Cells

Nucleus
Controls cell

Ribosomes
Protein synthesis

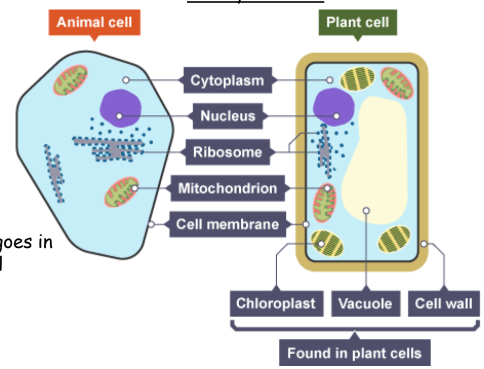
Cell Membrane
Controls what goes in and out the cell

Mitochondria
Respiration

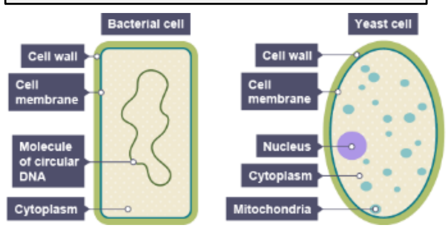
Chloroplast
Photosynthesis

Cytoplasm
Where chemical reactions occur

Eukaryotic cells



Prokaryotic cells – no membrane bound organelles (loose DNA)



Diffusion

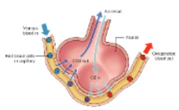
Movement of particles from a high concentration to a low concentration (down a concentration gradient)

To increase rate of diffusion:

- Increase temperature
- Increase surface area
- Increase concentration gradient
- Shorten distance

Large organisms have a small surface area:volume so require specialised exchange surfaces with large surface area so diffusion is fast enough.

Small Intestine: Villi increase surface area
Blood flow maintains conc. Gradient
Thin wall 1 cell thick



Stem Cells

Undifferentiated cells taken from an embryo or adult bone marrow.

Specialised Cells – Cells that have differentiated

Neurone		• Long and thin. • Have a myelin sheath to prevent loss of impulse. • Form connections with other neurones. • Can carry electrical impulses in one direction.
Sperm		• Contain digestive enzymes for breaking down the outer layer of an egg cell. • Many mitochondria. • Have long tail.
Red Blood		• Large surface area. • Small diameter. • No nucleus. • Contain haemoglobin.
Root Hair		• Found close to xylem • Thin membrane. • Large surface area.
Cone Cells		• Outer segment filled with visual pigment that changes chemically in coloured light. • Lots of mitochondria so that you constantly see in colour. • Specialised synapses connecting to the optic nerve.

Tissues and Organs

Tissues: cells working together

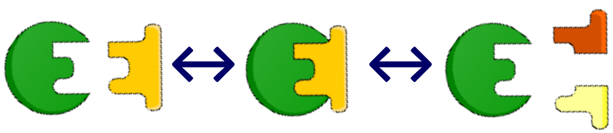
Animal	Glandular	• Ribosomes – make enzymes and hormones • Vesicles to store enzymes and hormones
	Muscular	• Long, thin cells contracts • Lots of mitochondria for energy
	Epithelial	• Goblet cells make mucus • Cells have cilia
Plant	Mesophyll	• Lots of chloroplasts • Photosynthesis
	Epidermal	• Thin and translucent to allow light through
	Xylem	• Transports water
	Phloem	• Transports sugars

Organs: tissues working together

Stomach: Glandular: Makes enzymes and acid
Epithelial: mucus protects lining
Muscular: contracts, churns food

Enzymes – biological catalyst made from protein in ribosomes

- Enzymes have an active site (shape)
- Active site fits a substrate and breaks it down



enzyme + reactant ↔ enzyme-reactant complex ↔ enzyme + products

Denature: Active site changes
No longer recognises substrate

- **Temperature** – too cold too slow
  - optimum = 37°C
  - too hot = denatures
- **pH** – enzymes only work at specific pH
  - stomach enzymes need pH 1-2 (acid)
  - intestinal enzymes need pH 7-8 (bile)

Digestive Enzymes

Carbohydrase (e.g. amylase)	Large sugars (starch) → Simple sugars (glucose)	Salivary glands, pancreas, Small intestine	pH7-8 37°C
Protease (e.g. pepsin)	Protein → Amino acids	Stomach Pancreas Small intestine	Stomach = pH1-2 37°C
Lipase (e.g. pancreatic lipase)	Fats → Fatty acids and glycerol	Stomach Pancreas Small intestine	pH 7-8 37°C

Commercial Use – speed up reactions, increase yields but need to monitor temperature and pH.

Industry	Function of Enzymes
Diet foods	change glucose into fructose, which is sweeter so less is needed and is used in 'slimming' foods (isomerase).
Baby food	start off digestion of food (proteases and lipases)
Biological detergent	break down stains (proteases and lipases).

AQA BIOLOGY B1: Cells & Organisation

Year 9 | Term 1

Kettlethorpe HIGH SCHOOL

REQUIRED PRACTICAL: Food Tests

Type of Food	Name of Test	Positive Result	Negative Result
Starch	Iodine	Blue/Black	Brown
Glucose	Benedict's (must be heated)	Green → Yellow → Brick red	Blue
Protein	Biuret	Lilac	Blue
Lipids	Emulsion	Cloudy precipitate	Clear

Health and Risk Factors

- **Communicable disease:** Any disease transmitted from one person or animal to another, also called contagious disease.
- **Non Communicable disease:** Medical condition or disease that is non-infectious or non-transmissible.

Risk Factors:

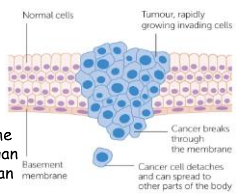
- **Cardiovascular disease:** diet/obesity, age, genetics and exercise.
- **Lung disease:** smoking and cleanliness of the environment.
- **Liver disease:** alcohol, diet/obesity, genetics, drugs and viral infection
- **Type 2 diabetes:** genetics, diet/obesity and exercise

Cancer

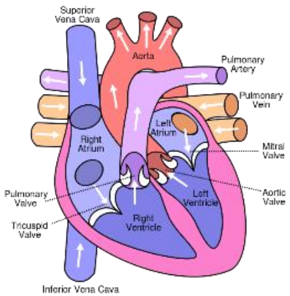
When our cells divide, mutations can occur in the DNA which lead to abnormal cells.

Malignant cancer can spread to other parts of the body. We call this **metastasis**.

A cancer cell can detach from the tumour and be carried by the blood to other parts of the body. The cancer cell can become stuck in a capillary by an organ and then begin growing until it has invaded that organ too.



The Heart



Double circulation

Right = lungs for gas exchange

Left = Rest of body

Needed because humans are more active and lungs are very delicate so blood can't be at a high pressure but must be to go round the rest of the body.

What could happen if our coronary arteries narrow?

Plaque (fatty deposit) builds on the walls of the blood vessel.

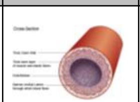
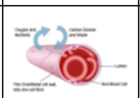
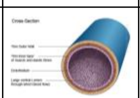
The blood vessel can become blocked or in some cases the blood pressure increases causing some plaque to break away.

The plaque blocks narrower vessels causing blood clots and a lack of oxygen to tissue and organs.

- Lack of oxygen
- Lack of glucose
- For respiration
- No energy for contraction of cardiac muscle
- Heart stops (cardiac arrest)

Procedure	How they work	Advantages	Disadvantages
Statins	Drugs that lower blood cholesterol levels preventing plaque forming	Cheap Preventative	Can cause side effects
Stents	Insert a balloon and wire mesh to artery. Inflate balloon and leave wire in place	Invasive Minor surgery	Anticoagulant drugs are needed which prevents blood clotting
Bypass Surgery	Piece of vein is grafted from leg to bypass the blocked coronary artery	Permanent solution	Expensive Scars Major surgery
Mechanical Valve Replacement	Synthetic valve used to replace faulty one.	Last longer	Need anticoagulant drugs
Biological Valve Replacement	Animal valve used to replace faulty one	No drugs needed	Only lasts 15 years
Pacemaker	Device used to trigger the heart to beat in its normal rhythm	Keeps heart beating properly	Surgical procedure Can stop working near machinery and electronic devices
Heart Transplant	Donor heart used to replace patient's heart	Permanent solution	Major surgery Rejection Immunosuppressant drugs needed

Blood Vessels

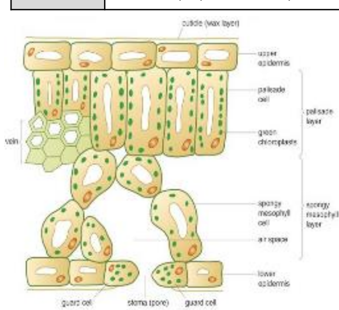
Blood Vessel	Diagram	Type of Blood	Pressure	Special Features
Artery		Oxy	High	Thick muscular elastic walls Smaller lumen
Capillary		Both	Med	1 cell thick walls for fast diffusion
Vein		Deoxy	Low	Large lumen Valves to prevent back flow of blood

Blood

- Red Blood Cells – haemoglobin carries oxygen, biconcave disk increases surface area, no nucleus to fit in more haemoglobin.
- White blood cells – fight pathogens
- Plasma – transports dissolved substances
- Platelets – bits of cytoplasm used to form blood clots

Plants and Photosynthesis

Roots	• Uptake of water and minerals • Large surface area due to root hair cells • Protein channels for active transport • Meristems – plant stem cells
Stem	• Hold leaves in position • Waxy epidermis to prevent water loss • Xylem – transports water • Phloem – transports sugars
Leaves	• Broad, flat to increase surface area • Contain 4 types of tissue to carry out photosynthesis (see below) • Guard cells close stomata at night to prevent water loss by transpiration • Waxy epidermis to prevent water loss



How is the leaf adapted for efficient photosynthesis?

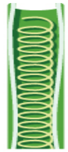
- Sun hits palisade cells at top
- Palisade – lots of chloroplasts
- Spongy mesophyll allows gas movement
- Xylem brings water
- Phloem maintains concentration gradient by removing glucose
- Guard cells open to allow carbon dioxide to diffuse into the leaf.

Transpiration and Translocation

Phloem

- Phloem vessels are made of long, thin-walled cells that form tubes.
- Sugars and amino acids dissolved in sap are transported in the phloem by a process called **translocation**.
- The ends of the phloem tubes are called **sieve plates** and they have small holes in them to allow transport in both directions.
- Phloem cells have no nuclei. They have **companion cells** next to them to control them which are filled with mitochondria.

Xylem

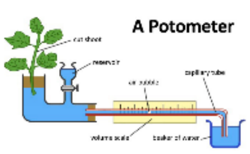


- Xylem tubes are made from long cells with thick, reinforced walls made from **lignin**.
- The vessel has a large hollow lumen for water and minerals to flow through in one direction.
- The cell walls are waterproof which makes the cells die which results in wood in trees!

Transpiration Stream

1. Higher concentration of water in soil than in roots
2. Water moves into roots by osmosis
3. Higher concentration of water in roots than in leaves
4. Water moves up the xylem by osmosis to the leaves
5. Water lost through stomata and used for photosynthesis maintains concentration gradient.
6. This causes more water to be drawn in by the roots. This is called the transpiration stream

A Potometer

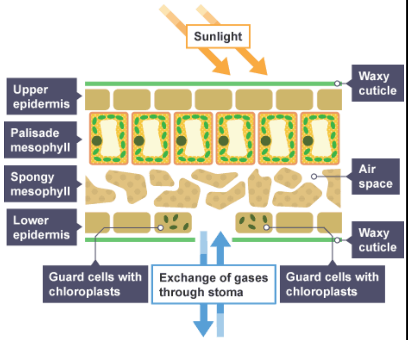


Photosynthesis

Carbon Dioxide + Water → Glucose + Oxygen

$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

- Gases diffuse through stomata
- Palisade cells have lots of chloroplasts
- Xylem brings water
- Spongy to allow gases to move through leaf.

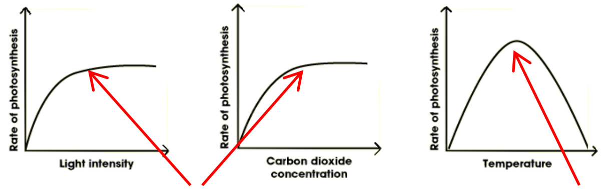


Uses of glucose:

- Respiration – energy – growth
- Starch – storage
- Protein – glucose + nutrients from the soil
- Fats – stored in seeds
- Cellulose – cell walls

Limiting factors

- Light
- Carbon dioxide concentration
- Temperature



Something else limits the rate (temperature, CO_2, amount of chlorophyll)

Controlled by **enzymes** that are too slow when cold and **denature** when too hot

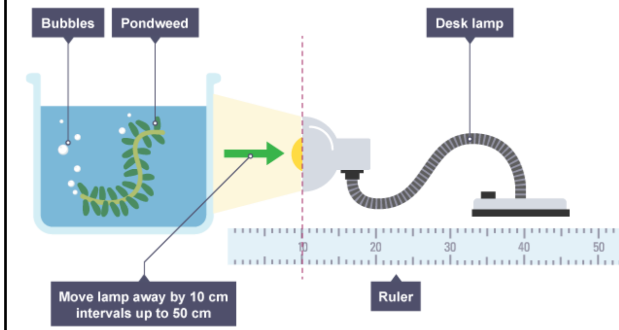
Greenhouses

+ Control the conditions (heat, CO_2, water, light, pests, weeds)
+ Grow plants all year round
+ Grow plants not native to certain countries
+ Increased crop yields

- Costs to maintain conditions
- Conditions need to be monitored

Hydroponics: Plants grown in mineral solution rather than water – control nutrients, no fungal infections from soil.

REQUIRED PRACTICAL: Photosynthesis



In the experiment above:

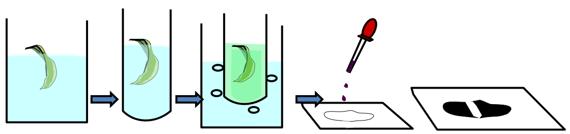
1. Pondweed is in water with sodium carbonate solution (to provide CO_2 for photosynthesis)
2. Move light bulb different distances and count the bubbles of oxygen that are produced per minute.

The closer the light, the more oxygen is made because the rate of photosynthesis increases.

Starch Testing a Variegated Leaf

We test for the presence of **starch** in leaves in order to determine that photosynthesis has occurred. Glucose is rapidly converted into starch for **storage** in the chloroplast and cytoplasm.

De-starching is the process by which the starch reserves in a plant are depleted by depriving the plant of either light or carbon dioxide. We need to **remove all traces of starch** in leaves so that we can provide evidence that photosynthesis takes place during the experiment.

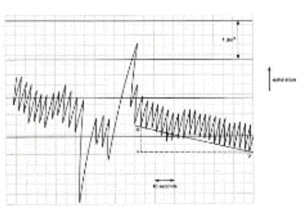


- Boiling ethanol breaks down cellulose and removes chlorophyll.
- Iodine solution turns blue/black where starch is present i.e. where photosynthesis has taken place.

Measuring HR and BR

HR – heart rate monitor
BR – spirometer

Tidal volume – normal volume breathed in and out.



Respiration – energy RELEASE not made (exothermic)

Aerobic: Glucose + Oxygen → Carbon Dioxide + Water
$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

- Occurs in mitochondria
- Needs oxygen
- Releases a lot of energy (ATP)

Some microorganisms (e.g. yeast) respire anaerobically producing ethanol and CO_2. This is called **fermentation** and is used to make bread and alcohol.

Anaerobic: Glucose → Lactic acid
$C_6H_{12}O_6 \rightarrow 2C_3H_6O_3$

- Occurs in mitochondria
- No oxygen
- Leads to **oxygen debt** (which is why you breathe heavily after sport to pay it back)
- Very little energy is released.

Exercise effect on HR and BR

Heart Rate increases – more oxygen to muscle
- more glucose to muscle
- more CO_2 and water to lungs

Breathing Rate increases – more oxygen into blood
- more CO_2 and water out of the blood

Stored glycogen in muscle turned into glucose.

Metabolic Rate: The speed of chemical reactions in the body.

- Older = slower
- Female = slower
- High fat to muscle ratio = slower
- Could be inherited

Metabolic reactions:

- Respiration – catabolic (big → smaller molecules)
- Photosynthesis – anabolic (small → bigger molecules)
- Break down of proteins to urea in **liver** – catabolic
- Enzymes breaking down food – catabolic
- Combining glucose with nitrate ions to form amino acids and then protein – anabolic

Anabolic reactions require **energy** from cellular respiration.

Carbohydrates	Energy
Protein	Cell repair, growth and replacement
Fat	Energy and insulation
Fibre	Digestion
Minerals	Calcium – Bones, Iron – Blood
Vitamins	Immune system

Biotic and Abiotic Factors

Abiotic Factors

These are **non-living** factors that can affect an ecosystem.

- Light intensity
- Temperature
- Moisture
- Wind intensity/direction
- CO_2 level
- Oxygen level
- Soil pH

Biotic Factors

These are **living** factors that can affect an ecosystem.

- Competition with other species
- Food availability
- New predators
- New diseases

Key Terms

Habitat – where an organism lives
Population – all organisms of a species in a habitat
Community – populations of different species in a habitat
Ecosystem – the interaction of biotic and abiotic factors

The animals and plants are usually **interdependent**:

- Animals eat plants
- Animals pollinate plants
- Animals eat animals
- Animals use plants to build shelters
- Plants use nutrients from animal droppings

A **stable community** is one where all the species and environmental factors are in balance, so population sizes remain fairly constant e.g. tropical rainforests.

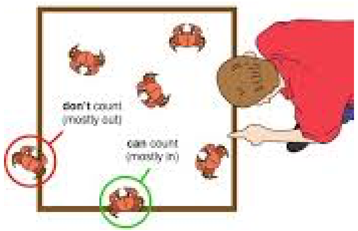
Distribution of Organisms

Where organisms live depends on:

- Temperature
- Amount of light
- Availability of water
- Availability of nutrients
- Availability of oxygen and carbon dioxide

Quadrats – To estimate a population

1. Throw randomly (prevent bias) many times
2. Count number of organisms / % coverage
3. Calculate the mean
4. See how many quadrats fit in whole area
5. Multiply number of quadrats by the mean



Line/Belt Transects – To show distribution

1. Lay tape along the area
2. Place quadrat at regular intervals
3. Count number of organisms / % coverage

Adaptations

Structural: the features of an organism's body structure, e.g. shape, size or colour.

Behavioural: how an organism behaves e.g. some species **migrate** to warmer climates during winter months.

Functional: internal processes of an organism e.g. desert animals produce **little sweat** and small amounts of urine to conserve water.

Arctic
- prevent heat loss
- small SA:Vol = lose less heat
- camouflage from prey

Desert
- large SA:Vol = easily lose and gain heat
- camouflage from prey
- no leaves
- water storage
- deep roots

Predators
- Camouflage
- Mimicry
- Poisons and spikes
- Warning colours

Extremophile – organisms with adaptations to live in harsh habitats to reduce competition.

Competition

Plants – light, space, water, minerals
Animals – space, food, water, mates

Decay

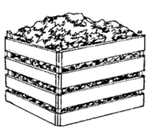
- Detritus feeders = worms, beetles, maggots
- Decomposers = bacteria, fungi
- They respire using waste, dead organisms etc.

Conditions needed = **WARM**, **MOIST** and **OXYGEN**

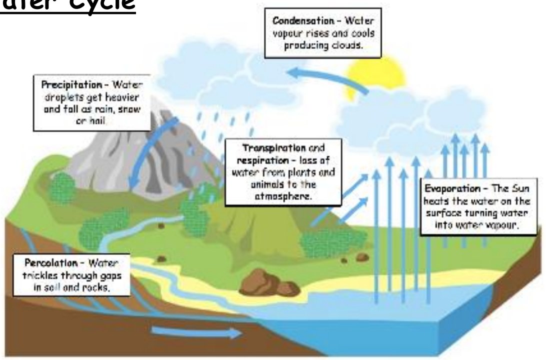
Decay puts nitrates back into the soil and carbon dioxide back into the atmosphere.

Compost Heaps – Decay releases nutrients from dead plants and animals to make fertile soil.

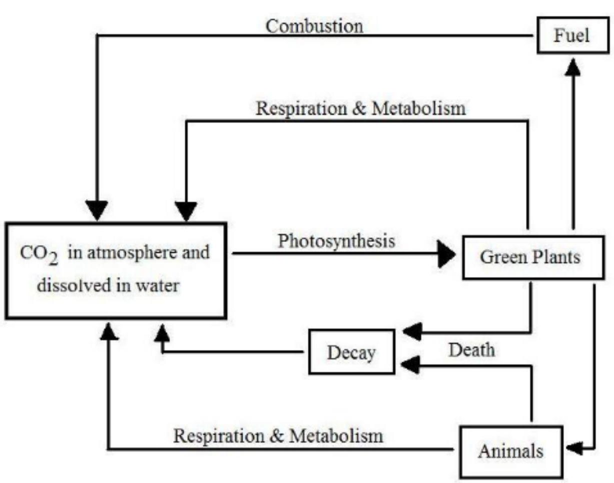
- **Air holes** – let oxygen in, regulate temperature.
- **Warmth** generated by respiring microorganisms.
- Finely shredded waste increases surface area.



Water Cycle



Carbon Cycle



Remember to follow the path of carbon e.g. CO_2 in air taken in by plants (photosynthesis), plants eaten by animals, animals die (decay), microorganisms respire, CO_2 back in the air.

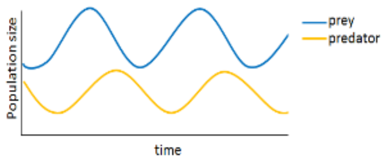
Food Chains

Grass → Rabbit → Fox

(producer → primary consumer → secondary consumer)

Always start with a producer (plant) as they produce their own food – they **photosynthesise** using the Sun's energy to produce **glucose**. Some of this glucose is used to produce new biological molecules in the plant, increasing its **biomass** (an energy store). Some of this biomass is passed on to the animal that eats the plant (secondary consumer). Therefore energy is transferred through organisms in a food chain.

Predator-Prey Relationships



The amount of food limits the population of a species. If the population of prey increases then so will the population of predators. But, as the number of predators increase, the number of prey decrease.

The predator-prey cycles are slightly **out of phase** with each other because it takes a short white for a population to **respond** to changes in the other.

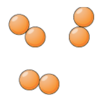
If the number of rabbits increase it will take a while for the foxes to reproduce.

Elements, Mixtures and Compounds

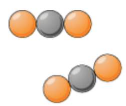
Rule 1 – If two identical elements combine then the name doesn't change

Rule 2 – When two elements join the end is usually ________ide.

Rule 3 – When three or more elements combine and one of them is oxygen the ending is ______ate



An element is just a pure substance, for example oxygen (O_2)

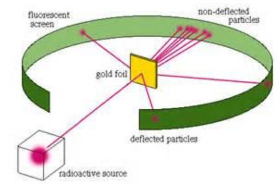


A compound is a material that is made up of more than one type of atom chemically bonded together, for example Carbon Dioxide (CO_2)

A mixture contains two or more different types of compounds or elements that are not chemically bonded together

Atomic Structure

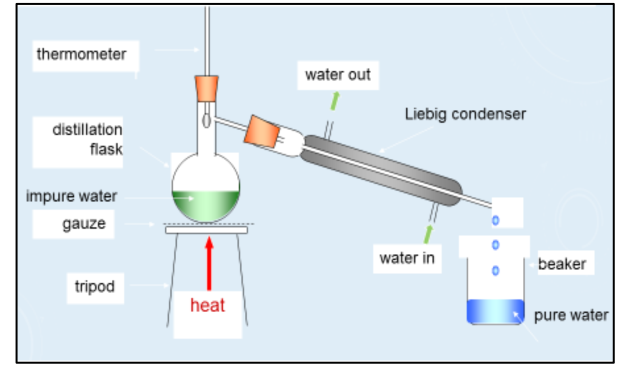
1. In 1901 JJ Thompson suggested the **plum pudding model – this was an atom** that the atom is a ball of positive charge with negative electrons embedded in it.



2. In 1909 Rutherford changed the accepted model using his alpha scattering experiment. The results from the alpha particle scattering experiment led to the conclusion that the mass of an atom was concentrated at the centre (nucleus) and that the nucleus was charged. This nuclear model replaced the plum pudding model.

3. Niels Bohr adapted the nuclear model by suggesting that electrons orbit the nucleus at specific distances.
4. 20 years later, James Chadwick provided the evidence to show the existence of neutrons within the nucleus.

Distillation



Distillation can be used to separate liquids from a mixture, if they have different boiling points. Distillation is the process in which evaporation of a liquid is followed by condensation

The Atom

Mass Number → 12

C

Atomic Number → 6

Name of particle	Relative charge	Relative mass
Proton	+1	1
Neutron	0	1
Electron	–1	Very small

Atoms are very small, having a radius of about 0.1 nm (1×10^{-10} m).

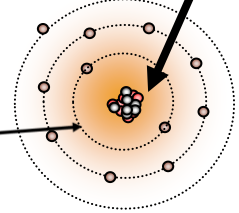
The radius of a nucleus is less than 1/10 000 of that of the atom (about 1×10^{-14} m).

The mass number tells us the number of protons + neutrons.

The number of protons in an atom is known as its atomic number, this is also the number of electrons

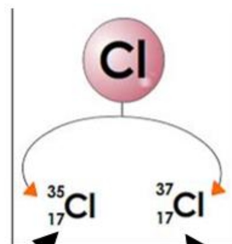
The Nucleus
a dense core of protons and neutrons containing nearly all the mass of the atom

'Shells' of electrons
electrons are really very very tiny so the atom is mostly empty space.



Relative Atomic Mass

RAM is the average mass of all the stable isotopes of that element and includes the relative abundance.



Chlorine - 35 Chlorine - 37

Element	Relative mass of isotope	Relative abundance
Chlorine	35	3
	37	1

$$R.A.M. = \frac{(35 \times 3) + (37 \times 1)}{3 + 1} = 35.5$$

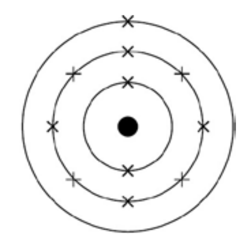
Electronic Structure

The electrons in an atom occupy the lowest available energy levels (innermost available shells).

The electronic structure of an atom can be represented by numbers or by a diagram.

Up to two electrons can occupy the lowest energy level, up to eight in the second energy level and up to eight in the third energy level.

For example, the electronic structure of sodium is 2,8,1.



Development of the Periodic Table


Newlands

Before the discovery of protons, neutrons and electrons, scientists attempted to classify the elements by arranging them in order of their atomic weights.

The early periodic tables were incomplete and some elements were placed in inappropriate groups if the strict order of atomic weights was followed.


Mendeleev

Mendeleev overcame some of the problems by leaving gaps for elements that he thought had not been discovered and in some places changed the order based on atomic weights.

Elements with properties predicted by Mendeleev were discovered and filled the gaps. Knowledge of isotopes made it possible to explain why the order based on atomic weights was not always correct.

Transition Metals (Triple Only)

The transition elements are metals with similar properties. Their properties are different from those found in Group 1. Lots of transition metals are used as catalysts.

Properties of transition metals;
- High melting + boiling point
- Form positive ions
- Good electrical conductors
- High thermal conductivity
- Malleable
- Form colored compounds

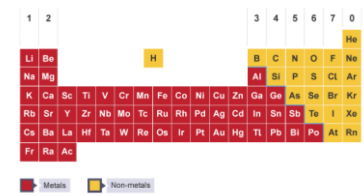
Copper Good conductor of heat and electricity	**Iron** Alloys are very strong	**Manganese** Resistant to corrosion
Cobalt Strong when alloyed with other metals	**Chromium** Can speed up reactions (Catalyst)	**Nickel** Alloys are resistant to corrosion

Metals and non-metals

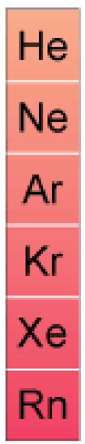
Elements that react to form positive ions are metals. Elements that do not form positive ions are non-metals.

The formation of ions can be worked out using the Periodic Table:
- Group 1 elements form 1+ ions, group 2 elements form 2+ ions and group 3 elements form 3+ ions.
- Group 5 elements form 3- ions, group 6 elements form 2- ions and group 7 elements form 1- ions.
- Group 0 do not form ions due to having a stable structure/full outer shell.

The majority of elements are metals. Metals are found to the left and towards the bottom of the periodic table. Non-metals are found towards the right and top of the periodic table.



Group 0

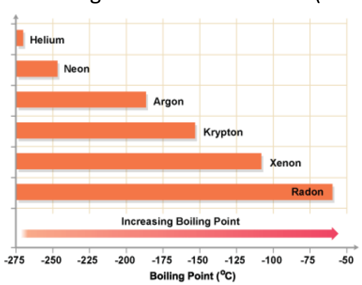


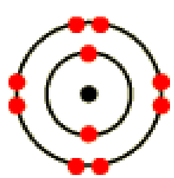
The elements in Group 0 of the periodic table are called the noble gases.

They are unreactive and do not easily form molecules because their atoms have stable arrangements of electrons.

The noble gases have eight electrons in their outer shell, except for helium, which has only two electrons.

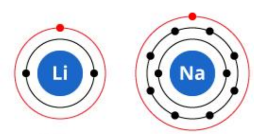
The boiling points of the noble gases increase with increasing relative atomic mass (down the group).





Group 1

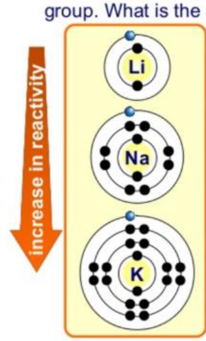
The elements in Group 1 of the periodic table are known as the alkali metals and have characteristic properties because of the single electron in their outer shell.



Lithium Sodium

How does electron structure affect reactivity?

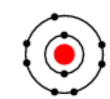
The reactivity of alkali metals **increases** going down the group. What is the reason for this?



- The atoms of each element get larger going down the group.
- This means that the outer shell electron gets further away from the nucleus and is shielded by more electron shells.
- The further an electron is from the positive nucleus, the easier it can be lost in reactions.
- This is why the reactivity of the alkali metals increases going down group 1.

Group 7

The elements in Group 7 of the periodic table are known as the halogens and have similar reactions because they all have seven electrons in their outer shell.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The halogens are non-metals and consist of molecules made of pairs of atoms.


Cl

In Group 7, the further down the group an element is the higher its relative molecular mass, melting point and boiling point.

In Group 7, the reactivity of the elements decreases going down the group.

A more reactive halogen can displace a less reactive halogen from an aqueous solution of its salt.

Displaced is just a chemist's word for pushed out.

chlorine + sodium bromide → sodium chloride + bromine

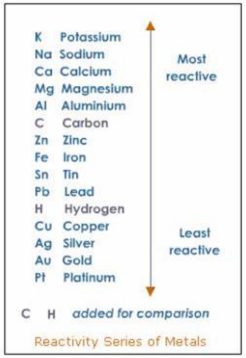
$Cl_2 + 2NaBr \rightarrow 2NaCl + Br_2$

Extraction of Metals + Metal Oxides

Metals react with oxygen to form metal oxides

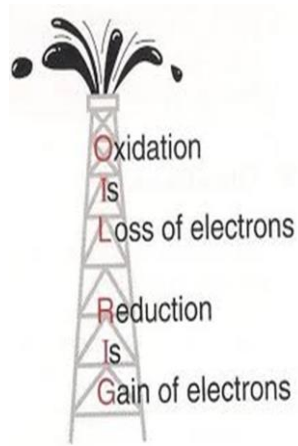
Chromium + Oxygen → Chromium oxide
Iron + Oxygen → Iron oxide
Copper + Oxygen → Copper oxide

Many metals are found in the ground as metal compounds. The metal needs to be extracted. For metals that are below carbon in the reactivity series this can be done by heating the metal compound with carbon The carbon removes the oxygen from the metal oxide.



1. Copper oxide + Carbon → Carbon dioxide + Copper
2. Lead oxide + Carbon → Carbon dioxide + Lead
3. Iron oxide + Carbon → Carbon dioxide + Iron

Oxidation and Reduction



Oxidation is the gain of oxygen and the loss of electrons, reduction is the loss of oxygen and gain of electrons.

A chemical reaction where both oxidation and reduction occur is called a redox reaction.

The equation below shows a word equation, a balanced symbol equation, ionic and half equations which show the movement of electrons.

Zinc + copper sulphate → zinc sulphate + copper
$Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$
Zn - oxidised Cu^{2+} - reduced
$Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$
$Zn - 2e^- \rightarrow Zn^{2+}$ or $Zn \rightarrow Zn^{2+} + 2e^-$
$Cu^{2+} + 2e^- \rightarrow Cu$

Metals + Acids and Metal Carbonates + Acid

Metal + Acid → Metal salt + Hydrogen

Calcium + Hydrochloric acid → Calcium chloride + Hydrogen
$Ca + 2HCl \rightarrow CaCl_2 + H_2$
Zinc + Hydrochloric acid → Zinc chloride + Hydrogen
$Zn + 2HCl \rightarrow ZnCl_2 + H_2$

Metal Carbonate + Acid → Metal salt + Carbon Dioxide + Water

Calcium Carbonate + Hydrochloric acid → Calcium chloride + Carbon Dioxide + Water
$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$
Potassium Carbonate + Nitric acid → Potassium nitrate + Carbon Dioxide + Water
$K_2CO_3 + 2HNO_3 \rightarrow 2KNO_3 + CO_2 + H_2O$

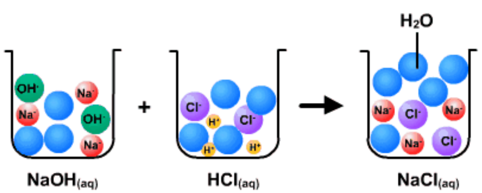
Acid + Alkali → Metal salt + Water

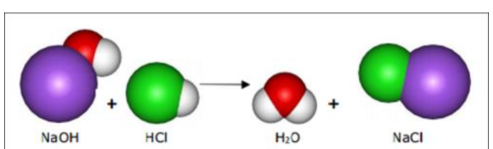
Hydrochloric acid + Sodium hydroxide → Sodium chloride + Water
$2HCl + NaOH \rightarrow NaCl_2 + H_2O$
Sulphuric acid + Potassium hydroxide → Potassium Sulphate + Water
$H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$

Neutralisation

The acid used will determine the salt produced in a neutralisation reaction:

- hydrochloric acid produces chlorides
- nitric acid produces nitrates
- sulfuric acid produces sulfates





Soluble salts (Required practical)

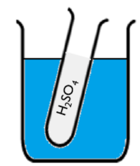
Soluble salts can be made from acids by reacting them with solid insoluble substances, such as metals, metal oxides, hydroxides or carbonates.

The solid is added to the acid until no more reacts and the excess solid is filtered off to produce a solution of the salt.

Salt solutions can be crystallised to produce solid salts.

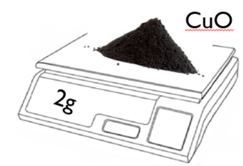
Soluble salts (Required practical): Method

1



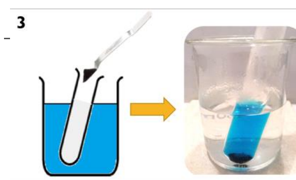
Sulfuric acid is warmed in a water bath

2



Weigh 2g of black copper oxide powder

3



Add copper oxide to the sulphuric acid until a blue solution is formed and excess copper oxide sinks to the bottom of the tube.

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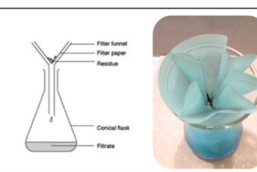
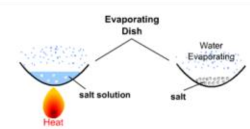


Filter the unreacted copper oxide from the solution and collect the filtrate

5

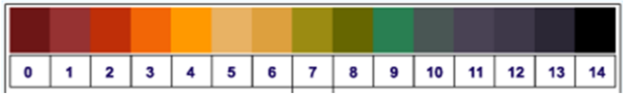


Transfer the solution to an evaporating dish and heat gently

6

Leave to cool, copper sulfate crystals will form. Remove and dry crystals.

pH and Acids + Alkalis



Acids produce H^+ (as H_3O^+) ions in water and they taste sour. They also corrode metals and have a pH of less than 7. They also turns blue litmus paper to red.

Alkalis produce OH^- ions in water and they taste bitter with a pH greater than 7. Alkalis turns red litmus paper to blue.

A solution is defined as an acid if the concentration of H^+ ions is greater than the concentration of OH^- ions. $[H^+] > [OH^-]$

A solution is defined as alkali/base if the concentration of hydrogen ions is less than the concentration of hydroxide ions. $[H^+] < [OH^-]$

Strong and weak acids

A strong acid is completely ionised in aqueous solution. $HCl + H_2O \longrightarrow H^+ + Cl^-$

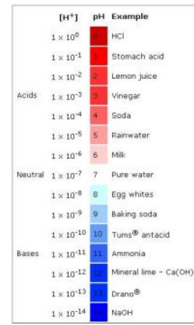
Examples of strong acids are hydrochloric, nitric and sulfuric acids.

A weak acid is only partially ionised in aqueous solution. $CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H^+$

Examples of weak acids are ethanoic, citric and carbonic acids.

For a given concentration of aqueous solutions, the stronger an acid, the lower the pH.

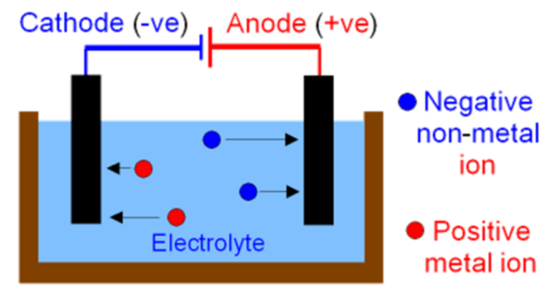
As the pH decreases by one unit, the hydrogen ion concentration of the solution increases by a factor of 10.



	$[H^+]$	pH	Example
	1×10^{0}	0	HCl
	1×10^{-1}	1	Stomach acid
	1×10^{-2}	2	Lemon juice
Acids	1×10^{-3}	3	Vinegar
	1×10^{-4}	4	Soda
	1×10^{-5}	5	Rainwater
	1×10^{-6}	6	Milk
Neutral	1×10^{-7}	7	Pure water
	1×10^{-8}	8	Egg whites
	1×10^{-9}	9	Baking soda
	1×10^{-10}	10	Tums® antacid
Bases	1×10^{-11}	11	Ammonia
	1×10^{-12}	12	Mineral lime - $Ca(OH)_2$
	1×10^{-13}	13	Drano®
	1×10^{-14}	14	NaOH

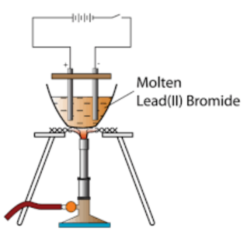
Electrolysis

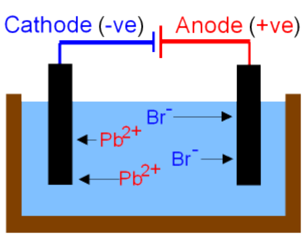
When an ionic compound is melted or dissolved in water, the **ions** are free to move about within the liquid or solution. These liquids and solutions are able to conduct electricity and are called electrolytes. Passing an electric current through electrolytes causes the ions to move to the electrodes. Positively charged ions move to the negative electrode (the cathode), and negatively charged ions move to the positive electrode (the anode).



Electrolysis of molten ionic compounds

When a simple ionic compound (eg lead bromide) is electrolysed in the molten state using inert electrodes, the metal (lead) is produced at the cathode and the non-metal (bromine) is produced at the anode.





Cathode (-ve electrode)

$Pb^{2+} + 2e^- \rightarrow Pb$

Anode (+ve electrode)

$2Br^- - 2e^- \rightarrow Br_2$

OR $2Br^- \rightarrow Br_2 + 2e^-$

Electrolysis Extended

At the negative electrode, hydrogen is produced if the metal is more reactive than hydrogen.
At the positive electrode oxygen is produced unless the solution contains halide ions when the halogen is produced.

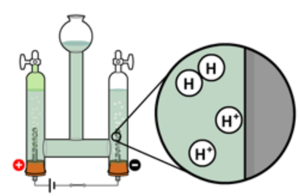
This is due to water molecules breaking down in aqueous solution to form hydrogen and hydroxide ions.

At the cathode positively charged ions gain electrons, whereas as the negatively charged ions lose electrons at the anode. These are both examples of oxidation and reduction. These can be represented as half equations.

$2H^+ + 2e^- \rightarrow H_2$

$4OH^- \rightarrow O_2 + 2H_2O + 4e^-$

$4OH^- - 4e^- \rightarrow O_2 + 2H_2O$



Rules for determining products

At the cathode

Whether hydrogen or a metal is produced at the cathode depends on the position of the metal in the metal **reactivity series**:

- the metal is produced at the cathode if it is less **reactive** than hydrogen
- hydrogen is produced at the cathode if the metal is more reactive than hydrogen

At the anode

Oxygen is produced (from hydroxide ions), unless **halide** ions (chloride, bromide or iodide ions) are present. In that case, the negatively charged halide ions lose electrons and form the corresponding **halogen** (chlorine, bromine or iodine).

The table summarises the product formed at the anode during the electrolysis of different **electrolytes** in solution.

Negative ion	Element given off at anode
Chloride, Cl^-	Chlorine, Cl_2
Bromide, Br^-	Bromine, Br_2
Iodide, I^-	Iodine, I_2
Sulfate, SO_4^{2-}	Oxygen, O_2
Nitrate, NO_3^-	Oxygen, O_2

Exothermic and endothermic reactions

Exothermic reactions **release** thermal energy (heat) into their surroundings. They can occur spontaneously and some are explosive. Most chemical reactions are exothermic. Temperature **increases**.

What are some examples?

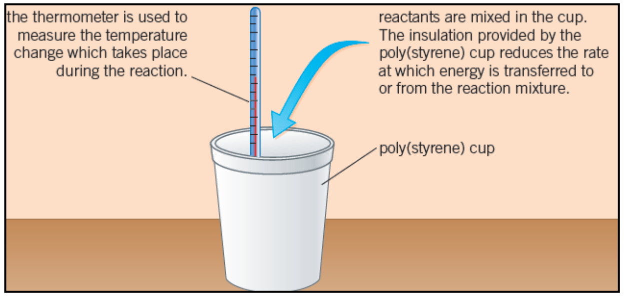
- combustion
- respiration
- neutralization of acids with alkalis
- reactions of metals with acids
- $Mg (s) + HCl (aq) \rightarrow MgCl_2 (aq) + H_2 (g)$
- the Thermite Process.
- Endothermic reactions absorb thermal energy, and so cause a **decrease** in temperature.

What are some examples?

- thermal decomposition, e.g. calcium carbonate in a blast furnace
- photosynthesis
- some types of electrolysis
- Sherbet
- $NH_4NO_3 (s) + H_2O (l) \rightarrow NH_4^+ (aq) + NO_3^- (aq)$

Investigating temperature changes

Record the initial temperatures of any solutions, and the maximum and minimum temperatures reached in the course of the reaction.



Using energy transfers from reactions

- Exothermic changes can be used in hand warmers and self heating cans. Crystallisation of the supersaturated solution is used in reusable warmers. However, disposable, one-off hand warmers heat up the surrounding for longer.
- Endothermic changes can be used in instant cold packs for sports injuries.

Reaction profiles and Activation energy

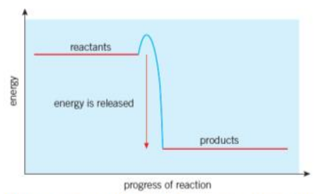


Figure 1 *The reaction profile for an exothermic reaction*

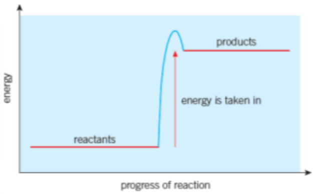


Figure 2 *The reaction profile for an endothermic reaction*

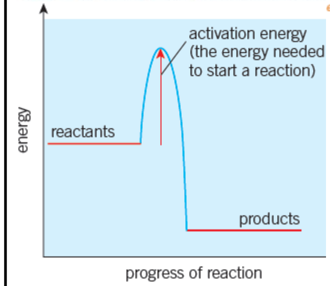


Figure 3 *This reaction profile shows the activation energy for an exothermic reaction*

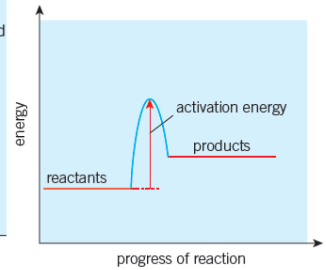


Figure 4 *This reaction profile shows the activation energy for an endothermic reaction*

Bond breaking is endothermic whereas bond making is exothermic.

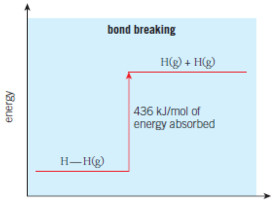
Bond energy calculations

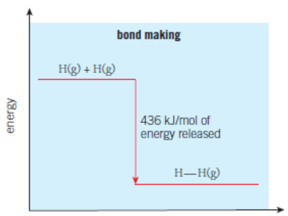
The energy needed to break a bond between 2 atoms is called the **bond energy** for that bond. They are measured in KJ/mol.

Table 1 *Common bond energies*

Bond	Bond energy in kJ/mol
C—C	347
C—O	358
C—H	413
C—N	286
C—Cl	346
Cl—Cl	243

Bond	Bond energy in kJ/mol
H—Cl	432
H—O	464
H—N	391
H—H	436
O═O	498
N≡N	945



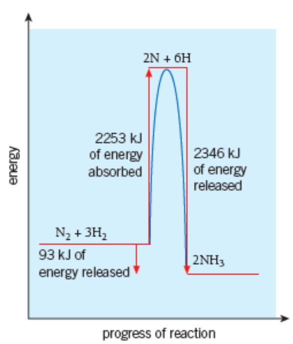


Breaking and making a particular bond always involves the same amount of energy

The formation of ammonia. The energy released, 93KJ, is from the formation of 2 moles of ammonia (see balanced equation below). So if you wanted to know the energy change for the reaction per mole of ammonia formed, it would release exactly half this, i.e. 46.5kJ/mol.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

- In chemical reactions, energy must be supplied to break the bonds between atoms in the reactants.
- When new bonds are formed between atoms in a chemical reaction, energy is released.
- In an exothermic reaction, the energy released when new bonds are formed is greater than the energy absorbed when bonds are broken.
- In an endothermic reaction, the energy released when new bonds are formed is less than the energy absorbed when bonds are broken.
- You can calculate the overall energy change in a chemical reaction using bond energies.



Cells and batteries

$Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$

The sulfate ions do not change in the displacement reaction above. They are spectator ions.

So you can leave them out of the equation and write an ionic equation:

$$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$$

You can think of this redox reaction as two half equations.

One will represent reduction:

$$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$$

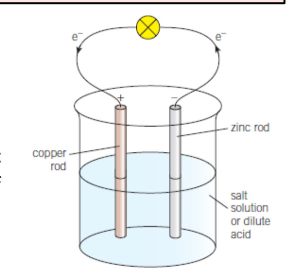
The Cu^{2+} ions are reduced to Cu.

The other will be an oxidation reaction:

$$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$$

The Zn atoms are oxidised to Zn^{2+} ions.

An electrical cell made from zinc and copper → The electrons flow from the more reactive metal (zinc) to the less reactive metal (copper). So zinc acts as the negative terminal of the cell, providing electrons to the external circuit.

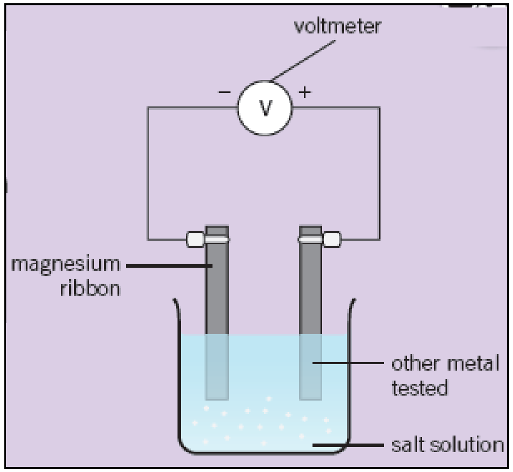


Cells and batteries continued…

- Metals lose electrons and form positive ions.
- When 2 metals are dipped in a salt solution and joined by a wire, the more reactive metal will donate electrons to the less reactive metal. This forms a simple electrical cell.
- The greater the difference in reactivity between the 2 metals, the higher the voltage produced by the cell.

Investigating chemical cells

This apparatus is used to investigate the voltage produced by different metals paired with magnesium ribbon. You can compare magnesium against zinc, iron, copper & tin in your electrical cells.



Fuel Cells

Scientists are developing hydrogen as a fuel.

Hydrogen + Oxygen → Water
$2H_2 + O_2 \rightarrow 2H_2O$

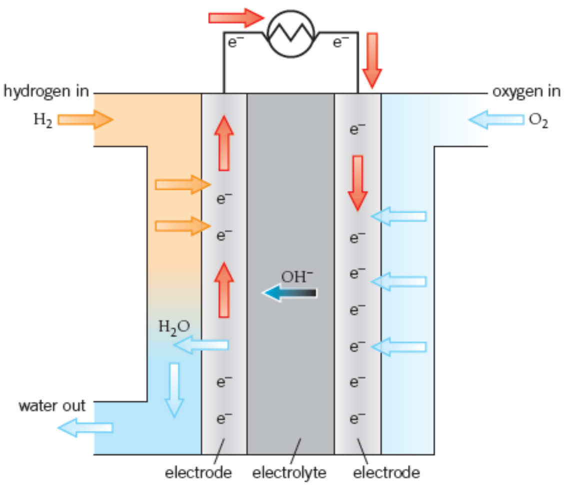
- The world relies on fossil fuels. However, they are non-renewable and they cause pollution.
- Hydrogen is one alternative fuel. It can be burned in combustion engines or used in fuel cells to power vehicles.
- Hydrogen gas is oxidised and provides a source of electrons in the hydrogen fuel cell, in which the only waste product is water.

Hydrogen gas is supplied as a fuel to the negative electrode. It diffuses through the graphite electrode and reacts with hydroxide ions to form water and provides a source of electrons to an external circuit.

$$2H_2(g) + 4OH^-(aq) \rightarrow 4H_2O(l) + 4e^-$$

Oxygen is supplied to the positive electrode. It diffuses through the graphite and reacts to form hydroxide ions, accepting electrons from the external circuit.

$$O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$$



A hydrogen fuel cell which has an alkaline electrolyte, such as potassium hydroxide. Only waste product is water.

Advantages of hydrogen fuel cells –
1) Do not need to be electrically recharged
2) No pollutants are produced
3) Can be a range of sizes for different uses

Disadvantages of hydrogen fuel cells–
1) Hydrogen is highly flammable
2) Hydrogen is sometimes produced for the cell by non-renewable sources
3) Hydrogen is difficult to store

Energy CANNOT be created or destroyed

Energy types

* Gravitational Potential – Increased with height
* Kinetic Energy – Increased with speed
* Elastic Energy – Increased when stretched or squashed
* Thermal Energy – Gained when heated, often lost (wasted) to the surroundings

Energy Transfers

* Mechanically – When a force is applied
* Heating – When an object is heated
* Electrically – When an object is powered by electricity

A ball rolling down a hill: Gravitational Potential Energy is turned mechanically into kinetic energy

Gravitational Energy $E_p = M \times G \times h$
(J) (Kg) (N/Kg) (m)

The higher an object or the more mass it has the more gravitational energy it has.

Kinetic Energy $E_k = \frac{1}{2} \times \text{mass} \times \text{Velocity}^2$
(J) (Kg) (m/s)

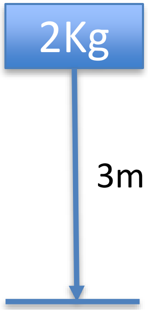
The faster and heavier an object the more kinetic energy it has.

Calculating Velocity

$E_p = M \times G \times H$
$= 2 \times 10 \times 3 = 60J$

$E_p = E_k \Rightarrow E_k = 60J$

$V = \sqrt{\frac{Ek}{\frac{1}{2} x m}} = \sqrt{\frac{60}{\frac{1}{2} x 2}} = 7.7m/s$



Springs

When you add a force (weight) to a spring it extends.

Extension = Stretched length – original length

The energy stored in a spring can be calculate:

$E_e = \frac{1}{2} \times \text{spring constant} \times \text{extension}^2$
(J) (N/m) (m)

Power is a measure of how quickly energy is used. The shorter the time the more powerful it is.

$\text{Power (W)} = \frac{\text{Energy (J)}}{\text{Time (s)}}$

Specific heat capacity (SHC)

The amount of energy needed to heat a 1Kg material by 1°C.

Heat Energy = Mass x SHC x Change in Temp
(J) (Kg) (J/Kg°C) (°C)

$C = \frac{E}{m x \Delta\theta}$ $m = \frac{E}{c \ x \ \Delta\theta}$ $\Delta\theta = \frac{E}{mxc}$

This experiment only gives an estimate for the values calculated as energy is lost to the surroundings.

Heat Transfer

1.The higher the thermal conductivity of a material the higher the rate of heat transfer by conduction.

Renewable Sources of electricity

ALL turn a turbine to turn a generator.

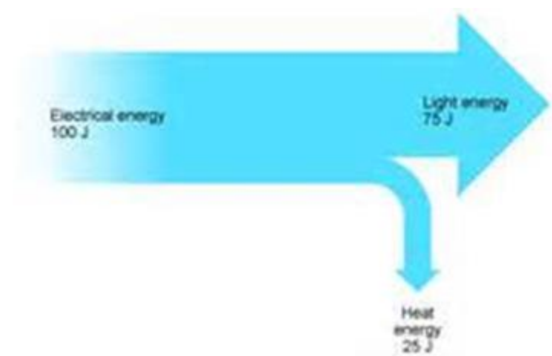
* Wind (Wind turns a turbine)
* Hydroelectric (water turns a turbine)
* Waves/Tide (The sea turns a turbine)
* Geothermal (Heat from volcanoes used to boil water – make steam – turn a turbine)
* Biomass (Living material burnt to boil water)

Advantages of ALL

*Don't give out CO_2 which causes global warming
* Renewable (will NOT run out)

Disadvantages

They are **all** more expensive than fossil fuels
* Wind – Not always windy
* Hydroelectric – Can damage habitats
* Waves/Tides – Can damage habitats
* Geothermal – Only a few places on Earth
* Biomass – Carbon neutral (gives out CO_2 when burnt)



$\text{Efficiency} = \frac{\text{Useful Energy Out}}{\text{Total Energy In}} \times 100$

$\text{Efficiency} = \frac{\text{Useful Power Out}}{\text{Total Power In}} \times 100$

Answers for efficiency must be written as a percentage or a decimal. E.g 80% or 0.8

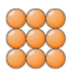
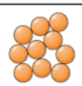
AQA PHYSICS P3: Particle model of matter

Year 9 | Term 2

Density:

$$\text{Density} \; (kg/m^3) = \frac{\text{Mass} \; (kg)}{\text{Volume} \; (m^3)}$$

Calculating the density of an irregular shape, can be done using a Eureka can and measuring the volume of water displaced.

State of matter	Diagram of structure	Movement of particles	Can it be compressed?	Density
Solid		Vibrate around a fixed position. They don't have enough energy to move apart	No, the particles have no space between them to move into.	High, there are lots of particles in a unit of area.
Liquid		They have enough energy to move from place to place but are still attracted to each other	No, the particles have no space between them to move into.	Quite high, there are lots of particles in a unit of area.
Gas		The have so much energy that they are not attracted to each other. Collisions with containers cause pressure.	Yes, the particles have lots of space between them to move into.	Low, there are few particles in a unit of area.

Internal Energy

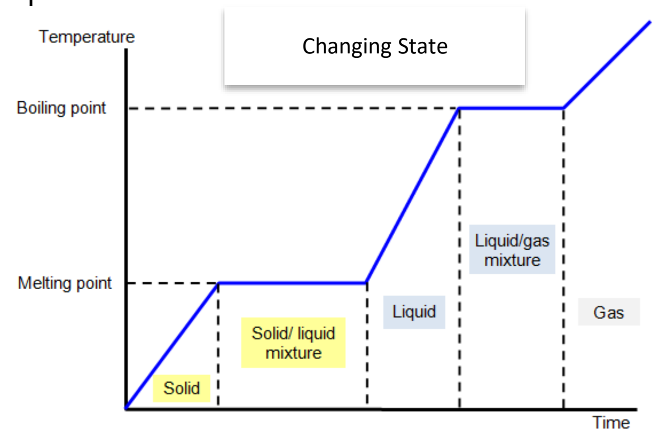
The energy in a substance is stored in its particles, this is called internal energy.

Internal energy = kinetic energy + potential energy.

Temperature: This is linked to the kinetic energy of the gas. The higher its temperature the higher its kinetic energy. If the temperature remains constant so does the kinetic energy of the particles.

Changing State

When a material changes state (melting or boiling) its internal energy increases, but its temperature does not. This means that its kinetic energy remains constant until it has changed state.



Specific Latent Heat

The specific latent heat of a substance is the energy needed to change 1kg of the substance with no change in state.

Energy (J) = Mass (kg) x Specific Latent Heat (J/kg)

$E = m \times L$

Specific heat of fusion: when turning from a solid into a liquid

Specific heat of vapourisation: when turning from a liquid into gas

Pressure and volume

Pressure (Pa) x Volume (m^3) = constant

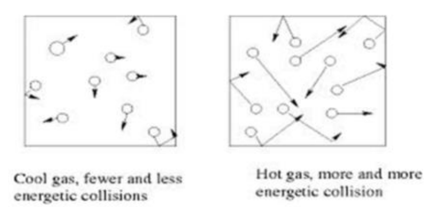
so $P_1 \times V_1 = P_2 \times V_1$

Increasing the volume of a gas (making the container bigger) whilst keeping the temperature constant will decrease the pressure of the gas.

Temperature and pressure

Increasing the temperature of a gas increases the kinetic energy of the gas particles, this increases the number of collisions with the surface, this increases the pressure acting on the sides of the container.

Temperature and gas



Particles move in different directions with a range of speeds.

As the particles hit the side of the container they create a net force which acts at right angles to the