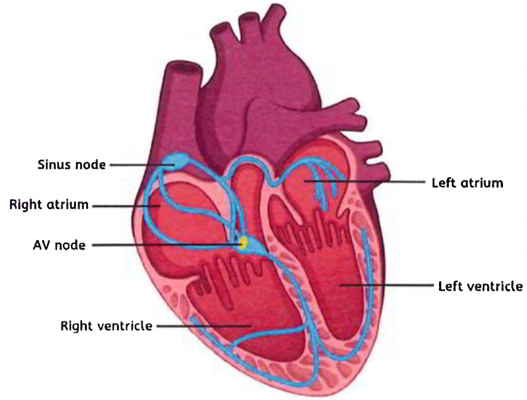
Blood is composed of red blood cells (erythrocytes), white blood cells and platelets, all suspended within a plasma (a tissue).

The **plasma** transports the different blood cells around the body as well as carbon dioxide, nutrients, urea and hormones. It also distributes the heat throughout the body.

Red blood cells transport oxygen attached to the haem group in their structure. It has a biconcave shape to increase surface area and does not contain a nucleus so it can bind with more oxygen molecules.

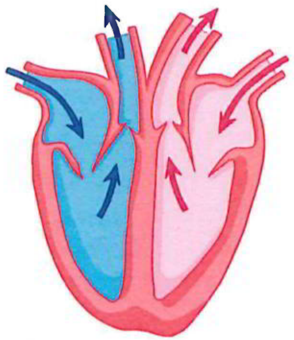
White blood cells form part of the immune system and ingest pathogens and produce antibodies. **Platelets** are important blood clotting factors.

at the lungs
haemoglobin + oxygen $\rightleftharpoons$ oxyhaemoglobin
at the cells



The **right atrium** receives deoxygenated blood via the **vena cava**. It is then pumped down through the valves into the right ventricle. From here, it is forced up through the **pulmonary artery** towards the **lungs** where it exchanges carbon dioxide for oxygen. The oxygenated blood then enters the **left atrium** via the **pulmonary vein** and down into the left ventricle. The muscular wall of the **left ventricle** is much thicker so it can pump the blood more forcefully out of the heart and around the entire body, via the **aorta**.

The blood only flows in **one direction**. This is because there are **valves** in the heart which close under pressure and prevent the backward flow of blood.



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Rate Calculations for Blood Flow

The number of beats the heart performs each minute is called the **pulse** (or heart rate).

It is easily measured by counting the number of beats in a given time, e.g. 15s, and finding the total beats **per minute**.

Typically, a lower resting pulse rate indicates a greater level of physical **fitness**. During exercise, and for some time after, the pulse rate increases while the heart is working to provide more **oxygen** to the muscles.

Cardiac output is a measure of the volume of blood pumped by the heart each **minute**. **Stroke volume** is a measure of the volume of blood pumped from the heart each **contraction** (heart beat).

Cardiac output (cm^3/min) = heart rate (bpm) × stroke volume (cm^3/beat)

Cancer

Cancer is the result of **uncontrolled** cell growth and division. The uncontrolled growth of cells is called a **tumour**.

Benign Tumour	Malignant Tumour
• Usually grows slowly. • Usually grows within a membrane and can be easily removed. • Does not normally grow back. • Does not spread around the body. • Can cause damage to organs and be life-threatening.	• cancerous • Usually grows rapidly. • Can spread around the body, via the bloodstream. • Cells can break away and cause secondary tumours to grow in other areas of the body (metastasis).

Plant Tissues, Organs and Systems

Leaves are plant organs and their main function is to absorb sunlight energy for use in **photosynthesis**. Within the cells are small organelles called **chloroplasts** which contain a green pigment called **chlorophyll**. This is the part of the plant which absorbs the sunlight and where photosynthesis occurs.

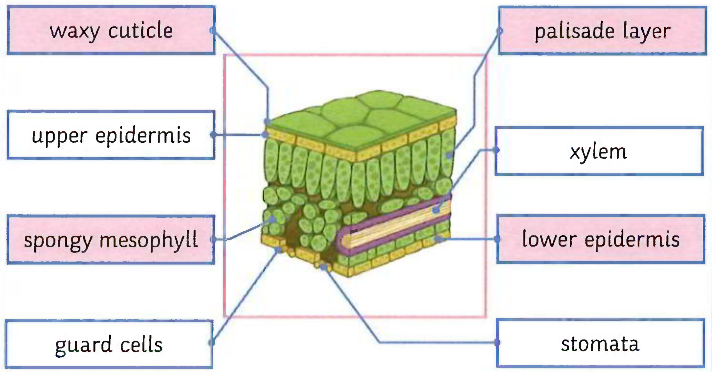
sunlight

carbon dioxide + water ⟶ oxygen + glucose

Leaves are adapted to carry out their function. Leaves are typically flat and thin with a large **surface area**. This means they have a maximum area to absorb the sunlight and carbon dioxide. The **thin** shape reduces the distance for **diffusion** of water and gases.

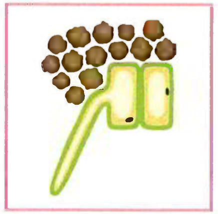
Leaves contain vessels called xylem and phloem. The **xylem** transport water and dissolved minerals toward the leaves. The **phloem** transport glucose and other products from photosynthesis around the plant.

The large **air spaces** between the cells of the spongy mesophyll layer allow for the diffusion of gases. **Carbon dioxide** enters the leaves and **oxygen** exits the leaves.



The **guard cells** are specially adapted cells located on the underside of the leaf. They are positioned in pairs, surrounding the **stomata** (a small opening in the epidermis layer). The guard cells change shape to open and close the stomata, controlling the rate of **gas exchange** in the leaf.

Root Hair Cells



Plants absorb water by **osmosis** through the root hair cells of the roots. Dissolved in the water are important minerals for the plant's growth and development, which are absorbed by **active transport**.

The **root hair cells** are adapted to their function with the following features:

- Finger-like projection in the membrane increases the **surface area** available for water and minerals to be absorbed across.
- The narrow shape of the projection can squeeze into small spaces between soil particles, bringing it closer and reducing the distance of the **diffusion pathway**.
- The cell has many **mitochondria**, which release energy required for the active transport of some substances.

Xylem and Phloem

Xylem vessels transport **water** through the plant, from roots to leaves. They are made up of **dead**, lignified cells, which are joined end to end with no walls between them, forming a long central tube down the middle. The movement of the water, and dissolved minerals, along the xylem is in a **transpiration** stream.

Xylem vessels also provide **support** and **strength** to the plant structure. They are found in the middle of roots so they aren't crushed within the soil. They are found in the middle of the stem to provide strength and prevent bending. In the leaves, they are found in **vascular bundles** alongside the phloem and can be seen as the veins which network across the leaf.

Phloem vessels transport **food** such as dissolved sugars and glucose from photosynthesis. The food is transported around the plant to where growth is occurring (root and shoot tips), as well as to the organs which store the food. The transport occurs in **all directions** throughout the plant. The cells making up the phloem tube are **living**, with small holes in the walls where the cells are joined.

Transpiration and Translocation

Transpiration is the loss of water, by **evaporation** and **diffusion**, from the leaves of the plant. Water is a cohesive molecule and as it evaporates, there is less water in the leaf, so water from further back moves up to take its place. This, in turn, draws more water with it. This is the **transpiration stream**.

Transpiration occurs naturally as there is a tendency for water to diffuse from the leaves (where the concentration is relatively high) to the air around the plants (where the concentration is relatively low), via the **stomata**.

Environmental factors can change the rate at which transpiration occurs:

- Increased **light intensity** will increase the rate of transpiration because light stimulates the stomata to open. The leaf will also be warmed by the sunlight.
- Increased **temperature** will cause the water to evaporate more quickly and so increase the rate of transpiration.
- Increased **humidity** (moisture in the air) will reduce the rate of transpiration. Whereas if the air becomes drier, the rate increases. A greater concentration gradient will increase the rate of diffusion.
- If the **wind speed** increases, then the rate of transpiration also increases. This is because as the water surrounding the leaves is moved away more quickly, the concentration gradient is increased.
- If the **water content** in the soil is decreased, then the rate of absorption in the roots decreases. This causes the stomata to become flaccid and close, reducing transpiration. If the loss of turgor affects the whole plant, then it will wilt.

Disease Interactions

Having one type of illness can often make a person more susceptible to another type of illness:

- immune disorders → increased risk of infectious disease
- viral infection of cells → increased risk of cancer
- immune reactions → can trigger allergies
- very poor physical health → increased risk of depression or other mental illness

Health and Disease

Health is the state of being free from **illness** or **disease**. It refers to **physical** and **mental** wellbeing.

Disease and lifestyle factors, such as diet, stress, smoking, alcohol consumption and the use of illegal drugs, can all impact the health of a person.

Some conditions are associated with certain lifestyle choices:

- Liver conditions are associated with poor **diet** and prolonged excessive **alcohol** consumption.
- Lung cancer is associated with **smoking**.
- Memory loss, poor physical health and hygiene are associated with the use of illegal or recreational **drugs**.
- Obesity and diabetes are associated with poor diet.
- Anxiety and depression are associated with **stress** and prolonged excessive alcohol consumption.

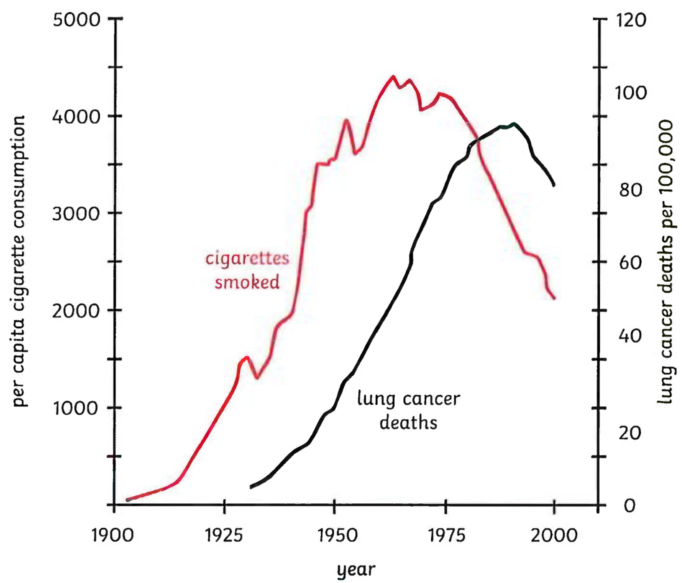
There can often be correlations between some factors and types of illness or specific diseases.

For example, in the graph shown to the right, there is a positive correlation between the number of cigarettes smoked and the number of lung cancer deaths.

However, there are other factors which can contribute to the development of lung cancer e.g. working with asbestos, genetic predisposition.

This means that although the evidence in the graph gives a strong indication that smoking is a cause of lung cancer, it cannot be stated that **'smoking will cause lung cancer'**. Not every person who smokes will develop lung cancer and not every person who develops lung cancer will be a smoker.

Therefore, it can be stated that **smoking increases the risk of lung cancer.**



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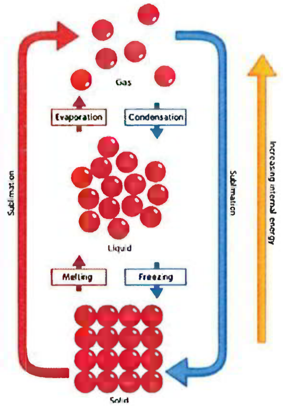
Heart Disease (Treatments)

There are a range of medical treatments for heart disease.

Treatment	Description	Advantages	Disadvantages
statins	**Drugs** used to lower cholesterol levels in the blood, by reducing the amount produced in the liver.	• Can be used to prevent heart disease developing. • Improved quality of life.	• Long-term treatment. • Possible negative side-effects.
stents	**Mechanical device** which is used to stretch narrow or blocked arteries, restoring blood flow.	• Used for patients where drugs are less effective. • Offers long-term benefits. • Made from metal alloys so will not be rejected by the patients body. • Improved quality of life.	• Requires surgery under general anaesthetic, which carries risk of infection.
heart transplant	The entire organ is replaced with one from an organ **donor** (a person who has died and previously expressed a wish for their organs to be used in this way).	• Can treat complete heart failure in a person. • extended life • Improved quality of life. • Artificial plastic hearts can be used temporarily until a donor is found.	• Requires major surgery under general anaesthetic, which carries risks. • Lack of donors available. • Risk of infection or transplant rejection. • Long recovery times.

AQA GCSE Chemistry (Separate Science) Unit 2: Bonding, Structure and Properties of Matter



The three states of matter are **solid, liquid and gas**.

For a substance to change from one state to another, **energy** must be **transferred**.

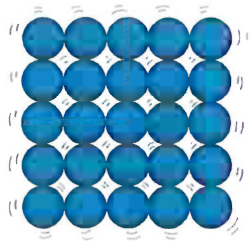
The particles gain energy. This results in the breaking of some of the **attractive forces** between particles during melting.

To evaporate or boil a liquid, more energy is needed to overcome the remaining chemical bonds between the particles.

Note the difference between **boiling** and **evaporation**. When a liquid **evaporates**, particles **leave the surface** of the liquid **only**. When a liquid **boils**, **bubbles** of gas form **throughout** the liquid before rising to the surface and escaping.

The amount of energy needed for a substance to change state is dependent upon the **strength** of the **attractive forces** between particles. The **stronger** the **forces of attraction**, the **more energy** needed to **break them apart**. Substances that have strong attractive forces between particles generally have **higher melting and boiling points**.

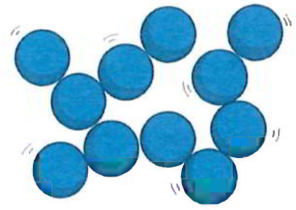
Solid



The particles in a **solid** are arranged in a regular pattern. The particles in a solid **vibrate** in a fixed position and are tightly packed together. The particles in a solid have a **low amount of kinetic energy**.

Solids have a **fixed shape** and are unable to flow like liquids. The particles **cannot be compressed** because the particles are very close together.

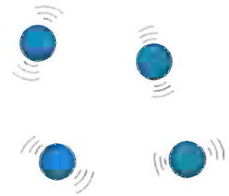
Liquid



The particles in a **liquid** are randomly arranged. The particles in a liquid are able to **move around** each other. The particles in a liquid have a **greater amount** of **kinetic energy** than particles in a **solid**.

Liquids are able to **flow** and can take the shape of the container that they are placed in. As with a solid, liquids **cannot be compressed** because the particles are close together.

Gas



The particles in a **gas** are randomly arranged. The particles in a gas are able to **move around very quickly** in all directions. Of the three states of matter, gas particles have the **highest amount** of **kinetic energy**.

Gases, like liquids, are able to **flow** and can fill the container that they are placed in. The particles in a gas are **far apart** from one another which allows the particles to move in any direction.

Gases can be **compressed**; when squashed, the particles have empty space to move into.

Limitations of the Particle Model (HT only)

The chemical bonds between particles are not represented in the diagrams above.

Particles are represented as solid spheres – this is not the case. Particles like atoms are mostly empty space. Particles are not always spherical in nature.

State Symbols

In chemical equations, the three states of matter are represented as symbols:

solid **(s)**
liquid **(l)**
gas **(g)**
aqueous **(aq)**

Aqueous solutions are those that are formed when a substance is dissolved in water.

Identifying the Physical State of a Substance

If the given temperature of a substance is **lower** than the **melting point**, the physical state of the substance will be **solid**.

If the given temperature of the substance is **between** the **melting point and boiling point**, the substance will be a **liquid**.

If the given temperature of the substance is **higher** than the **boiling point**, the substance will be a **gas**.

Formation of Ions

Ions are charged particle. They can be either positively or negatively charged, for example Na^+ or Cl^-.

When an element loses or gains electrons, it becomes an ion.

Metals **lose** electrons to become **positively charged**.

Non-metals **gain** electrons to become **negatively charged**.

Group 1 and 2 elements **lose** electrons and group 6 and 7 elements **gain** electrons.

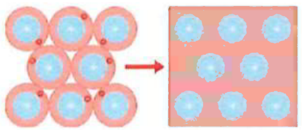
Group	Ions	Element Example
1	+1	$Li \rightarrow Li^+ + e^-$
2	+2	$Ca \rightarrow Ca^{2+} + 2e^-$
6	-2	$Br + e^- \rightarrow Br^-$
7	-1	$O + 2e^- \rightarrow O^{2-}$

Metals and Non-metals

Metals are found on the **left-hand side** of the **periodic table**. Metals are strong, shiny, malleable and good conductors of heat and electricity. On the other hand, non-metals are brittle, dull, not always solids at room temperature and poor conductors of heat and electricity. **Non-metals** are found on the **right-hand side** of the **periodic table**.

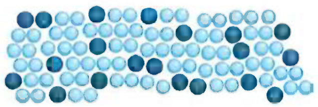
Metallic Bonding

Metallic bonding occurs between **metals only**. Positive metal ions are surrounded by a **sea of delocalised electrons**. The ions are tightly packed and arranged in rows.



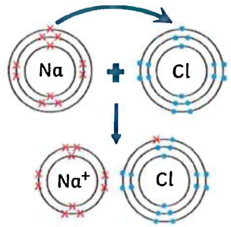
There are strong electrostatic forces of attraction between the positive metal ions and negatively charged electrons.

Pure metals are too soft for many uses and are often mixed with other metals to make alloys. The mixture of the metals introduces different-sized metal atoms. This **distorts the layers** and **prevents them from sliding over one another**. This makes it harder for alloys to be bent and shaped like pure metals.



Ionic Bonding

Ionic bonding occurs between a metal and a non-metal. Metals lose electrons to become positively charged. Opposite charges are attracted by electrostatic forces – an ionic bond.



Ionic Compounds

Ionic compounds form structures called giant lattices. There are **strong electrostatic forces of attraction** that **act in all directions** and act between the **oppositely charged ions** that make up the giant ionic lattice.

Properties of Ionic Compounds

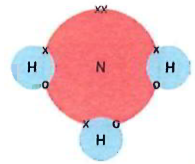
- High melting point – lots of energy needed to overcome the electrostatic forces of attraction.
- High boiling point
- **Cannot conduct electricity** in a **solid** as the ions are not free to move.
- Ionic compounds, when **molten** or in **solution**, can **conduct electricity** as the ions are free to move and can carry the electrical current.

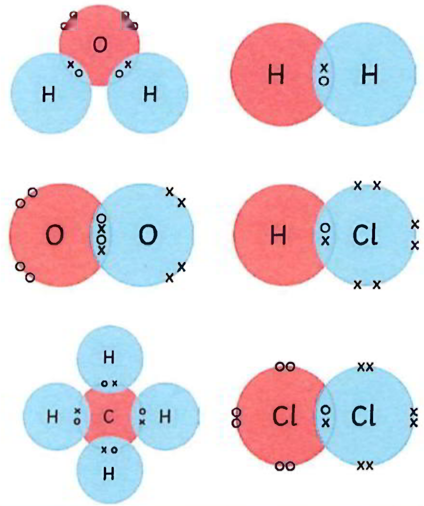
Covalent Bonding

Covalent bonding is the sharing of a pair of electrons between atoms to gain a full outer shell. This occurs between **non-metals only**. Simple covalent bonding occurs between the molecules below. Simple covalent structures have **low melting and boiling points** – this is because the **weak intermolecular forces** that hold the molecules together break when a substance is heated, not the strong covalent bonds between atoms. They **do not conduct electricity** as they do not have any free delocalised electrons.

Dot and cross diagrams are useful to show the **bonding** in **simple molecules**. The **outer electron shell** of each atom is represented as a **circle**, the circles from each atom overlap to show where there is a **covalent bond**, and the electrons from each atom are either drawn as **dots or crosses**. There are **two different types** of **dot and cross diagram** – one with a circle to represent the outer electron shell and one without.

You should be able to draw the dot and cross diagrams for the following simple covalent structures: chlorine, oxygen, nitrogen, water, ammonia, hydrogen chloride and methane.

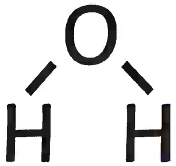




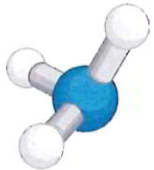
AQA GCSE Chemistry (Separate Science) Unit 2: Bonding, Structure and Properties of Matter

Structural Formulae

In this type of diagram, the element symbol represents the type of atom and the straight line represents the covalent bonding between each atom.

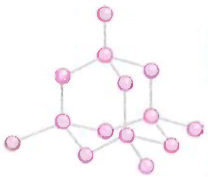


The structure of small molecules can also be represented as a 3D model.



Giant Covalent Structure – Diamond

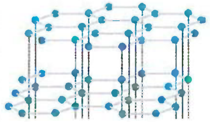
Each **carbon** atom is **bonded** to **four** other carbon atoms, making diamond very strong. Diamond has a high melting and boiling point. **Large** amounts of **energy** are needed to break the strong covalent bonds between each carbon atom. Diamond **does not conduct** electricity because it has **no free electrons**.



Silicon dioxide (silicon and oxygen atoms) has a similar structure to that of diamond, in that its atoms are held together by **strong covalent bonds**. Large amounts of energy are needed to break the strong covalent bonds therefore silicon dioxide, like diamond, has a high melting and boiling point.

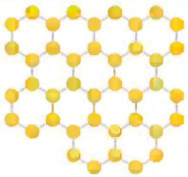
Giant Covalent Structure – Graphite

Graphite is made up of layers of **carbon** arranged in **hexagons**. Each carbon is bonded to **three** other carbons and has **one free delocalised electron** that is able to move between the layers. The layers are held together by weak intermolecular forces. The layers of carbon can slide over each other easily as there are no strong covalent bonds between the layers. Graphite has a high melting point because a lot of energy is needed to break the covalent bonds between the carbon atoms. Graphite can **conduct** electricity.



Giant Covalent Structure – Graphene

Graphene is one layer of graphite. It is very **strong** because of the covalent bonds between the carbon atoms. As with graphite, each carbon in graphene is bonded to three others with one **free delocalised electron**. Graphene is able to **conduct electricity**. Graphene, when added to other materials, can make them even stronger. Useful in electricals and composites.



Nanoscience

Nanoscience refers to structures that are **1–100nm** in size, of the order of a few hundred atoms. Nanoparticles have a **high surface area to volume ratio**. This means that smaller amounts are needed in comparison to normal sized particles. As the side length of a cube decreases by a factor of 10, the surface area to volume ratio increases approximately

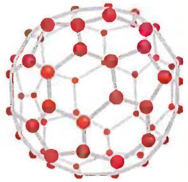
Name of Particle	Diameter
nanoparticle	1–100nm
fine particles ($PM_{2.5}$)	100–2500nm
coarse particles (PM_{10})	2500–10000nm

Polymers

Polymers are long chain molecules that are made up of many smaller units called **monomers**. Atoms in a polymer chain are held together by **strong covalent bonds**. Between polymer molecules, there are **intermolecular forces**. Intermolecular forces **attract** polymer chains towards each other. Longer polymer chains have stronger forces of attraction than shorter ones therefore making stronger materials.

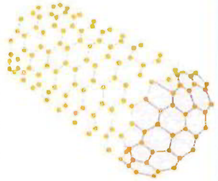
Fullerenes and Nanotubes

Molecules of carbon that are shaped like hollow tubes or balls, arranged in hexagons of five or seven carbon atoms. They can be used to **deliver drugs into the body**.



Buckminsterfullerene has the formula C_{60}

Carbon Nanotubes are tiny carbon cylinders that are very long compared to their width. Nanotubes can conduct electricity as well as strengthening materials without adding much weight. The properties of carbon nanotubes make them useful in electronics and nanotechnology.



Possible Risks of Nanoparticles

As nanoparticles are so **small**, it makes it possible for them to be inhaled and enter the lungs. Once inside the body, nanoparticles may **initiate harmful reactions** and toxic substances could bind to them because of their large surface area to volume ratio. Nanoparticles have many applications. These include medicine, cosmetics, sun creams and deodorants. They can also be used as catalysts.

Modern nanoparticles are a relatively new phenomenon therefore it is difficult for scientists to truly determine the risks associated with them.

Relative Formula Mass (M_r)

The **relative atomic mass (A_r)** of an element is an elements relative mass compared to the mass of an atom of carbon-12. A_r values are given in the periodic table.

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

Example 1: hydrochloric acid (HCl) consists of one hydrogen atom (A_r1) and one chlorine atom (A_r 35.5).

The M_r of HCl = 1 + 35.5 = 36.5

Example 2: sulfuric acid (H_2SO_4) consists of two hydrogen atoms (A_r 1), one sulfur atom (A_r 32) and four oxygen atoms (A_r 16).

The M_r of H_2SO_4 = (1 × 2) + 32 + (16 × 4) = 98

Neither A_r or M_r values have any units.

Law of Conservation of Mass

The **law of conservation of mass** states that during a chemical reaction, no atoms are lost or made.

For example: $2Mg + O_2 \longrightarrow 2MgO$

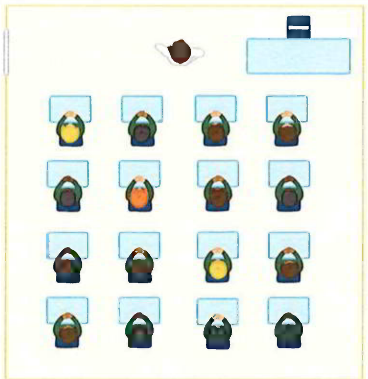
In a chemical reaction, mass is never lost or gained. What **goes in** must **come out**. The **total mass of the reactants** at the beginning of the chemical reaction **equals** the **total mass of the products** made at the end of the reaction.

For example, imagine if we used building bricks to represent the atoms in a chemical reaction: atoms, like building bricks, can be completely rearranged. However, the total mass of the atoms will stay the same. Rearranging the building blocks in different structures takes a little **energy**, just like in a chemical reaction.

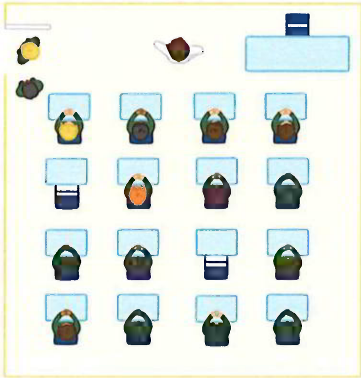
Reactions in Closed and Non-Enclosed Systems

If a reaction occurs in a **closed system**, the **mass** in a chemical reaction will remain **constant**.

In an **non-enclosed system, changes in mass can occur,** such as when a gas is released. It is important to remember that **no atoms are created or destroyed,** they are just **rearranged**. If a gas escapes a non-enclosed system, the total mass will look as if it has decreased. Similarly, if a gas is gained, the total mass will look as if it has increased. However, the **total mass** will **remain the same** if the mass of the gas is included in the reaction calculation.



In this **closed system** (the classroom), the mass in the reaction remains constant. As the system is a closed one, no children are allowed to leave or enter.



In this **non-enclosed system** (the classroom), the mass in the reaction can look as if it has changed as children are allowed to leave the classroom at any time.

Uncertainty

Whenever a measurement is made, there is always some degree of **uncertainty** about the result. Uncertainty is a **measure** of the **variability** in scientific data.

Uncertainty can be measured by considering the **resolution** of the scientific equipment being used or from the **range** of a set of scientific data.

There are two types of errors: **random error** and **systematic error.**

Random errors may be caused by **human error** such as a poor technique when taking measurements or by **equipment** that is **faulty**. For example, three mass balances all showing different mass values for the same object. Random errors are **random** and not something that can be predicted.

Systematic errors are errors that are produced **consistently**: if the experiment is repeated, the **same error** will occur. For example, not taring a mass balance properly or problems with the experimental method.

$$\text{uncertainty} = \frac{\text{range of results}}{2}$$

The **range** is the difference between the **largest** and **smallest** value.

For example, student A carried out a practical to determine how much dilute sulfuric acid is needed to react with exactly $50.0cm^3$ of a sodium hydroxide solution.

Repeat	1	2	3	Mean
Volume of H_2SO_4 needed to react with $50.0cm^3$ of NaOH.	23.13	24.00	23.56	23.56

Calculate the range:

range = 24.00 – 23.13 = $0.87cm^3$

Calculate the uncertainty of the mean:

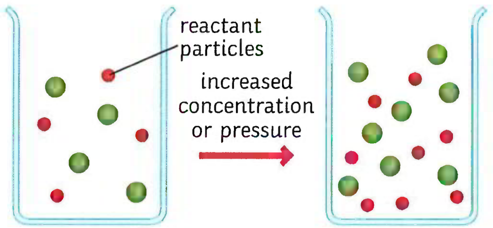
uncertainty = 0.87 ÷ 2 = $0.44cm^3$

The mean with uncertainty:

23.56 ± $0.44cm^3$

Concentration of Solutions

Concentration is a **measure** of the amount of a **substance** in a **volume** of liquid. The higher the concentration, the more particles of a substance are present in the solution.



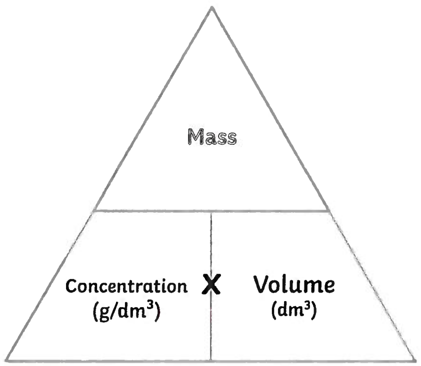
In chemistry, there are two ways to measure the concentration of a solution. This can be done by calculating the **mass** of the substance in grams or by calculating the number of **moles**.

In order to calculate concentration, you must be working in dm^3.

If it is not, it may mean that you need to do a conversion.

$cm^3 \longrightarrow dm^3$ = ÷ 1000

$m^3 \longrightarrow dm^3$ = × 1000



Calculate the **concentration** of a solution with a mass of 2.15g and a volume of $5dm^3$.

concentration = mass ÷ volume

concentration = 2.15g ÷ $5dm^3$

concentration = $0.43g/dm^3$

Calculate the **mass** of sodium chloride that you would need to dissolve in $400cm^3$ of water to make a $20g/dm^3$ volume solution.

mass = concentration × volume

convert $cm^3 \longrightarrow dm^3$

$400cm^3$ ÷ 1000 = $0.40dm^3$

mass = $20g/dm^3$ × $0.40dm^3$ = 8g

Calculate the **volume** of liquid required to add to 8.80g of a solid to make $42g/dm^3$ solution.

volume = mass ÷ concentration

volume = 8.80g ÷ $42g/dm^3$

concentration = $0.210dm^3$

The Mole – Higher Tier Only

When we talk about moles, we are not talking about the moles that live underground.

A **mole** (mol) is a **measurement** that is used in chemistry.

Example 1

Look at this reaction:

$2Mg + O_2 \longrightarrow 2MgO$

The reaction shows that **two moles** of magnesium react with oxygen to produce **two moles** of magnesium oxide. Using moles in a **balanced symbol equation** shows the **ratio** of **reactants** to **products**.

Avogadro's Constant

1 mole = 6.02×10^{23}

The number is known as **Avogadro's constant or Avogadro's number** and is named after the Italian scientist Amedeo Avogadro. The mole is abbreviated to **mol**.

This number is very important and one that you should remember. The mass of one mole of a substance in grams is equal to its relative formula mass. For example, one mole of carbon-12 has a mass of 12g

A mole is the amount of a substance that contains **6.02×10^{23}** particles of that substance. The particles could be atoms, molecules, ions or electrons.

For example, 1 mole of carbon will contain the same number of atoms **(6.02×10^{23})** as you would have molecules in 1 mole of water.

Calculating the Number of Particles

The number of particles can be calculated using Avogadro's constant if the number of moles is known.

In chemistry, Avogadro's constant is given the symbol N_A. To calculate the number of particles in a substance, the following equation can be used:

$N = n \times N_A$

N = the number of particles in a substance

n = the number of moles (mol)

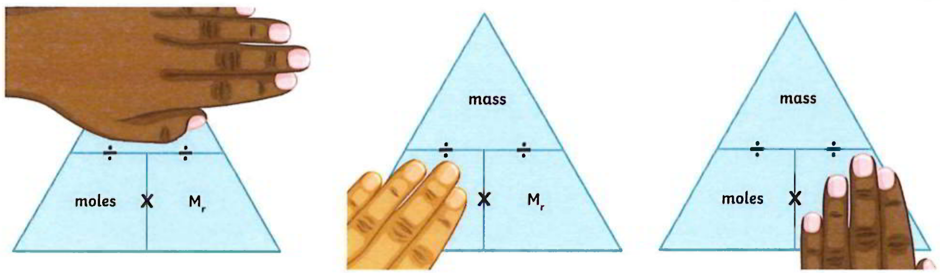
N_A = Avogadro's constant 6.02×10^{23}

For example, calculate the number of helium molecules in 10 mol of helium.

$N = n \times N_A$

N = $10 \times (6.02 \times 10^{23}) = 6.022 \times 10^{24}$

Calculating Moles, Mass and M_r



Calculating Moles, Mass and M_r

Calculate the number of **moles** in 330g of K_2S.

K_2S consists of two potassium atoms (A_r 39) and one sulfur atom (A_r 32).

Calculate the M_r of the compound =

$(39 \times 2) + 32 =$ **110**

moles = mass ÷ M_r

moles = 330 ÷ 110 = 3 moles

Calculate the **mass** of 0.9 moles of $Fe(NO_3)_3(H_2O)_9$.

Calculate the Mr of the compound.

$(16 \times 3) + 14 = 62$

$62 \times 3 =$ **186**

$(1 \times 2) + 16 = 18$

$18 \times 9 =$ **162**

$56 + 186 + 162 =$ **404**

mass = moles × M_r

mass = 0.9 × 404 = 363.6g

Relative Atomic Mass (A_r)

iron (Fe) = 56

oxygen (O) = 16

nitrogen (N) = 14

hydrogen (H) = 1

Amount of Substances in Equations – Higher Tier Only

How do we know the masses involved in the equation?

To work out the masses involved, write in the relative atomic mass (A_r) for an element and the relative formula mass (M_r) for a compound.

Example

Step 1: Write down the **balanced** symbol equation. $2Mg + O_2 \longrightarrow 2MgO$

Step 2: Write in the relative atomic and relative formula masses for the **reactants** and **products** involved in the chemical reaction.

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

$48g + 32g \longrightarrow 80g$

Masses in Equations

$Fe + 2HCl \longrightarrow FeCl_2 + H_2$

$56 + 2\,(1 + 35.5) \longrightarrow (56 + 2(35.5) + (1 \times 2))$

$56g + 73g \longrightarrow 127g + 2g$

One mole of iron **reacts** with two moles of hydrochloric acid to **produce** one mole of iron chloride and one mole of hydrogen.

Calculate the **mass of water** made when burning **300g of methane**.

Step 1: Balance the equation.

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

Step 2: Write down the relative formula mass of each compound.

$(12 + (1 \times 4)) + 2(16 \times 2) \longrightarrow 2((1 \times 2) + 16) + (12 + (16 \times 2))$

$16g + 64g \longrightarrow 36g + 44g$

Relative Atomic Mass (A_r)

Carbon (C) = 12

oxygen (O) = 16

hydrogen (H) = 1

We know from the equation that **16g of methane** reacts to produce **36g of water**.

The question asks us to calculate the mass of water made when burning **300g of methane**.

$\frac{\text{known mass}}{M_r} \times M_r$ of unknown mass

$\frac{300}{16} \times 36 = 675g$

AQA GCSE Chemistry (Separate Science) Unit 3: Quantitative Chemistry

Limiting Reactants

A chemical reaction ends once one of the **reactants** is used up. The other reactants have nothing to react with and so some are left over.

The **limiting reactant** is the reactant that is **completely used up** in a chemical reaction. This reactant is the one that determines the amount of product that is made.

The reactant in **excess** is the one that is left over and could further react if there was another reactant to react with.

The **amount of product** that is produced during a chemical reaction is **dependent** upon the **amount of the limiting reactant**.

Calculating the maximum mass of a product formed during a chemical reaction can be done by the following:

a. Writing a balanced equation.

b. Calculating the mass (g) of the limiting reactant.

c. The A_r and M_r of the product and limiting reactant.

Determine the **maximum mass of hydrogen** that can be produced when 36g of magnesium (Mg A_r 24) reacts completely with excess hydrochloric acid (HCl) to produce magnesium chloride ($MgCl_2$) and hydrogen (H_2).

$$Mg + 2HCl \longrightarrow MgCl_2 + H_2$$

number of moles = mass ÷ A_r

number of moles = 36 ÷ 24 = 1.5 mol

From the equation, 1 mol of magnesium forms 1 mol of hydrogen. Therefore, 1.5 mol of magnesium forms 1.5 mol of hydrogen.

mass of hydrogen = M_r × number of moles

= 2 × 1.5

= 3g

Balancing Equations

By using the masses of the products and reactants, it is possible to work out the balancing numbers in an equation.

For example, 12g of magnesium (Mg A_r 24) reacts with 8g of oxygen (O_2 M_r 32) to produce magnesium oxide (MgO M_r 40). Determine the balanced symbol equation for the reaction.

Calculate the amount of each of the reactants.

Mg = 12 ÷ 24 = 0.5 mol

O_2 = 8 ÷ 32 = 0.25 mol

Divide both values by the smaller amount.

Mg = 0.5 ÷ 0.25 = 2

O_2 = 0.25 ÷ 0.25 = 1

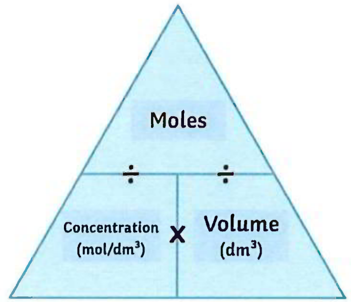
The equation shows that on the left-hand side of the equation, 2 mol of the reactant (Mg) reacts with 1 mol of oxygen. Using this information, it is then possible to balance the rest of the equation in the normal way.

$$2Mg + O_2 \longrightarrow 2MgO$$

Calculating Concentrations

The concentration of a solution can have the units g/dm^3 or mol/dm^3.

Concentration can be calculated using the mass of dissolved solute or the volume of the solvent or solution in dm^3.



Example:

Student A dissolved 1 mol of sodium hydroxide in 4dm^3 of water. Determine the concentration of the sodium hydroxide solution he made.

concentration = 1 mol ÷ 4dm^3

concentration = 0.25mol/dm^3

Converting between Units

To convert between g/dm^3 and mol/dm^3, the relative formula mass of the solute is used.

Multiply by the M_r to convert from **mol/dm^3 to g/dm^3**.

Divide by the M_r to convert from **g/dm^3 to mol/dm^3**.

Example:

Determine the concentration of 0.8mol/dm^3 sodium hydroxide **(M_r 40)** solution in g/dm^3.

concentration = 0.8 × 40 = 32g/dm^3

Volumes of Solutions

By rearranging the concentration equation, it is possible to calculate the amount of a solute in a given volume of solution if the concentration is known.

amount of solute (mol) = concentration (mol/dm^3) × volume (dm^3)

Example:

Determine the amount of $0.2 mol/dm^3$ sodium hydroxide in $75 cm^3$ of solution.

Step 1: Convert the volume to dm^3.

$75 cm^3 = 75.0 \div 1000 = 0.075 dm^3$

Step 2: amount of solute (mol) = concentration (mol/dm^3) × volume (dm^3)

$= 0.2 mol/dm^3 \times 0.075 dm^3$

= 0.015 mol

Calculating the Mass

Using the example above, calculate the mass of sodium hydroxide (M_r 40) in $75 cm^3$ of solution.

mass = amount × M_r

mass = 0.015 mol × 40

mass = 0.6g

Percentage Yield – Chemistry Only

The percentage yield can be calculated from the following equation.

$$\text{percentage yield} = \frac{\text{actual mass of product made}}{\text{maxium theoretical mass of product}} \times 100$$

The **theoretical yield** is **the maximum mass** that can be made during a chemical reaction. The law of conservation states that during a chemical reaction, no atoms are lost or made. It's not always possible to obtain the maximum calculated amount of product.

The loss of product may be due to some of the product being lost when filtered. Some of the reactants may not react as expected and so may not produce enough product. The reaction may be a reversible one and as a consequence, the reaction may not go to completion.

Example:

1.8g of copper sulfate crystals are made during a chemical reaction. The theoretical yield for this reaction is **2.0g**. Calculate the percentage yield of copper sulfate.

$$\text{percentage yield} = \frac{1.8g}{2.0} \times 100$$

percentage yield = 90%

Atom Economy – Chemistry Only

The percentage atom economy can be calculated from the following equation.

$$\text{atom economy} = \frac{\text{relative formula mass of desired product from equation}}{\text{sum of relative formula masses of all reactants from equation}}$$

The **atom economy** is a measure of the amount of starting materials (reactants) that end up as **useful products**. It is important for sustainable development and for economic reasons to use reactions with **high atom economy**. However, not all atoms end up as the desired product and may form other products. We call these **byproducts**.

Example:

When glucose (M_r 180) is fermented, ethanol (M_r 46) is produced.

$C_6H_{12}O_6 \longrightarrow 2CH_3CH_2OH + 2CO_2$

Calculate the atom economy for this reaction.

$$\text{atom economy} = \frac{2 \times 46}{180} \times 100$$

atom economy = 51.1%

Reaction Pathways – Higher Tier Only

There is often more than one way to make a substance. Reaction pathways **describe** the **reactions** that have taken place to form the **desired product**. Choosing a particular pathway is dependent upon a number of factors:

1. percentage yield
2. atom economy
3. rate of reaction
4. position of the equilibrium
5. usefulness of any byproducts

The raw materials needed for a particular reaction may affect its chosen pathway. For example, crude oil is a **non-renewable resource**; the resource will run out if we continue to use it. However, plant sugars are **renewable** and can be replenished as long as other plants are replanted.

Ethanol can be made through the fermentation of glucose or the hydration of ethene.

Method of Ethanol Production	Percentage Yield (%)	Atom Economy (%)	Rate of Reaction
fermentation	15	51.1	low
hydration	95	100	high

The hydration of ethene has a 100% atom economy; all atoms react to form the desired product. On the other hand, fermentation has an atom economy of 51.1%. However, its rate of reaction is low in comparison to the hydration method and only has a percentage yield of 15%. Therefore, hydration is the best method for making ethanol.

A byproduct of the fermentation process is carbon dioxide. The gas is sold to fizzy drinks manufacturers to provide the bubbles for some well known fizzy drinks. As the byproduct produced is one that can be useful, it means that the atom economy can be increased to 100%.

Ethene hydration is a reversible reaction. The position of the equilibrium lies to the left. Therefore, only 5% of the ethene supplied to the reaction is actually converted to ethanol. A 95% yield is achieved by recirculating the unreacted ethene.

Avogadro's Law – Higher Tier Only

When the temperature and pressure stay the same, Avogadro's law states that different gases that have the same volume contain equal numbers of molecules.

For example, 1 mol of methane gas occupies the same volume as 1 mol of argon gas.

$H_2 + Cl_2 \longrightarrow 2HCl$

When hyrdogen and chlorine react, hydrogen chloride is produced. In terms of the molar ratio, $10cm^3$ of hydrogen reacts completely with $10cm^3$ of chlorine. Therefore, the ratio between hydrogen and chlorine is 1:1.

The molar ratio between hydrogen and hydrogen chloride is 1:2. For example, $10cm^3$ of hydrogen reacts to produce $20cm^3$ of hydrogen.

Molar Gas Volume

The volume of one mole of any gas at room temperature and pressure (20°C and 1 atmosphere pressure) is $24dm^3$ (**$24\ 000\ cm^3$**).

To calculate a known volume of a gas:

volume = amount in mol × molar volume

For example, determine the volume of 0.55 mol of carbon monoxide at room temperature and pressure.

volume = amount in mol × molar volume

volume = 0.55 × 24

= $13.2dm^3$

Calculating the Amount of Gas

By **rearranging the equation,** it is possible to calculate the amount of a gas in moles.

For example, determine the amount of hydrogen gas that occupies $198cm^3$ at room temperature and pressure.

$$\text{amount in mol} = \frac{\text{volume}}{\text{molar volume}}$$

$$\text{amount in mol} = \frac{198}{24\ 000}$$

amount in mol = 0.0083 mol

Calculating a Volume from a Mass

When 3.5g of sodium reacts with water it produces sodium hydroxide and hydrogen gas.

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

1. Determine the molar amount of sodium (A_r 23).

$$\text{amount in mol} = \frac{\text{mass}}{\text{atomic mass}}$$

$$\text{amount in mol} = \frac{3.5}{23}$$

amount in mol = 0.15 mol

2. Determine the molar amount of hydrogen.

The molar ratio of **sodium to hydrogen**, according to the balanced symbol equation, is **2:1**.

Therefore, 0.15 mol of sodium produces 0.075 mol of hydrogen.

3. Determine the volume of hydrogen.

volume = amount in mol × molar volume

volume = 0.075 × $24dm^3$

= $1.8dm^3$

4. Calculating the mass from a volume.

Sodium reacts with chlorine to produce sodium chloride.

$2Na(s) + Cl_2(g) \longrightarrow 2NaCl(s)$

5. Determine the mass of sodium chloride (Mr 58.5) that can be produced from $685cm^3$ of chlorine.

amount of chlorine = $685cm^3$ ÷ 24 000 = 0.029 mol

From the equation, the mole ratio between chlorine and sodium chloride is l:2. Therefore, 0.029 moles of chlorine would produce (0.029 × 2) = 0.058 mol.

mass of sodium chloride = 0.058 × 58.5 = 3.393g

Electricity – Separate Science

Required Practical

Investigating Resistance in a Wire

Independent variable: length of the wire.

Dependent variable: resistance.

Control variables: type of metal, diameter of the wire.

Conclusion: As the length of the wire increases, the resistance of the wire also increases.

Investigating Series and Parallel Circuits with Resistors

Independent variable: circuit type (series, parallel).

Dependent variable: resistance.

Control variables: number of resistors, type of power source.

Conclusion: Adding resistors in series increases the total resistance of the circuit. In a parallel circuit, the more resistors you add, the smaller the resistance.

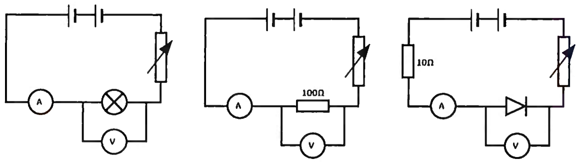
Investigating I-V Relationships in Circuits (Using a filament bulb, ohmic conductor, diode.)

Independent variable: potential difference/volts (V).

Dependent variable: current (A).

Control variable: number of components (e.g. 1 filament bulb, 1 resistor), type of power source.

Set up the circuits as shown below and measure the current and the potential difference.



Draw graphs of the results once collected.

Equations and Maths

Equations

Charge:	$Q = It$
Potential difference:	$V = IR$
Energy transferred:	$E = Pt$
Energy transferred:	$E = QV$
Power:	$P = VI$
Power:	$P = I^2R$

Maths

1kW = 1000W

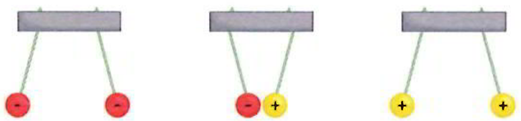
0.5kW = 500W

50 000W = 50kW

Static

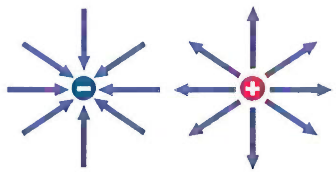
A build-up of static is caused by friction. When materials are rubbed together, the electrons move from one to the other. One material becomes positively charged and the other is negatively charged. The positive charges do not move.

Too much static can cause a spark. If the potential difference is large enough, the electrons can jump across the gap - this is the spark.



repulsion attraction repulsion

Electric charges create an **electric field**. The closer you get to the object, the **stronger** the field. The electric field can be shown by drawing field lines, they go from **positive to negative**.

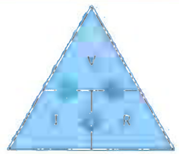


If a charged object is placed near the field, it will experience a force. The force becomes stronger as the charged object gets closer.

Resistance

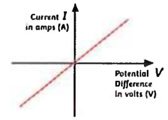
voltage (V) = current (A) × resistance (Ω)

V = IR

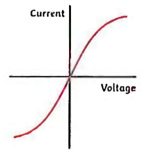


Graphs of I-V Characteristics for Components in a Circuit

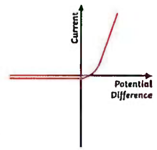
1. **Ohmic conductor**: the current is directly proportional to the potential difference - it is a straight line (at a constant temperature).



2. **Filament lamp**: as the current increases, so does the temperature. This makes it harder for the current to flow. The graph becomes less steep.



3. **Diode**: current only flows in one direction. The resistance is very high in the other direction which means no current can flow.

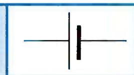
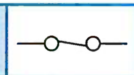
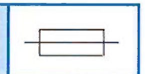
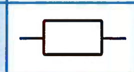
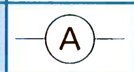
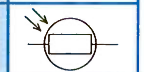
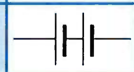
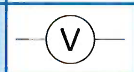
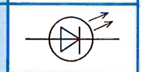
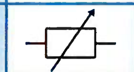
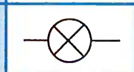
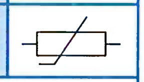
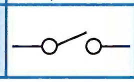
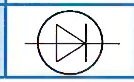


Current and Circuit Symbols

Current: the flow of electrical charge.

Potential difference (voltage): the push of electrical charge.

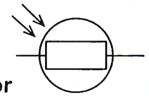
Resistance: slows down the flow of electricity.

cell		closed switch		fuse	
resistor		ammeter		LDR	
battery		voltmeter		LED	
variable resistor		bulb		thermistor	
open switch		diode			

Electricity – Separate Science

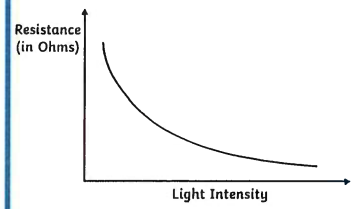
Circuit Devices

LDR – Light Dependent Resistor

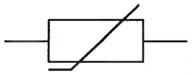


An LDR is dependent on light intensity. In bright light the resistance falls and at night the resistance is higher.

Uses of LDRs: outdoor night lights, burglar detectors.

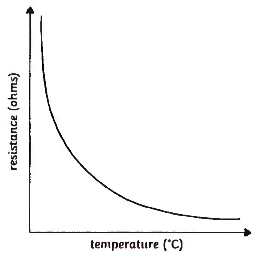


Thermistor



A thermistor is a temperature dependent resistor. If it is hot, then the resistance is less.
If it becomes cold, then the resistance increases.

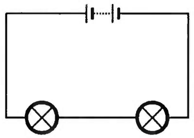
Uses of thermistors: temperature detectors.



Series and Parallel Circuits

Series Circuits

Once one of the components is broken then all the components will stop working.



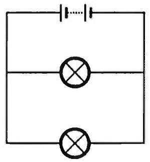
Potential difference – the total p.d. of the supply is shared between all the components. $V_{total} = V_1 + V_2$

Current – wherever the ammeter is placed in a series circuit the reading is the same. $I_1 = I_2 = I_3$

Resistance – In a series circuit, the resistance will add up to make the total resistance. $R_{total} = R_1 + R_2$

Parallel Circuits

They are much more common - if one component stops working, it will not affect the others. This means they are more useful.



Potential Difference – this is the same for all components. $V_1 = V_2$

Current – the total current is the total of all the currents through all the components. $I_{total} = I_1 + I_2 + I_3$

Resistance – adding resistance reduces the total resistance.

Charge

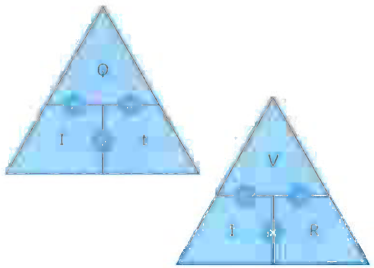
Electric current is the flow of electric charge. It only flows when the circuit is complete.

The **charge** is the current flowing past a point in a given time. Charge is measured in **coulombs (C)**.

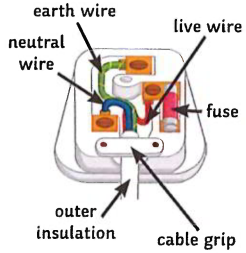
Calculating Charge

charge flow (C) = current (A) × time (s)
$Q = It$

potential difference = current x resistance
V (V) = I (A) × R (Ω)



Electricity in the Home



AC – alternating current. Constantly changing direction - UK mains supply is 230V and has a frequency of 50 hertz (Hz).

DC – direct current. Supplied by batteries and only flows in one direction.

Cables – most have three wires: live, neutral and earth. They are covered in plastic insulation for safety.

Live wire – provides the potential difference from the mains.

Neutral wire – completes the circuit.

Earth wire – protection. Stops the appliance from becoming live. Carries a current if there is a fault.

Touching the live wire can cause the current to flow through your body. This causes an electric shock.

Energy Transferred – this depends on how long the appliance is on for and its power.

energy transferred (J) = power (W) × time (s) $E = Pt$

Energy is transferred around a circuit when the charge moves.

energy transferred (J) = charge flow (C) × potential difference (V) $E = QV$

power (W) = potential difference (V) × current (A) $P = VI$

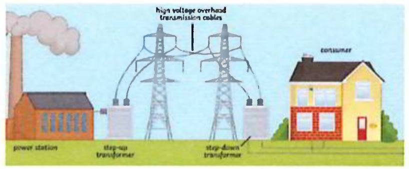
power (W) = current² (A) × resistance (Ω) $P = I^2R$

The National Grid

The National Grid is a system of **cables** and **transformers**. They transfer electrical power from the power station to where it is needed. Power stations are able to change the amount of electricity that is produced to meet the demands. For example, more energy may be needed in the evenings when people come home from work or school. Electricity is transferred at a low current, but a high voltage so less energy is being lost as it travels through the cables.

Step-up transformers – increase the voltage as the electricity flows through the cables.

Step-down transformers – decrease the potential difference to make it safe.



AQA Physics (Separate Science) Unit 3: Particle Model of Matter

Required Practical

Measuring the density of a regularly shaped object:

- Measure the mass using a balance.
- Measure the length, width and height using a ruler.
- Calculate the volume.
- Use the density ($\rho = m/V$) equation to calculate density.

Measuring the density of an irregularly-shaped object:

- Measure the mass using a balance.
- Fill a eureka can with water.
- Place the object in the water - the water displaced by the object will transfer into a measuring cylinder.
- Measure the volume of the water. This equals the volume of the object.
- Use the density ($\rho = m/V$) equation to calculate density.

Density

Density is a measure of how much mass there is in a given space.

Density (kg/m^3) = mass (kg) ÷ volume (m^3)

A more dense material will have more particles in the same volume when compared to a less dense material.

Example

The density of an object is 8050kg/m^3 and it has a volume of 3.4m^3. What is its mass in kg?

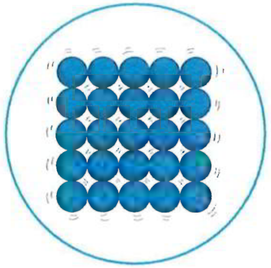
8050 = mass ÷ 3.4

8050 × 3.4 = mass

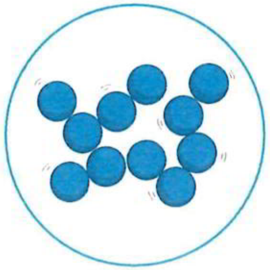
27 370kg

States of Matter

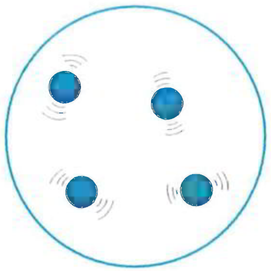
Solids have strong forces of attraction between the particles. The particles are held together very closely in a fixed, regular arrangement. The particles do not have much energy and can only vibrate.



Liquids have weaker forces of attraction between the particles. The particles are close together, but can move past each other. They form irregular arrangements. They have more energy than particles in a solid.

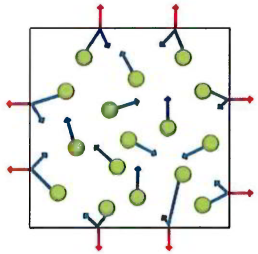


Gases have almost no forces of attraction between the particles. The particles have the most energy and are free to move in random directions.



Motion in Gas Particles

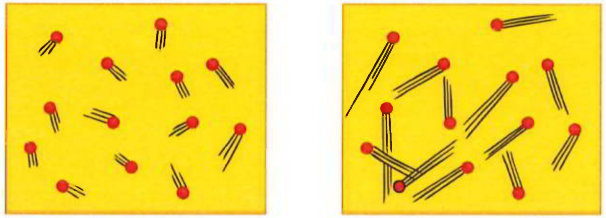
Gas particles move about randomly, at high speed. They intercept other gas particles and anything else that is in the way. When this occurs, a pressure is exerted. If the gas is within a sealed container, pressure occurs when the gas particles hit the walls of the container. They produce a force at right angles to the wall of the container.



If the temperature of the gas increases, then the pressure will also increase. The hotter the temperature, the more kinetic energy the gas particles have. They move faster, colliding with the sides of the container more often.

Internal Energy

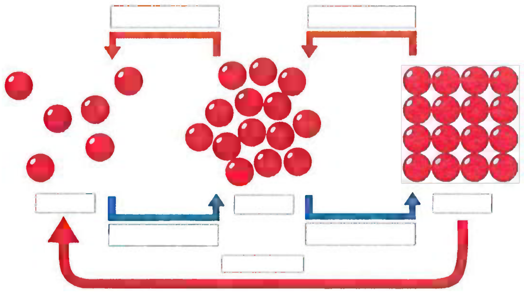
Particles within a system have kinetic energy when they vibrate or move around. The particles also have a potential energy store. The total internal energy of a system is the kinetic and potential energy stores.



Low Temperature High Temperature

If the system is heated, the particles will gain more kinetic energy, so increasing the internal energy.

Changing State

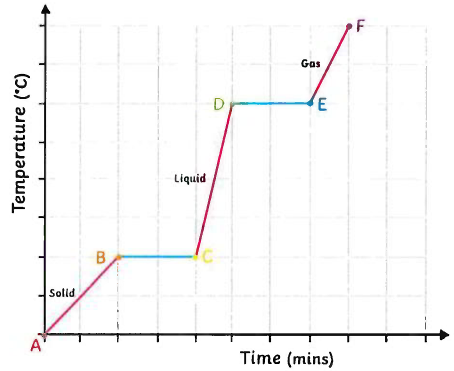


If a system gains more energy, it can lead to a change in temperature or change in state. If the system is heated enough, then there will be enough energy to break bonds.

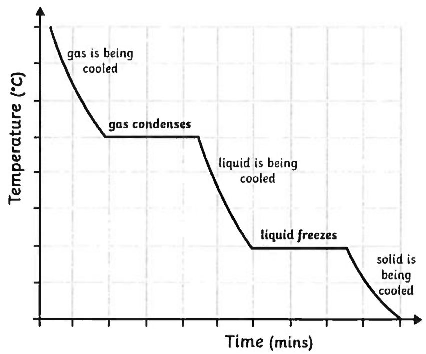
When something changes state, there is no chemical change, only physical. No new substance is formed. The substance will change back to its original form. The number of particles does not change and mass is conserved.

Specific Latent Heat

Energy is being put in during melting and boiling. This increases the amount of internal energy. The energy is being used to break the bonds, so the temperature does not increase. This is shown by the parts of the graph that are flat.



When a substance is condensing or freezing, the energy put in is used to form the bonds. This releases energy. The internal energy decreases, but the temperature does not go down.



The energy needed to change the state of a substance is called the latent heat.

Specific latent heat is the amount of energy needed to change 1kg of a substance from one state to another without changing the temperature. Specific latent heat will be different for different materials.

- solid ⟶ liquid - specific latent heat of **fusion**
- liquid ⟶ gas - specific latent heat of **vaporisation**

Specific Latent Heat Equation

The amount of energy needed/released when a substance of mass changes state.

energy (E) = mass (m) × specific latent heat (L)

$E = mL$

Pressure in Gases

Heating

Heating up the gas particles provides them with more energy to move more quickly. This means they are likely to collide more frequently with other particles. This, in turn, increases the pressure.

Volume

If the volume of the container is increased, the number of collisions will decrease. This causes an overall decrease in pressure.

The equation for a fixed mass and a constant temperature is as follows (you will be given this in the exam):

$P \times V = \text{constant}$

P = pressure (Pa)

V = volume (m^3)

If the volume increases, the pressure decreases.

If the volume decreases, the pressure increases.

If the pressure of a gas changes, the volume of the gas can also change. A helium-filled balloon, once released, will rise into the atmosphere; the pressure outside of the balloon will decrease. The volume of the balloon will increase (due to less pressure outside the balloon), meaning the pressure inside the balloon will decrease.

Work Done on a Gas (Higher Tier Only)

Work done on a gas causes it to gain internal energy and so will increase the temperature. Pumping up the tyre of a bicycle involves doing work and this will increase the temperature of the gas inside the bicycle tyre.