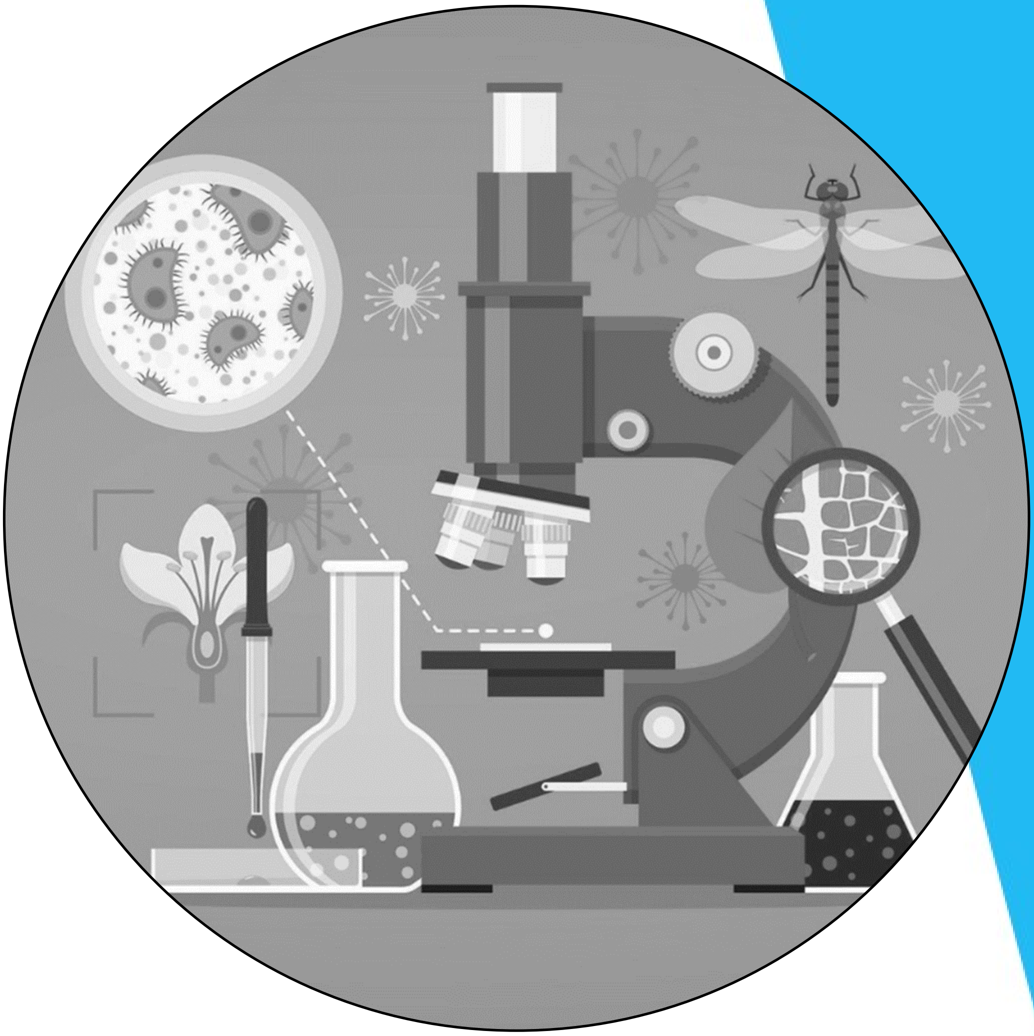
Knowledge Organiser



# Science: Triple Award

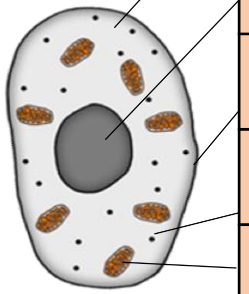
RAYNES
PARK HIGH SCHOOL

# AQA Cell Structure

## Eukaryotes complex organisms

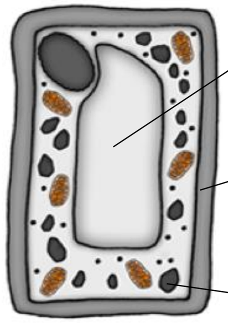
**animal cell**

**plant cell**



| | | |
|---|---|---|
| **cytoplasm** | *site of chemical reactions in the cell* | gel like substance containing enzymes to catalyse the reactions |
| **nucleus** | *contains **genetic material*** | controls the activities of the cell and codes fro proteins |
| **cell membrane** | *semi permeable* | controls the movement of substances in and out of the cell |
| **ribosome** | *site of protein synthesis* | mRNA is translated to an amino acid chain |
| **mitochondrion** | *site of respiration* | where energy is released for the cell to function |

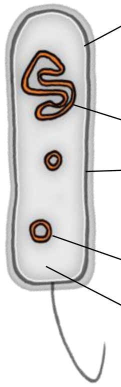
**contains all the parts of animal cells plus extras**



| | | |
|---|---|---|
| **permanent vacuole** | *contains cell sap* | keeps cell turgid, contains sugars and salts in solution |
| **cell wall** | *made of cellulose* | supports and strengthens the cell |
| **chloroplast** | *site of photosynthesis* | contains chlorophyll, absorbs light energy |

## Prokaryotes simpler organisms

Bacterial cells are much smaller than plant and animal cells



| | | |
|---|---|---|
| cell membrane | *site of chemical reactions in the cell* | gel like substance containing enzymes to catalyse the reactions |
| bacterial DNA | *not in nucleus floats in the cytoplasm* | controls the function of the cell |
| cell wall | ***NOT** made of cellulose* | supports and strengthens the cell |
| plasmid | *small rings of DNA* | contain additional genes |
| cytoplasm | *semi permeable* | controls the movement of substances in and out of the cell |

## Cell differentiation

how a cell changes and becomes **specialised**
**Undifferentiated** call are called **STEM** cells

*animal cell differentiation*

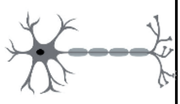
early stages of development only for repair and replacement

*plant cell differentiation*

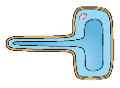
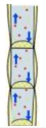
all stages of life cycle the stem cells are grouped together in meristems

## Specialised cells

### specialised animal cells

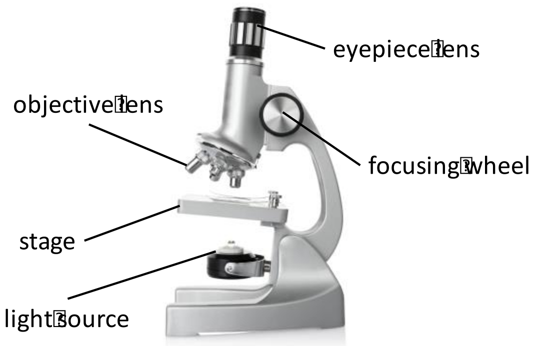
| | | | |
|---|---|---|---|
| **nerve** |  | *carry electrical signals* | long branched connections and insulating sheath |
| **sperm** |  | *fertilise an egg* | streamlined with a long tail<br>acrosome containing enzymes<br>large number of mitochondria |
| **muscle** |  | *contract to allow movement* | contains a large number of mitochondria<br>long |

### specialised plant cells

| | | | |
|---|---|---|---|
| **root hair** |  | *absorb water and minerals from soil* | hair like projections to increase the surface area |
| **xylem** |  | *carry water and minerals* | TRANSPIRATION - dead cells<br>cell walls toughened by lignin<br>flows in one direction |
| **phloem** |  | *carry glucose* | TRANSLOCATION - living cells cells have end plates with holes<br>flows in both directions |

## Microscopy

$$\text{magnification } M = \frac{\text{size of image } I}{\text{real size of the object } A}$$



| Feature | Light (optical) microscope | Electron microscope |
|---|---|---|
| **Radiation used** | Light rays | Electron beams |
| **Max magnification** | ~ 1500 times | ~ 2 000 000 times |
| **Resolution** | 200nm | 0.2nm |
| **Size of microscope** | Small and portable | Very large and not portable |
| **Cost** | ~£100 for a school one | Several £100,000 to £1 million plus |

## PREFIXES

| Prefix | Multiple | Standard form |
|---|---|---|
| **centi (cm)** | 1 cm = 0.01 m | x $10^{-2}$ |
| **milli (mm)** | 1 mm = 0.001 m | x $10^{-3}$ |
| **micro (µm)** | 1 µm = 0.000 001 m | x $10^{-6}$ |
| **nano (nm)** | 1nm = 0.000 000 001 m | x $10^{-9}$ |

# AQA
# Cell Biology 2

largest

smallest

| | |
|---|---|
| cell | The smallest structural and functional unit of an organism. |
| nucleus | A structure that contains genetic material and controls the activities of the cell. |
| chromosome | A thread like structure of coiled DNA found in the nucleus of eukaryotic cells. |
| DNA | A polymer made up of two strands forming a double helix. |
| gene | A section of DNA that codes for a specific protein or characteristic. |

## ADAPTATIONS FOR DIFFUSION

The greater the difference in concentrations the faster the rate of diffusion.

| | |
|---|---|
| **Small intestines** | *Villi – increase surface area, Good blood supply – to maintain concentration gradient, Thin membranes – short diffusion distance.* |
| **Lungs** | *Alveoli– increase surface area, Good blood supply – to maintain concentration gradient, Thin membranes – short diffusion distance.* |
| **Gills in fish** | *Gill filaments and lamella – increase surface area, Good blood supply – to maintain concentration gradient, Thin membranes – short diffusion distance.* |
| **Roots** | *Root hair cells - increase surface area.* |
| **Leaves** | *Large surface area, thin leaves for short diffusion path, stomata on the lower surface to let $O_2$ and $CO_2$ in and out.* |

## Transport in cells

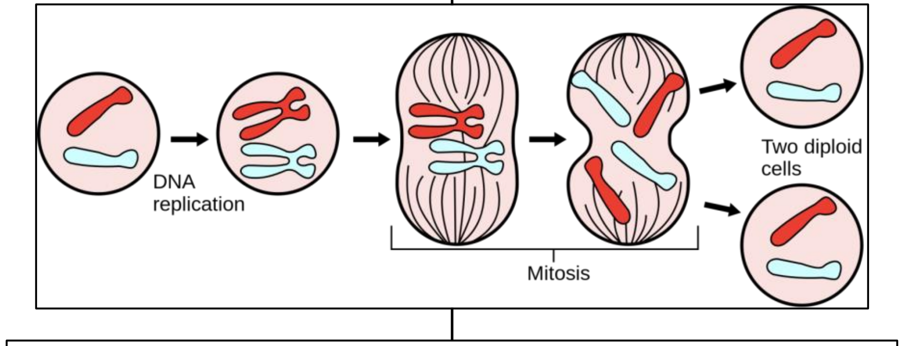
| | | |
|---|---|---|
| **Diffusion**<br>**No** energy required | *Movement of particles in a solution or gas from a higher to a lower concentration* | E.g. $O_2$ and $CO_2$ in gas exchange, urea in kidneys. Factors that affect the rate are concentration, temperature and surface area. |
| **Osmosis**<br>**No** energy required | *Movement of water from a dilute solution to a more concentrated solution* | E.g. Plants absorb water from the soil by osmosis through their root hair cells. Plants use water for several vital processes including photosynthesis and transporting minerals. |
| **Active transport**<br>***ENERGY*** required | *Movement of particles from a dilute solution to a more concentrated solution* | E.g. movement of mineral ions into roots of plants and the movement of glucose into the small intestines. |

## Cell division

## MITOSIS AND THE CELL CYCLE

*Cells divide in a series of stages. The genetic material is doubled and then divided into two identical cells.*

| | | |
|---|---|---|
| **Stage 1** | *Growth* | Increase the number of sub-cellular structures e.g. ribosomes and mitochondria. |
| **Stage 2** | *DNA Synthesis* | DNA replicates to form two copies of each chromosome. |
| **Stage 3** | *Mitosis* | One set of chromosomes is pulled to each end of the cell and the nucleus divides. Then the cytoplasm and cell membranes divide to form two cells that are identical to the parent cell. |



*Mitosis occurs during growth, repair, replacement of cells. Asexual reproduction occurs by mitosis in both plants & simple animals.*

## STEM CELLS

*Undifferentiated cell of an organism*

Divides to form more cells of the same type, and can differentiate to form many other cell types.

| | | |
|---|---|---|
| **Human Embryonic stem cells** | *Can be cloned and made to differentiate into most cell types* | Therapeutic cloning uses same genes so the body does not reject the tissue. Can be a risk of infection |
| **Adult bone marrow stem cells** | *Can form many types of human cells e.g. blood cells* | Tissue is matched to avoid rejection, risk of infection. Only a few types of cells can be formed. |
| **Meristems (plants)** | *Can differentiate into any plant cell type throughout the life of the pant.* | Used to produce clones quickly and economically, e.g. rare species, crop plants with pest /disease resisitance |

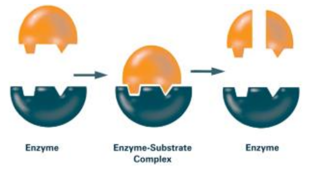
*Treatment with stem cells may be able to help conditions such as diabetes and paralysis. Some people object to the use of stem cells on ethical or religious grounds*

# AQA GCSE ORGANISATION Part 1

## Enzymes in digestion

**Enzymes catalyse (increase the rate of) specific reactions in living organisms**

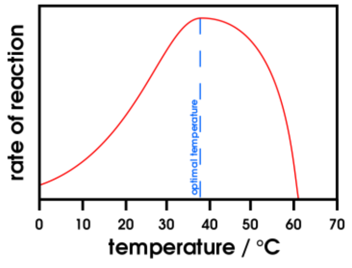
**The 'lock and key theory' is a simplified model to explain enzyme action**



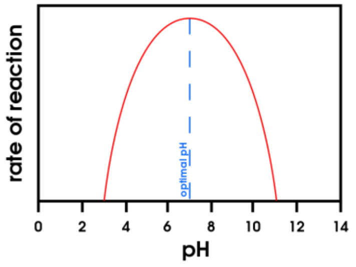
Enzymes catalyse specific reactions in living organisms due to the shape of their active site

**The activity of enzymes is affected by changes in temperature and pH**

*Enzymes activity has an optimum temperature*



*Enzyme activity has an optimum pH*

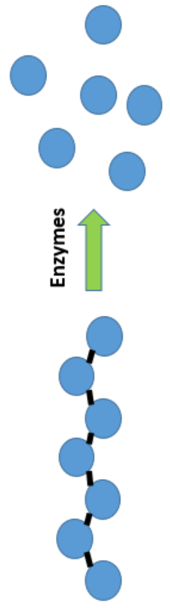


**Large changes in temperature or pH can stop the enzyme from working (denature)**

| *Temperature too high* | *pH too high or too low* |
|---|---|

Enzyme changes shape (denatures) the substrate no longer fits the active site.

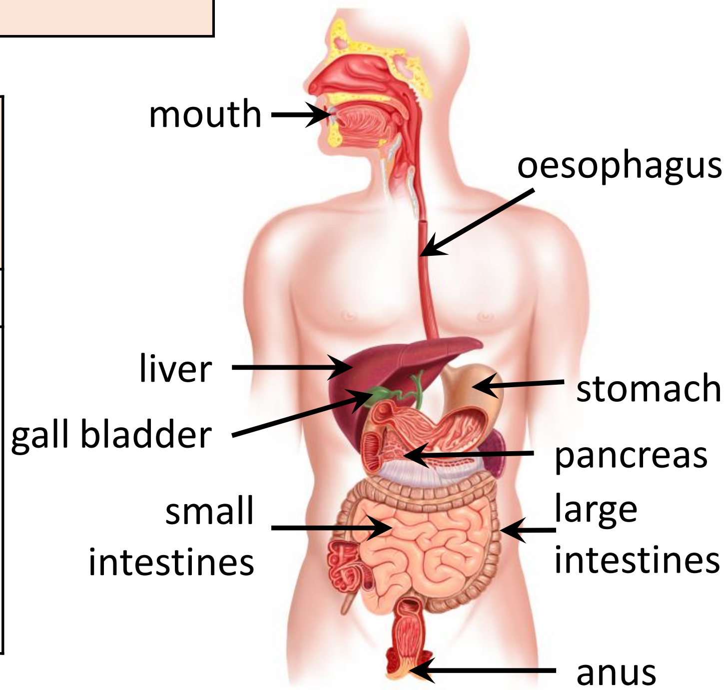
**Digestive enzymes speed up the conversion of large insoluble molecules (food) into small soluble molecules that can be absorbed into the bloodstream**

| | | | |
|---|---|---|---|
| **Carbohydrases (e.g. amylase)** |  | *Made in salivary glands, pancreas, small intestine* | Break down carbohydrates to simple sugar (e.g. amylase breaks down starch to glucose). |
| **Proteases** | | *Made in stomach, pancreas* | Break down protein to amino acids. |
| **Lipases** | | *Made in pancreas (works in small intestine)* | Break down lipids (fats) to glycerol and fatty acids). |
| **Bile (not an enzyme)** | | *Made in liver, stored in gall bladder.* | Emulsifies lipids to increase surface area to increase the rate of lipid break down by lipase. Changes pH to neutral for lipase to work |

The products of digestion are used to build new carbohydrates, lipids and proteins. Some glucose is used for respiration.

## The human digestive system

**An organ system in which organs work together to digest and absorb food.**



### Non-communicable diseases

**More energy consumed in food and drink than used**

*obesity*

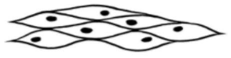
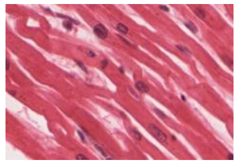
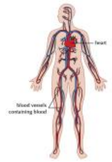
Linked to increased rates of cardiovascular disease and development of diabetes type 2.

### Food tests

| | | |
|---|---|---|
| **Sugars (glucose)** | *Benedicts' test* | Orange to brick red precipitate. |
| **Starch** | *Iodine test* | Turns black. |
| **Biuret** | *Biuret reagent* | Mauve or purple solution. |

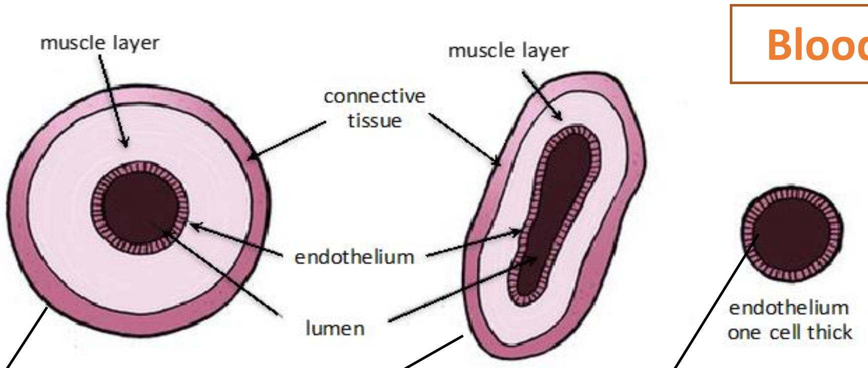
## Principles of organisation

### Cells, tissues, organs and systems

| | | | |
|---|---|---|---|
| **Cells** |  | *e.g. muscle cells* | The basic building blocks of all living organisms. |
| **Tissues** |  | *e.g. muscle tissue* | A group of cells with a similar structure and function. |
| **Organs** |  | *e.g. the heart* | Aggregations (working together) of tissues performing a specific function. |
| **Organ systems** |  | *e.g. the circulatory system* | Organs working together to form organ systems, which work together to form an organism. |

# AQA GCSE ORGANISATION part 2

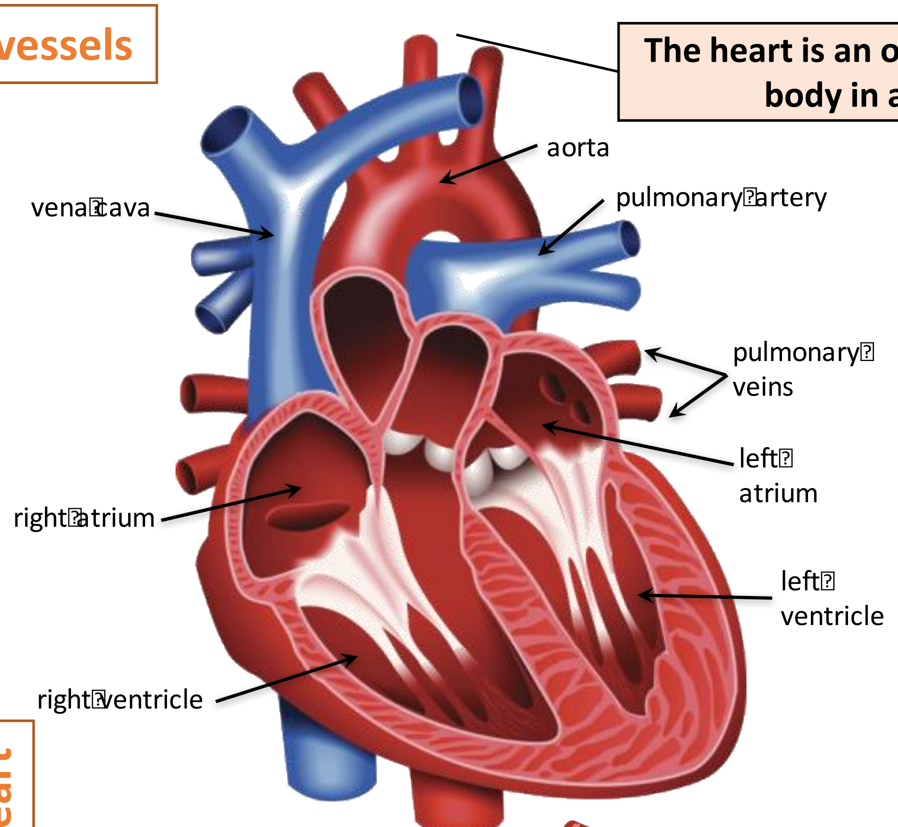
## Blood vessels

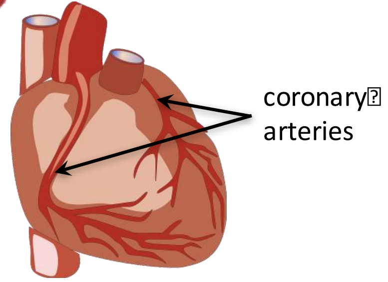


| Artery | Vein | Capillary |
|---|---|---|
| ***Carry blood away from the heart*** | ***Carry blood to the heart*** | ***Connects arteries and veins*** |
| Thick muscular walls, small lumen, carry blood under high pressure, carry oxygenated blood (except for the pulmonary artery). | Thin walls, large lumen, carry blood under low pressure, have valves to stop flow in the wrong direction, carry deoxygenated blood (except for the pulmonary vein). | One cell thick to allow diffusion, Carry blood under very low pressure. |

## Heart

### The heart is an organ that pumps blood around the body in a double circulatory system





| | | |
|---|---|---|
| **Different structure in the heart have different functions** | ***Right ventricle*** | Pumps blood to the lungs where gas exchange takes place. |
| | ***Left ventricle*** | Pumps blood around the rest of the body. |
| | ***Pacemaker (in the right atrium)*** | Controls the natural resting heart rate. Artificial electrical pacemakers can be fitted to correct irregularities. |
| | ***Coronary arteries*** | Carry oxygenated blood to the cardiac muscle. |
| | ***Heart valves*** | Prevent blood in the heart from flowing in the wrong direction. |

## Blood

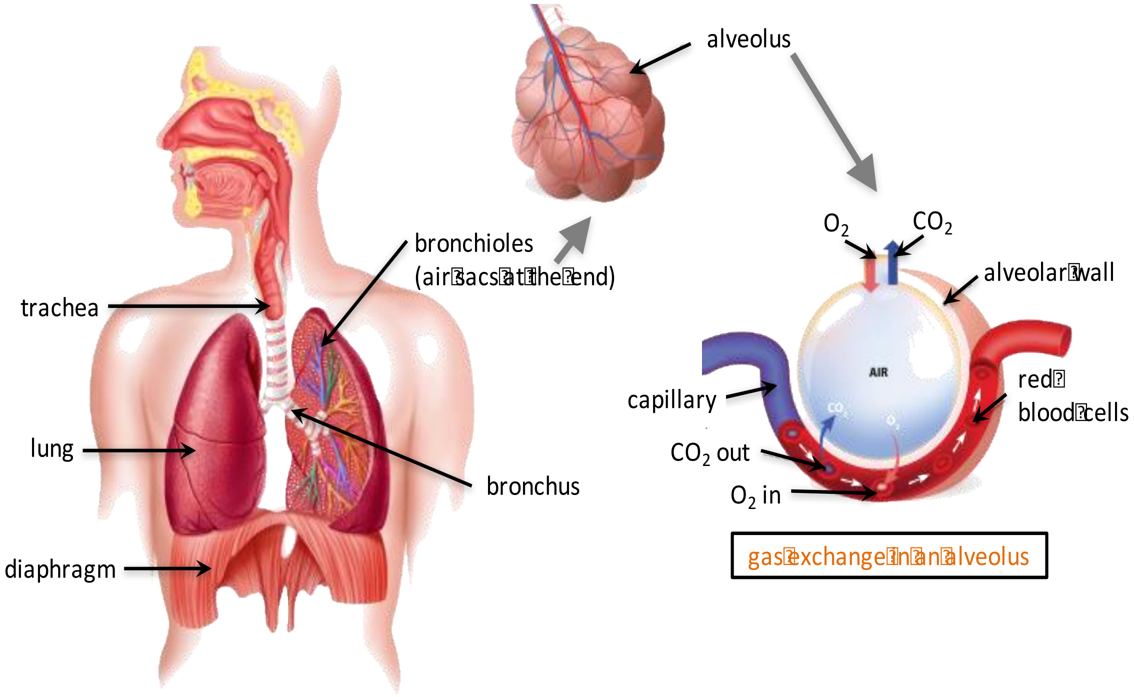
### Blood is a tissue consisting of plasma, in which blood cells, white blood cells and platelets are suspended

| | | |
|---|---|---|
| **Plasma (55%)** | ***Pale yellow fluid*** | Transports CO$_2$, hormones and waste. |
| **Red blood cells (45%)** | ***Carries oxygen*** | Large surface area, no nucleus, full of haemoglobin. |
| **White blood cells (<1%)** | ***Part of the immune system*** | Some produce antibodies, others surround and engulf pathogens. |
| **Platelets (<1%)** | ***Fragments of cells*** | Clump together to form blood clots. |

## Lungs and gas exchange

### The heart pumps low oxygen/high carbon dioxide blood to the lungs

| | | |
|---|---|---|
| **Trachea** | ***Carries air to/from the lungs*** | Rings of cartilage protect the airway. |
| **Bronchioles** | ***Carries air to/from the air sacs (alveoli)*** | Splits into multiple pathways to reach all the air sacs. |
| **Alveoli** | ***Site of gas exchange in the lungs*** | Maximises surface area for efficient gas exchange. |
| **Capillaries** | ***Allows gas exchange between into/out of blood*** | Oxygen diffuses into the blood and carbon dioxide diffuses out. |



gas exchange in an alveolus

# AQA GCSE ORGANISATION part 3

Heart failure can be treated with a transplant or artificial heart

| Disease | *Cause* | Effect | Treatment |
|---|---|---|---|
| **Coronary heart disease (CHD)** | *A build up for fatty substances in the coronary arteries (atherosclerosis)* | Oxygen-ated blood cannot get to the cardiac muscle. | Stents: inserted into the blocked artery to open it up. Statins: lower harmful cholesterol. |
| **Faulty heart valves** | *Valves don't open or close properly* | Blood can leak or flow in the wrong direction | Biological valve transplant or a mechanical valve can be inserted |

## Non-communicable diseases

## Cancer

**The result of changes in DNA that lead to uncontrolled growth and division**

| | |
|---|---|
| *Benign tumour* | Contained in one area of the body (usually by a membrane) – not cancer. |
| *Malignant tumour* | Invade tissues and spread to different parts of the body to form secondary tumours. |

Some cancers have genetic risk factors.

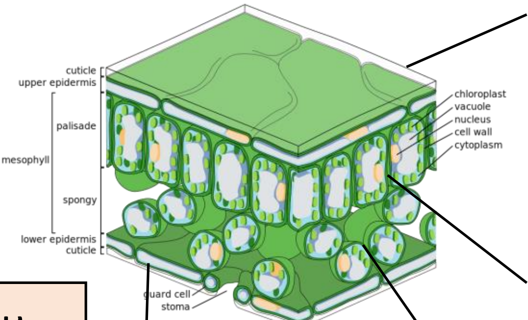
Carcinogens and ionising radiation increase the risk of cancer by changing/ damaging DNA

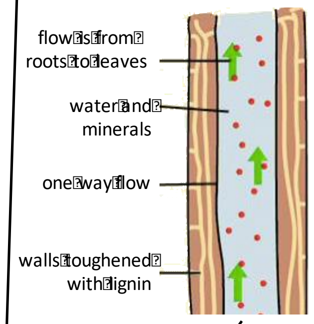
**Risk factors for heart/lung disease and certain types of cancer include drinking alcohol, diet, obesity and smoking**

These risks factors can also affect the brain, liver and the health of unborn babies

## Plant organ systems

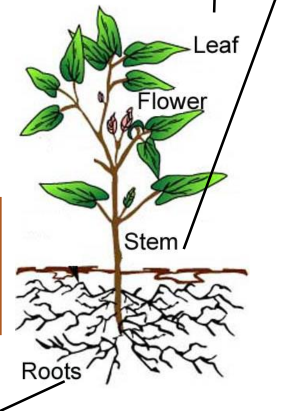
**The roots, stem and leaves form a plant organ system for transport of substances around the plant**

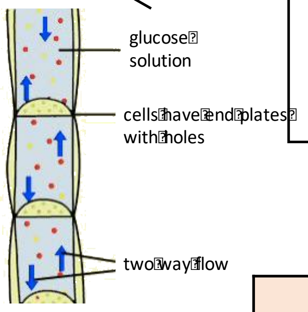


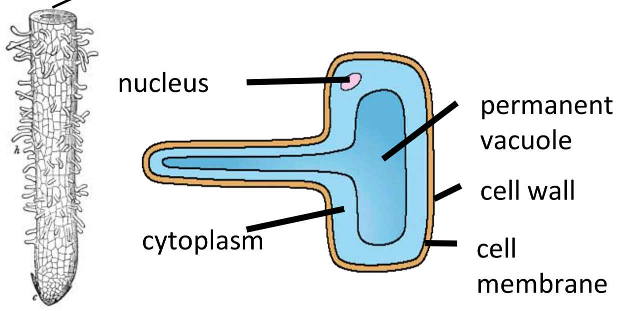


xylem

phloem



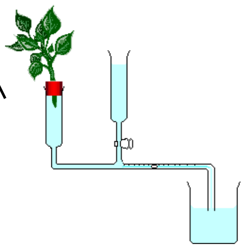


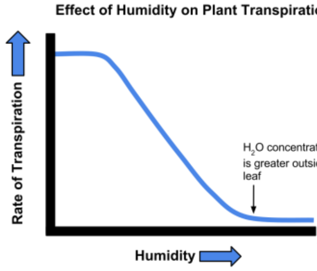


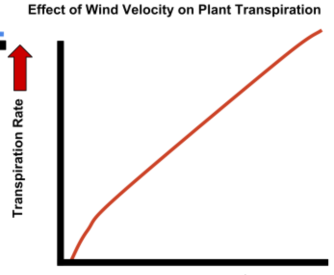
## Plant tissues

| | | |
|---|---|---|
| **Epidermal tissues** | *Waxy cuticle (top layer of the leaf)* | Reduces water loss from the leaf |
| | *Guard cells and stomata* | Guard cells open and close the stomata to control water loss and allow for gas exchange (oxygen and carbon dioxide). |
| **Palisade mesophyll** | *Palisade cells* | Cells near the top surface of the leaf that are packed with chloroplasts that contain chlorophyll. Both adaptations maximize photosynthesis. |
| **Spongy mesophyll** | *Air spaces in the leaf between cells* | Increased surface area for gas exchange so that carbon dioxide can diffuse into photosynthesising cells. |
| **xylem** | *Hollow tubes strengthened by lignin adapted for the transportation of water in the transpiration stream* | Allows transport of water and mineral ions from the roots to the stem and the leaves. |
| **phloem** | *Cell sap moves from one phloem cell to the next through pores in the end walls* | Transports dissolved sugars from the leaves to the rest of the plant for immediate use or storage (translocation). |
| **Meristem tissue** | *New cells (roots and shoot tips) are made here including root hair cells* | Root hair cells have an increased surface area for the uptake of water by osmosis, and mineral ions by active transport. |

A potometer is used to measure the amount of water lost over time (rate of transpiration)

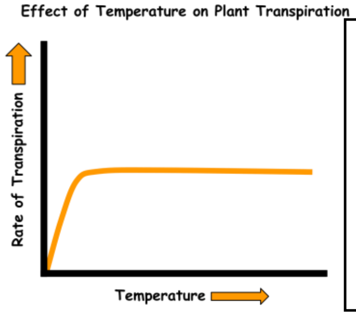






## Transpiration

| | | |
|---|---|---|
| **Transpiration** | *The rate at which water is lost from the leaves of a plant. The transpiration stream is the column of water moving through the roots, stem and leaves* | Temperature, humidity, air movement and light intensity affect the rate of transpiration. |



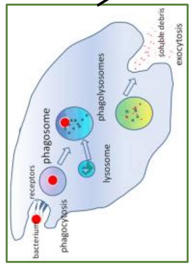
The shape of the graph for light intensity is the same for temperature (energy)

# AQA GCSE INFECTION AND RESPONSE part 1

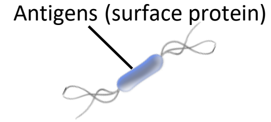
## Human defence systems

### Immune system

**White blood cells are part of the immune system**



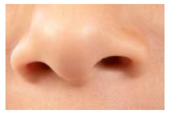
| **Phagocytes** | ***Phagocytosis*** | Phagocytes engulf the pathogens and digest them. |
|---|---|---|
| **Lymphocytes** | ***Antibody production*** | Specific antibodies destroy the pathogen. This takes time so an infection can occur. If a person is infected again by the same pathogen, the lymphocytes make antibodies much faster. |
| | ***Antitoxin production*** | Antitoxin is a type of antibody produced to counteract the toxins produced by bacteria. |



Pathogens are identified by white blood cells by the different proteins on their surfaces **ANTIGENS.**

### Non-specific defence systems

**The human body has several non specific ways of defending itself from pathogens getting in**

| | | |
|---|---|---|
|  | ***Nose*** | Nasal hairs, sticky mucus and cilia prevent pathogens entering through the nostrils. |
|  | ***Trachea and bronchus (respiratory system)*** | Lined with mucus to trap dust and pathogens. Cilia move the mucus upwards to be swallowed. |
|  | ***Stomach acid*** | Stomach acid (pH1) kills most ingested pathogens. |
|  | ***Skin*** | Hard to penetrate waterproof barrier. Glands secrete oil which kill microbes |

Pathogens may infect plants or animals and can be spread by direct contact, water or air

| **Pathogen** | ***Disease*** | **Symptoms** | **Method of transmission** | **Control of spread** |
|---|---|---|---|---|
| **Virus** | ***Measles*** | Fever, red skin rash. | Droplet infection from sneezes and coughs. | Vaccination as a child. |
| **Virus** | ***HIV*** | Initially flu like systems, serious damage to immune system. | Sexual contact and exchange of body fluids. | Anti-retroviral drugs and use of condoms. |
| **Virus** | ***Tobacco mosaic virus*** | Mosaic pattern on leaves. | Enters via wounds in epidermis caused by pests. | Remove infected leaves and control pests that damage the leaves. |
| **Bacteria** | ***Salmonella*** | Fever, cramp, vomiting, diarrhoea. | Food prepared in unhygienic conditions or not cooked properly. | Improve food hygiene, wash hands, vaccinate poultry, cook food thoroughly. |
| **Bacteria** | ***Gonorrhoea*** | Green discharge from penis or vagina. | Direct sexual contact or exchange of body fluids. | Use condoms. Treatment using antibiotics. |
| **Protists** | ***Malaria*** | Recurrent fever. | By an animal vector (mosquitoes). | Prevent breeding of mosquitoes. Use of nets to prevent bites. |
| **Fungus** | ***Rose black spot*** | Purple black spots on leaves. | Spores carried via wind or water. | Remove infected leaves. Spray with fungicide. |

## Communicable diseases

### Pathogens

**Pathogens are microorganisms that cause infectious disease**

Viruses live and reproduce inside cells causing damage

Bacteria may produce toxins that damage tissues and make us fell ill

| **Viruses** | **Bacteria (prokaryotes)** | **Protists (eukaryotes)** | **Fungi (eukaryotes)** |
|---|---|---|---|
| ***e.g. cold, influenza, measles, HIV, tobacco mosaic virus*** | ***e.g. tuberculosis (TB), Salmonella, Gonorrhoea*** | ***e.g. dysentery, sleeping sickness, malaria*** | ***e.g. athlete's foot, thrush, rose black spot*** |
| DNA or RNA surrounded by a protein coat | No membrane bound organelles (no chloroplasts, mitochondria or nucleus). Cell wall. Single celled organisms | Membrane bound organelles. Usually single celled. | Membrane bound organelles, cell wall made of chitin. Single celled or multi-cellular |

## Plants have several ways of defending themselves from pathogens and animals

| ***Physical*** | ***Mechanical*** |
|---|---|
| Thick waxy layers, cell walls stop pathogen entry | Thorns, curling up leaves to prevent being eaten |
| ***Chemical*** | |
| Antibacterial and toxins made by plant | |

## Detection and identification of plant diseases (bio only)

| ***Detection*** | **Identification** |
|---|---|
| ***Stunted growth*** | Reference using gardening manual or website, laboratory test for pathogens, testing kit using monoclonal antibodies. |
| ***Spots on leaves*** | |
| ***Area of decay*** | |
| ***growths*** | |
| ***Malformed stem/leaves*** | |
| ***Discolouration*** | |
| ***Presence of pests*** | |

**Nitrate ions** needed for protein synthesis – lack of nitrate = stunted growth.

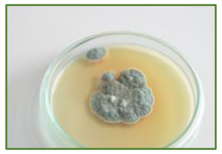
**Magnesium ions** needed to make chlorophyll – not enough leads to chlorosis – leaves turn yellow.

# AQA INFECTION AND RESPONSE

## Discovery and drug development

Most new drugs are synthesised by chemists in the pharmaceutical industry.

**Traditionally drugs were extracted from plants and microorganisms**

| *Digitalis* | *Aspirin* | *Penicillin* |
|---|---|---|
| Extracted from foxglove plants and used as a heart drug | A painkiller and anti-inflammatory that was first found in willow bark | Discovered by Alexander Fleming from the *Penicillium* mould and used as an antibiotic |
|  |  |  |

**Drugs have to be tested and trialled before to check they are safe and effective**

**New drugs are extensively tested for:**

|  |  |
|---|---|
| *Efficacy* | Make sure the drug works |
| *Toxicity* | Check that the drug is not poisonous |
| *Dose* | The most suitable amount to take |

Preclinical trials - using cells, tissues and live animals - must be carried out before the drug can be tested on humans.

Double blind trial: patients and scientists do not know who receives the new drug or placebo until the end of the trial. This avoids bias.

**Clinical trials use healthy volunteers and patients**

| *Stage 1* | *Stage 2* | *Stage 3* | *Stage 4* |
|---|---|---|---|
| Healthy volunteers try small dose of the drug to check it is safe record any side effects | A small number of patients try the drug at a low dose to see if it works | A larger number of patients; different doses are trialled to find the optimum dose | A double blind trial will occur. The patients are divided into groups. Some will be given the drug and some a placebo. |

A placebo can look identical to the new drug but contain no active ingredients

## Antibiotics and painkillers

*Bacteria can mutate*

Sometimes this makes them resistant to antibiotic drugs.

**Antibiotics have greatly reduced deaths from infectious bacterial disease**

|  |  |  |
|---|---|---|
| **antibiotics** | *e.g. penicillin* | Kill infective bacteria inside the body. Specific bacterial infections require specific antibiotics. |
| **Painkillers and other medicines** | *e.g. aspirin, paracetamol, ibuprofen* | Drugs that are used to treat the symptoms of a disease. They do not kill pathogens |

Antibiotics cannot be use to treat viral pathogens

It is difficult to develop drugs to kill viruses without harming body tissues because viruses live and reproduce inside cells

## Vaccination

**Used to immunise a large proportion of the population to prevent the spread of a pathogen**

| Vaccination | | | |
|---|---|---|---|
| | *Small amount of dead or inactive form of the pathogen* | *1st infection by pathogen* | White blood cells detect pathogens in the vaccine. Antibodies are released into the blood. |
| | | *Re-infection by the same pathogen* | White blood cells detect pathogens. Antibodies are made much faster and in larger amounts. |

A person is unlikely to suffer the symptoms of the harmful disease and it's spread in a population is prevented

Created more side effects than expected (fatal in some cases) and are not as widely used as everybody hoped when first developed.

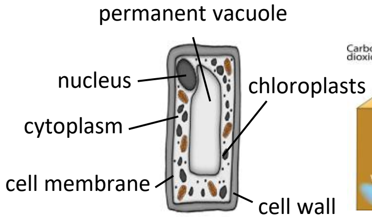
## Monoclonal antibodies (Biology only HT)

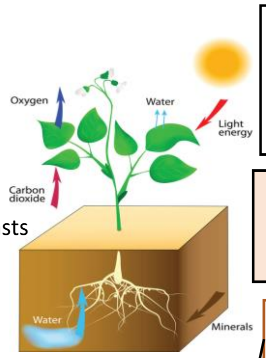
Specific to one binding site on the antigen. Can target specific chemicals or cells in the body

| Monoclonal antibodies | | |
|---|---|---|
| | *Identical copies of one types of antibody produced in laboratory* | 1. A mouse is injected with pathogen |
| | | 2. Lymphocytes produce antibodies |
| | | 3. Lymphocytes are removed from the mouse and fused with rapidly dividing mouse tumour cells |
| | | 4. The new cells are called hybridomas |
| | | 5. The hybridomas divide rapidly and release lots of antibodies which are then collected |

**Monoclonal antibodies can be used in a variety of ways**

| *Diagnosis* | *Detecting pathogens* | *Detecting molecules* | *Treatment* |
|---|---|---|---|
| e.g. pregnancy test – measure the level of hormones | Can detect very small quantities of chemicals in the blood | Fluorescent dye can be attached so it can be seen inside cells or tissues | Bound to radioactive substance, toxic drug or chemical Cancer cells are targeted to normal body cells are unharmed |





Respiration, stored as insoluble starch, fats or oils for storage, cellulose for cell walls, combine with nitrates from the soil to form amino acids for protein synthesis

**Plants use the glucose produced in photosynthesis in a variety of ways**

## Photosynthetic reaction

The plant manufactures glucose from carbon dioxide and water using energy transferred from the environment to the chloroplasts by light

| | | |
|---|---|---|
| **Photosynthesis** | *Plants make use of light energy from the environment (ENDOTHERMIC) to make food (glucose)* | Carbon dioxide + Water $\xrightarrow{\text{light}}$ Oxygen + Glucose |
| | | $CO_2 + H_2O \xrightarrow{\text{light}} O_2 + C_6H_{12}O_6$ |

**The rate of photosynthesis is affected by temperature, light intensity, carbon dioxide concentration, and the amount of chlorophyll**

**Factors affecting the rate of photosynthesis**

| Factor | How the rate is affected | Limiting factors (why the rate stops going up) |
|---|---|---|
| **Temperature** | *As the temperature of the environment the plant is in increases rate of photosynthesis increases (up to a point) as there is more energy for the chemical reaction.* | Photosynthesis is an enzyme controlled reaction. If the temperature increases too much, then the enzymes become denatured and the rate of reaction will decrease and stop |
| **Light intensity** | *Light intensity increases as the distance between the plant and the light sources increases. As light intensity increases so does the rate of photosynthesis (up to a point) as more energy is available for the chemical reaction.* | At point X another factor is limiting the rate of photosynthesis. This could be carbon dioxide concentration, temperature or the amount of chlorophyll |
| **Carbon dioxide concentration** | *Carbon dioxide is needed for plants to make glucose. The rate of photosynthesis will increase when a plant is given higher concentrations of carbon dioxide (up to a point).* | At point X another factor is limiting the rate of photosynthesis. This could be light intensity, temperature or the amount of chlorophyll |
| **Amount of chlorophyll** | *Chlorophyll is a photosynthetic pigment that absorbs light and allows the reaction between water and carbon dioxide to occur (photosynthesis)* | Another factor could limit the rate of photosynthesis. This could be light intensity, temperature or the carbon dioxide concentration |

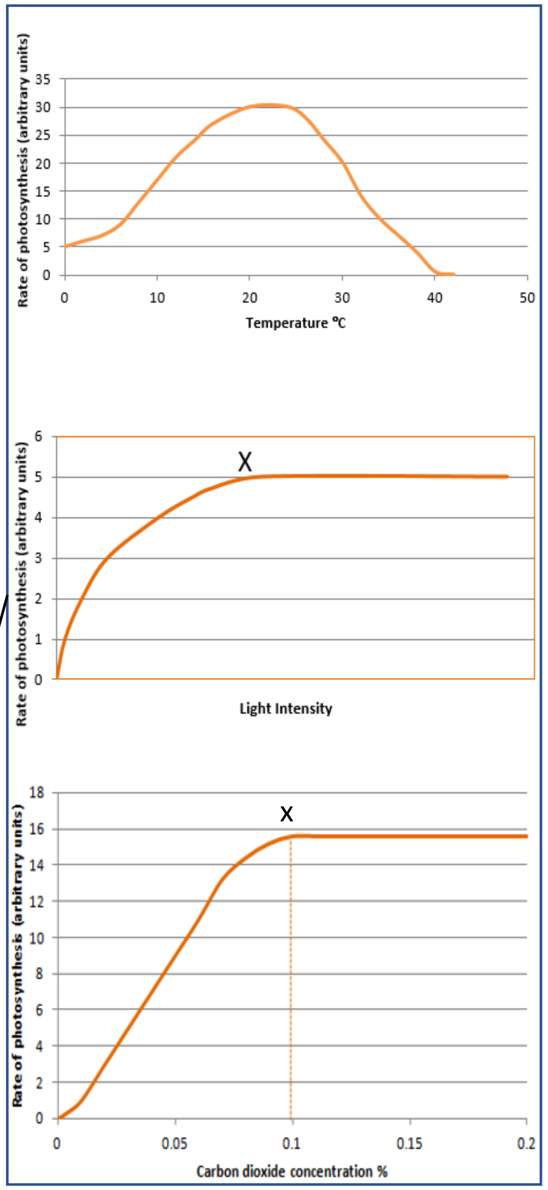
**Control conditions in greenhouses to reduce limiting factors can improve crop yields**

| | |
|---|---|
| *Heating* | Used to provide optimum temperatures for maximum plant growth. |
| *Artificial lighting* | Enhances the natural sunlight especially overnight and on cloudy days. |
| *Extra carbon dioxide* | Gas can be pumped into the air inside the greenhouse. |

Growers must balance the economics of additional costs of controlling the conditions to maximise photosynthesis with making a profit.

# AQA GCSE BIOENERGETICS part 1

## Rate of photosynthesis



**Light intensity obeys the inverse square law. This means that if you double the distance between the plant and the light source you quarter the light intensity**

## Rate of photosynthesis **HT Only**

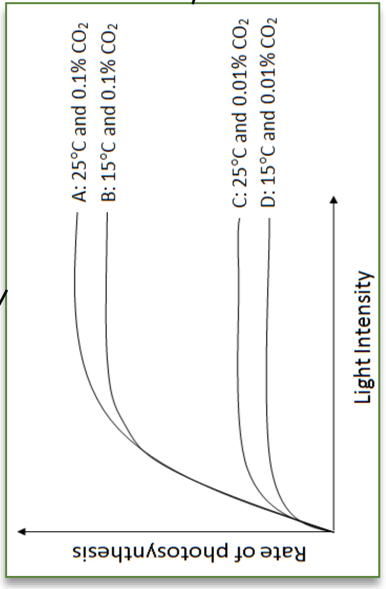
*Graph lines C and D*: If temperature is increased by 10°C then a slight increase in rate of photosynthesis occurs.

**Explain graphs of two or three factors and decide which is the limiting factor**

*Graph lines A and D*: If carbon dioxide concentration and temperature are increased the rate of photosynthesis increases significantly up to a point.

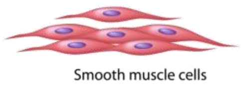
*Graph Lines A and B*: If carbon dioxide concentration is increased from 0.01% to 0.1% then a large increase in rate occurs up to a point.

*Graph line A*: Rate could be limited by temperature and/or amount of chlorophyll. Plant tissue can be damaged when carbon dioxide concentrations exceed 0.1%

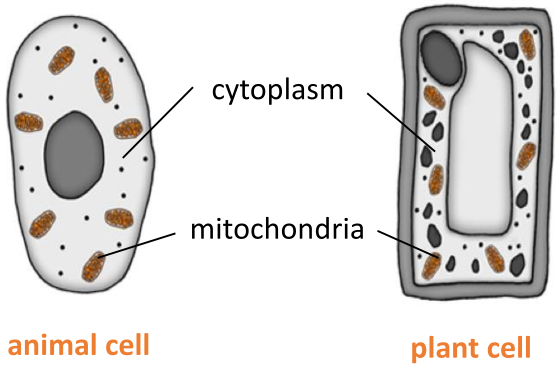


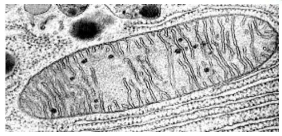
# AQA GCSE BIOENERGETICS part 2

## Respiration

| **An organism will receive all the energy it needs for living processes as a result of the energy transferred from respiration** | | | |
|---|---|---|---|
| | ***For movement*** |  Smooth muscle cells | To enable muscles to contract in animals. |
| | ***For keeping warm*** |  | To keep a steady body temperature in a cold environment. |
| | ***For chemical reactions*** |  | To build larger molecules from smaller one. |

**Cellular respiration is an exothermic reaction which is continuously occurring in all living cells**





Electron micrograph of a mitochondrion

### Anaerobic respiration

***Respiration when oxygen is in short supply. Occurs during intensive exercise***

During hard exercise, muscle cells are respiring so fast that blood cannot transport enough oxygen to meet their needs.

Glucose is partially oxidised to produce lactic acid which builds up in muscle tissue causing them to become painful and fatigued.

glucose ⟶ lactic acid

***Anaerobic respiration releases a much smaller amount of energy than aerobic respiration.***

The incomplete oxidation of glucose causes a build up of lactic acid and creates an oxygen debt

### Aerobic respiration

***Respiration with oxygen. Occurs inside the mitochondria continuously***

Glucose is oxidised by oxygen to transfer the energy the organism needs to perform it's functions.

$C_6H_{12}O_6 + O_2 \longrightarrow CO_2 + H_2O$

**glucose + oxygen ⟶ carbon dioxide + water**

***Aerobic respiration releases a large amount of energy from each glucose molecule***

### Anaerobic respiration in plant and yeast cells

***The end products are ethanol and carbon dioxide. Anaerobic respiration in yeast cells is called fermentation***

**glucose ⟶ ethanol + carbon dioxide**

This process is economically important in the manufacture of alcoholic drinks and bread.

## Response to exercise

During long periods of vigorous activity muscles become fatigued and stop contracting efficiently

| **During exercise the human body reacts to increased demand for energy** | | |
|---|---|---|
| | ***Heart rate increases*** | Top pump oxygenated blood faster to the muscle tissues and cells. |
| | ***Breathing rate and breath volume increase*** | This increases the amount of oxygen entering the blood stream. |

## Metabolism

**Metabolism is the sum of all the reactions in a cell or the body**

| **Metabolism** | | |
|---|---|---|
| | ***The energy transferred by respiration in cells is used by the organism for the continual enzyme controlled processes of metabolism.*** | Conversion of glucose to starch, glycogen and cellulose. |
| | | The formation of lipid molecules from a molecule of glycerol and three molecules of fatty acid. |
| | | The use of glucose and nitrate ions to form amino acids which in turn are used to synthesise proteins. |
| | | Respiration |
| | | Breakdown of excess proteins to form urea for excretion. |

## Response to exercise HT only

**The extra amount of oxygen required to remove all lactic acids from cells is called the oxygen debt**

Lactic acid builds up in the muscles cells during exercise

Blood flows through the muscle cells and transports the lactic acid to the liver

The liver oxidises the lactic acid and converts it back to glucose

# AQA GCSE HOMEOSTASIS AND RESPONSE part 1

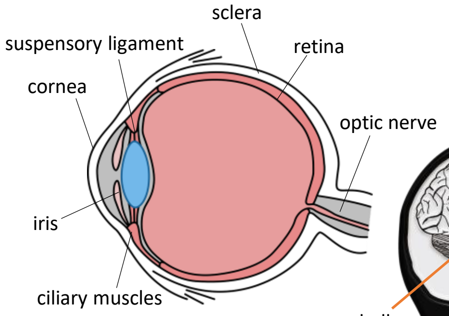
## The Eye (Bio only)

Sense organ containing receptors sensitive to light intensity and colour

The iris can dilate the pupil (aperture) to let in more light in dim conditions

**Structures of the eye**

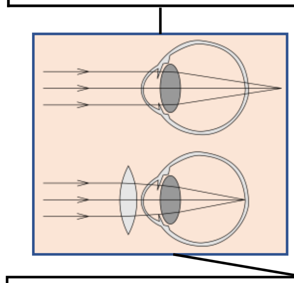
| | |
|---|---|
| ***Retina*** | Light sensitive cell layer. |
| ***Optic nerve*** | Carries impulse to brain. |
| ***Sclera*** | Protects the eye. |
| ***Cornea*** | Transparent layer that covers the pupil and iris. |
| ***Iris*** | Pigmented layer, controls size of pupil. |
| ***Ciliary muscles*** | Controls thickness of lens. |
| ***Suspensory ligaments*** | Connects lens to ciliary muscles. |

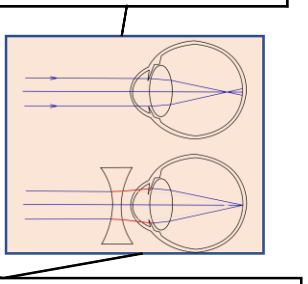


**Accommodation is the process of changing the shape of the lens to focus**

| ***Near object*** | ***Far object*** |
|---|---|
| Ciliary muscles contract, suspensory ligaments loosed, lens get thicker, light is more refracted. | Ciliary muscles relax, suspensory ligaments pulled tight, lens pulled thin, light is only slightly refracted. |

| ***Hyperopia (long sightedness)*** | ***Myopia (short sightedness)*** |
|---|---|
| Treated using a convex lens so the light is focused on the retina. | Treated using a concave lens so light is focused on the retina. |





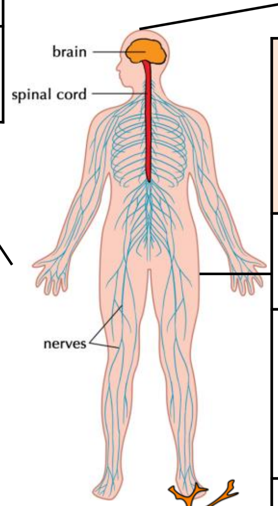
New technologies now include hard/soft contact lens, laser surgery to change the shape of the cornea and a replacement lens in the eye.

## The human nervous system

**Enables humans to react to their surroundings and to co-ordinate their behaviour**

**Human control systems include**

| | |
|---|---|
| ***Cells called receptors*** | Detect stimuli (changes in environment). |
| ***Coordination centres*** | e.g. brain, spinal cord and pancreas that receive information from receptors. |
| ***Effectors*** | Muscles or glands, which bring about responses to restore optimum levels. |

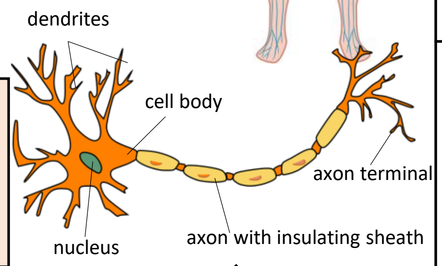


**Information from receptors passes along cells (neurones) as electrical impulses to the central nervous system (CNS)**

***The CNS is the brain and the spinal cord.***

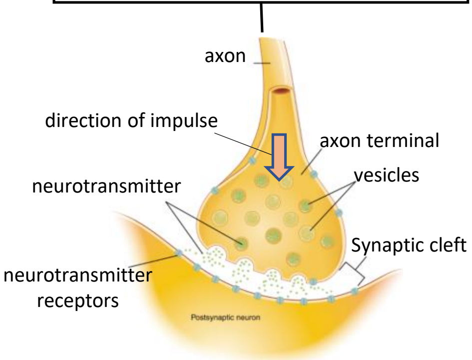
Coordinates the response of effectors; muscles contracting or glands secreting hormones

| | |
|---|---|
| Stimulus | Lights switch on |
| ⇩ | ⇩ |
| Receptor | Cells in retina |
| ⇩ | ⇩ |
| Coordinator | CNS |
| ⇩ | ⇩ |
| Effector | Muscles connected to iris |
| ⇩ | ⇩ |
| Response | Pupils get smaller |



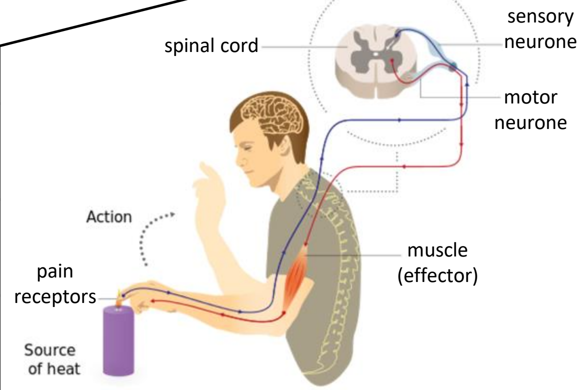
Typical motor neurone

Synapse (gap where two neurones meet).



**Reflex arc**

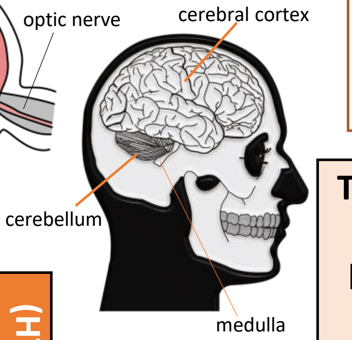
| | |
|---|---|
| ***Receptor*** | Detect stimuli. |
| ***Sensory neurone*** | Long axon carries impulse from receptor to spinal cord. |
| ***Synapse*** | Gap where neurones meet. Chemical message using neurotransmitter. |
| ***Relay neurone*** | Allows impulses to travel between sensory and motor neurones in the spinal cord. |
| ***Motor neurone*** | Long axon carries impulse from receptor to effector. |
| ***Effector*** | Muscle or gland that carries out response. |



Reflex actions are automatic and rapid; they do not involve the conscious part of the brain and can protect humans from harm.

## The Brain (Bio only)

**The brain controls complex behaviour. It is made of billions of interconnected neurones.**



**The brain has different regions that carry out different functions.**

| | |
|---|---|
| ***Cerebral cortex*** | Largest part of the human brain. Higher thinking skills e.g. speech, decision making. |
| ***Cerebellum*** | Balance and voluntary muscle function e.g. walking, lifting. |
| ***Medulla*** | Involuntary (automatic) body functions e.g. breathing, heart rate. |

**(HT) The complexity and delicacy of the brain makes investigating and treating brain disorders very difficult**

Neuroscientists have been able to map regions of the brain by studying patients with brain damage, electrical stimulation and MRI.

**Treating brain damage and disease**

***e.g. Lobotomy – cutting part of the cerebral cortex***

| | |
|---|---|
| **Benefit:** thought to alleviate the symptoms of some mental illnesses. | **Risks:** bleeding in the brain, seizures, loss of brain function. Procedure was abandoned in the 1950s due to risk. |

# AQA GCSE HOMEOSTASIS AND RESPONSE PART 2

## Homeostasis

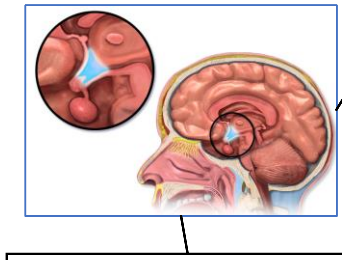
Response to internal and external change

**The regulation of internal conditions of a cell or organism to maintain optimum conditions for function.**

Homeostasis maintains optimal conditions for enzyme action and all cell functions.

| | | |
|---|---|---|
| **Controls in the human body** | *Blood glucose concentration* | These automatic control systems may involve nervous responses or chemical responses. |
| | *Body temperature* | |
| | *Water levels* | |

## Control of body temperature (Biology only)

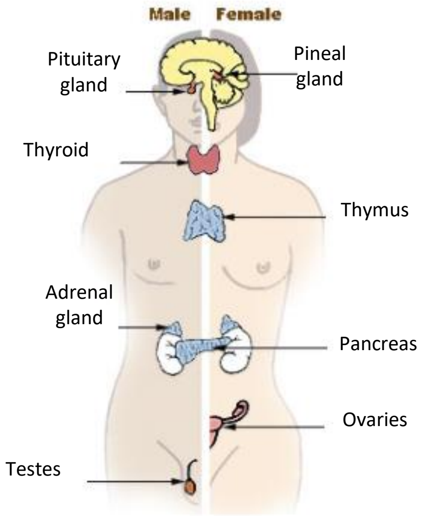


Thermoregulatory centre (hypothalamus)

| | | |
|---|---|---|
| **Monitoring body temperature** | *Thermoregulatory centre* | Contains receptors sensitive to the temperature of the blood. |
| | *Skin* | Contains temperature receptors, sends nervous impulses to the thermoregulatory centre. |

| | | | |
|---|---|---|---|
| **Body temperature** | *Too high* | Blood vessels dilate (vasodilation), sweat produced from sweat glands. | **(HT)** Thermal energy is lost from blood near the surface of the skin, sweat evaporates transferring thermal energy. |
| | *Too low* | Blood vessels constrict (vasoconstriction), sweating stops, muscles contract (shivering). | **(HT)** Thermal energy loss at the surface of the skin is reduced, respiring muscles cells transfer chemical to thermal energy. |

## Human endocrine system



| | | |
|---|---|---|
| **Endocrine system** | *Composed of glands which secrete chemicals called hormones directly into the bloodstream.* | The blood carries the hormone to a target organ where is produces an effect. Compared to the nervous system effects are slower but act for longer. |
| **Pituitary gland** | *'Master gland'; secretes several hormones into the blood* | Stimulates other glands to produce hormones to bring about effects. |

## Control of blood glucose concentration

**Blood glucose concentration**

*Monitored and controlled by the pancreas*

| Too high | **(HT only)** Too low |
|---|---|
| Pancreas produces the hormone insulin, glucose moves from the blood into the cells. In liver and muscle cells excess glucose is converted to glycogen for storage. | Pancreas produces the hormone glucagon that causes glycogen to be converted into glucose and released into the blood. |

**(HT)** Rising glucose levels inhibit the release of glucagon in a negative feedback system. Insulin is released to reduce glucose levels and which cause the pancreas to release glucagon

**Diabetes**

| *Type 1* | *Type 2* |
|---|---|
| Pancreas fails to produce sufficient insulin leading to uncontrolled blood glucose levels. Normally treated by insulin injection. | Obesity is a risk factor. Body cells no longer respond to insulin. Common treatments include changing by diet and increasing exercise. |

| | | |
|---|---|---|
| **Negative feedback (HT only)** | *Adrenaline* | Produced in adrenal glands, increases breathing/heart rate, blood flow to muscles, conversion glycogen to glucose. Prepares body for 'fight or flight'. |
| | *Thyroxine* | Produced in the thyroid gland, stimulates the basal metabolic rate. Important in growth and development. |

Increasing thyroxine levels prevent the release of thyroid stimulating hormone which stops the release of thyroxine.

## Water and nitrogen balance
## (Biology only)

| | | |
|---|---|---|
| **If body cells lose or gain too much water by osmosis they do no function efficiently.** | *Uncontrolled water/ion urea loss* | Water exhaled in lungs, water, ions and urea in sweat. |
| | *Controlled water/ion/urea loss* | Via the kidneys in urine. |

Kidney failure is treated by organ transplant or dialysis.

A dialysis machine removes urea from the blood by diffusion while maintaining ion and glucose levels.

| | | |
|---|---|---|
| **Kidney function** | *Maintain water balance of the body.* | Produce urine by filtration of the blood and selective reabsorption of glucose, ions and water. |
| **(HT only) ADH** | *Acts on kidney tubules to control water levels.* | Released by pituitary gland when blood is too concentrated. Water is reabsorbed back into the blood from the kidney tubules **(NEGATIVE FEEDBACK).** |

**(HT only)** digestion of proteins results in excess amino acids. In the liver they are de-aminated to form toxic ammonia which is converted to urea

# AQA GCSE HOMEOSTASIS AND RESPONSE PART 3

## The use of hormone to treat infertility (HT only)

**Hormones are used in modern reproductive technologies to treat infertility**

FSH and LH are used as 'fertility drugs' to help someone become pregnant in the normal way

**In Vitro Fertilisation (IVF) treatment.**

*Involves giving a mother FSH and LH to stimulate the maturation of several eggs*

The eggs are collected from the mother and fertilised by sperm from the father in a laboratory.

↓

The fertilised eggs develop into embryos.

↓

At the stage when they are tiny balls of cells, one or two embryos are inserted into the mother's uterus (womb).

| | |
|---|---|
| *Potential disadvantages of IVF* | Emotional and physical stress. |
| | Success rates are not high. |
| | Multiple births risk to mother and babies. |

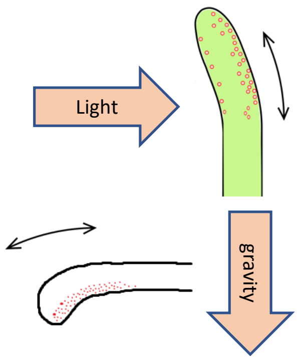
## Contraception

| | | |
|---|---|---|
| **Fertility can be controlled by hormonal and non hormonal methods** | *Oral contraceptives* | Contain hormones to inhibit FSH production so that no eggs mature. |
| | *Injection, implant, skin patch* | For slow release of progesterone to inhibit the maturation and release of eggs for months or years. |
| | *Barrier methods* | Condoms or diaphragms which prevent sperm reaching the egg. |
| | *Intrauterine devices* | Prevent implantation of an embryo or release a hormone. |
| | *Spermicidal agents* | Kill or disable sperm. |
| | *Abstaining* | Avoiding intercourse when an egg may be in the oviduct. |
| | *Surgery* | Male or female sterilisation. |

## Plant hormones

**Plants produce hormones to coordinate and control growth**

| | | |
|---|---|---|
| **Plant responses using hormones (auxins)** | *Light (phototropism)* | Light breaks down auxins and they become unequally distributed in the shoot. The side with the highest concentration of auxins has the highest growth rate and the shoot grows toward the light. |
| | *Gravity (geotropism or gravitropism)* | Gravity causes an unequal distribution of auxins. In roots the side with the lowest concentration has the highest growth rate and the root grows in the direction of gravity. |
| | | In new shoots from a seedling the unequal distribution of auxins causes the shoot to grow away from gravity. |



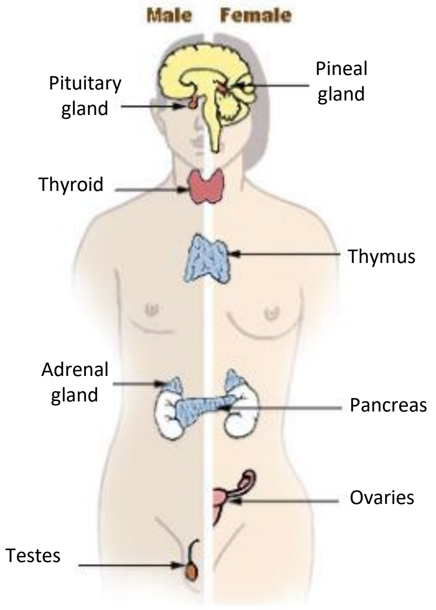
**(HT only)** Gibberellins are important in initiating seed germination.

**(HT only)** Ethene controls cell division and ripening of fruits.

## Use of plant hormones (HT only)

| | | |
|---|---|---|
| **Plant growth hormones are used in agriculture and horticulture** | *Auxins* | Weed killers, rooting powders, promoting growth in tissue culture. |
| | *Ethene* | Control ripening of fruit during storage and transport. |
| | *Gibberellins* | End seed dormancy, promote flowering, increase fruit size. |

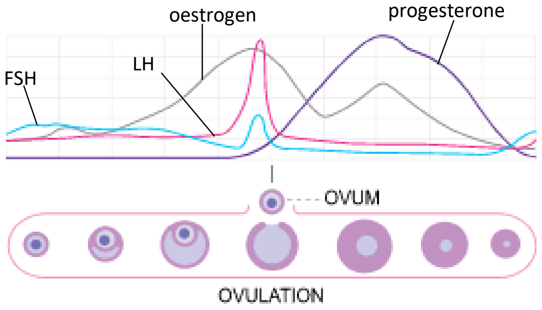
## Hormones in human reproduction



**During puberty reproductive hormones cause secondary sexual characteristics to develop**

| *Oestrogen (main female reproductive hormone)* | *Testosterone (main male reproductive hormone)* |
|---|---|
| Produced in the ovaries. At puberty eggs being to mature releasing one every 28 days – **ovulation**. | Produced in the testes stimulation sperm production. |

**(HT only)** a graph of hormone levels over time



| | | | |
|---|---|---|---|
| **Menstrual cycle** | *Follicle stimulating hormone (FSH)* | Causes maturation of an egg in the ovary. | **(HT)** FSH stimulates ovaries to produce oestrogen. |
| | *Luteinising hormone (LH)* | Stimulates release of an egg. | **(HT)** Oestrogen stops FSH production and stimulates LH production in pituitary gland. |
| | *Oestrogen and progesterone* | Maintain uterus lining. | |

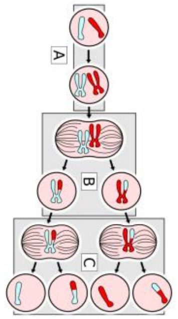
# AQA GCSE INHERITANCE, VARIATION AND EVOLUTION Part 1

## Sexual and asexual reproduction

### Meiosis

**Meiosis halves the number of chromosomes**

| | | |
|---|---|---|
| **Gametes are made in reproductive organs (in animals ovaries and testes)** | *Cells divide by meiosis to form gametes* | Copies of the genetic information are made. |
| | | The cell divides twice to form four gametes each with single set of chromosomes. |
| | | All gametes are genetically different from each other. |

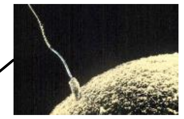


**Gametes join at fertilisation to restore the number of chromosomes**

The new cell divides by mitosis. The number of cells increase. As the embryo develops cells differentiate.

**Meiosis leads to non-identical cells being formed while mitosis leads to identical cells being formed**

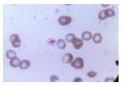
| | | |
|---|---|---|
| **Sexual reproduction involves the fusion of male and female gametes.** | *Sperm and egg in animals.* | Produced by meiosis. There is mixing of genetic information which leads to a variety in the offspring. |
| | *Pollen and egg cells in flowering plants.* | |
| **Asexual reproduction involves only one parent and no fusion of gametes.** | *e.g. cloning of females only in an aphid population.* | Only mitosis is involved. There is no mixing of genetic information. This leads to genetically identical clones. |



## Advantages and disadvantages of sexual and asexual reproduction (Biology only)

**Reproduction advantages/disadvantages**

| *Sexual* | *Asexual* |
|---|---|
| Needs two parents. | Only one parent needed (quicker). |
| Produces variation in the offspring. | Identical offspring (no variation). |
| If the environment changes variation gives a survival advantage by natural selection. | Vulnerable to rapidly changing conditions due to lack of variation. |
| Negative mutations are not always inherited. | Negative mutation can affect all offspring. |
| Natural selection can by speeded up using selective breeding to increase food production. | Food/medicine production can be extremely quick. |

| | | | |
|---|---|---|---|
| **Some organisms use both methods depending on the circumstances** | *Malarial parasites* |  | Asexually in the human host but sexually in a mosquito. |
| | *Fungi* |  | Asexually by spores, sexually to give variation. |
| | *Plants* |  | Produce seeds sexually, asexually by runners in strawberry plants, bulbs division in daffodils. |

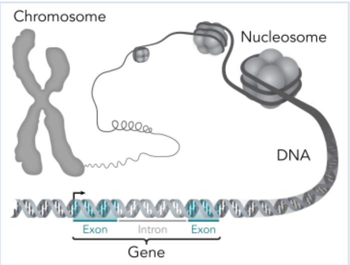
## DNA and the genome

**Genetic material in the nucleus is composed of a chemical called DNA.**

**DNA structure**

*Polymer made up of two strands forming a double helix.*

Contained in structures called chromosomes. A gene is a small section of DNA on a chromosome. Each gene codes for a sequence of amino acids to make a specific protein.

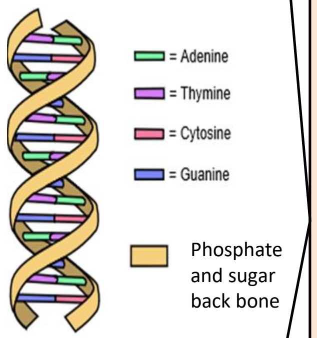


The genome is the entire genetic material of an organism.

**(HT only)** Not all parts code for proteins. Non-coding parts can switch genes on and off. Mutations may affect how genes are expressed.

| | | |
|---|---|---|
| **The whole human genome has now been studied.** | *It is of great importance for future medical developments* | Searching for genes linked to different types of disease. |
| | | Understanding and treatment of inherited disorders. |
| | | Tracing migration patterns from the past. |

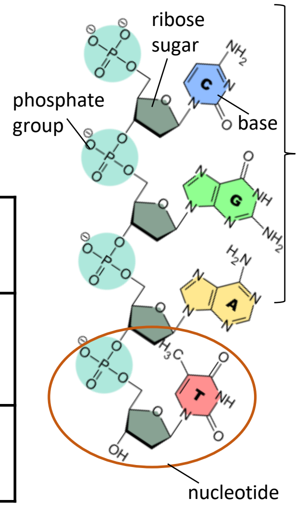
## DNA structure (Biology only)



**DNA is polymer made from four different nucleotides. Each nucleotide consists of a common sugar, phosphate group and one of 4 different bases A, C, G & T**

Repeating nucleotide units.

In DNA the complementary strands C, A, T, G always link in the same way. C always linked to G on the opposite strand and A to T.



**Protein synthesis (HT only)**

**Mutations occur continuously (HT only)**

Some change the shape and affect the function of proteins e.g. and enzyme active site will change or a structural protein loses its strength

Most do not alter the protein so that its appearance or function is not changed.

When the protein chain is complete it folds to form a unique shape. This allows proteins to do their job as enzymes, hormones or new structures such as collagen.

### (HT) Making new proteins (protein synthesis)

*Composed of chains of amino acids. A sequence of 3 bases codes for a particular amino acid.*

DNA in the nucleus unravels.

⇩

Enzymes make a copy of the DNA strand called mRNA.

⇩

mRNA moves from the nucleus to ribosome in the cytoplasm.

⇩

Ribosomes translate each 3 bases into amino acids according to mRNA template

⇩

Ribosomes link amino acids brought by carrier proteins.

⇩

A long chain of amino acids form. Their specific order forms a specific protein.

A sequence of 3 bases is the code for a particular amino acid. The order of bases controls the order in which each amino acid is assemble to produce a specific protein.

# AQA GCSE INHERITANCE, VARIATION AND EVOLUTION PART 2

## The genome and its interaction with the environment influence the development of phenotypes

### Mutations occur continuously

Very rarely a mutation will lead to a new phenotype which if is suited to environmental change can lead to rapid change in the species.

| | | |
|---|---|---|
| **Embryo screening /gene therapy issues** | ***Economic*** | Costly and not 100% reliable. |
| | ***Social*** | Not available to everyone (due to cost). |
| | ***Ethical*** | Should only 'healthy' embryos be implanted following screening. |

***Embryo screening:*** small piece of developing placenta removed to check for presence of faulty genes

***Gene therapy:*** replacing the faulty allele in somatic cells with a normal allele

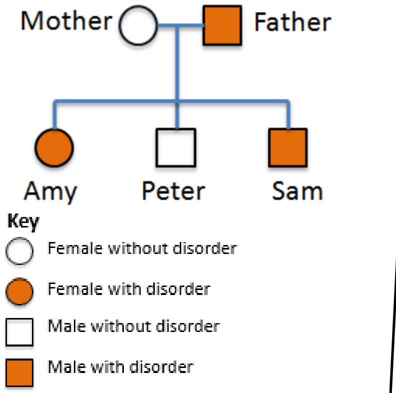
**Embryo screening and gene therapy may alleviate suffering**

### Variation

| | | |
|---|---|---|
| **Variation: difference in the characteristics of individuals in a population may be due to** | ***Genetic causes (inheritance)*** | There is usually extensive genetic variation within the population of a species e.g. hair colour, skin colour, height that can also be affected by environment e.g. nutrition, sunlight. |
| | ***Environmental causes (condition they have developed in)*** | |
| | ***A combination of genes and environment*** | |

All genetic variation arises in mutation, most have no effect on phenotype, some influence but very few determine phenotype.

### Inherited disorders



***Using a family tree:*** If the father was homozygous dominant then all of the offspring would have the disorder. He must be heterozygous

**Some disorders are inherited. They are caused by the inheritance of certain alleles**

| ***Polydactyly*** | ***Cystic fibrosis*** |
|---|---|
| Caused by inheriting a dominant allele. | Caused by inheriting a recessive allele (both parents have to at least carry it). |
| Causes a person/animal to have extra toes or fingers. | A disorder of the cell membrane. Patients cannot control the viscosity of their mucus. |

### Sex determination

**Ordinary human body cells contain 23 pairs of chromosomes**

**One pair of chromosomes carry the genes that determine sex**

| ***Female*** | ***Male*** |
|---|---|
| XX | XY |

| Gametes | X | Y |
|---|---|---|
| X | XX | XY |
| X | XX | XY |

The probability of a male of female child is 50%. The ratio is 1:1

### Genetic inheritance

| | | |
|---|---|---|
| **Define terms linked to genetics** | ***Gamete*** | Sex cells produced in meiosis. |
| | ***Chromosome*** | A long chain of DNA found in the nucleus. |
| | ***Gene*** | Small section of DNA that codes for a particular protein. |
| | ***Allele*** | Alternate forms of the same gene. |
| | ***Dominant*** | A type of allele – always expressed if only one copy present and when paired with a recessive allele. |
| | ***Recessive*** | A type of allele – only expressed when paired with another recessive allele. |
| | ***Homozygous*** | Pair of the same alleles, dominant or recessive. |
| | ***Heterozygous*** | Two different alleles are present 1 dominant and 1 recessive. |
| | ***Genotype*** | Alleles that are present for a particular feature e.g. Bb or bb |
| | ***Phenotype*** | Physical expression of an allele combination e.g. black fur, blonde hair, blue eyes. |

Some characteristics are controlled by a single gene e.g. fur colour, colour blindness.

The alleles present, or genotype operate at a molecular level to develop characteristics that can be expressed as a phenotype.

Most characteristics are as a result of multiple genes interacting.

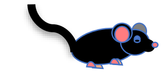
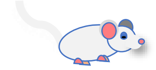
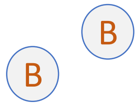
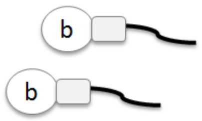
**The concept of probability in predicting results of a single gene cross.**

**Dominant and recessive allele combinations**

| ***Dominant*** | ***Recessive*** |
|---|---|
| Represented by a capital letter e.g. B. | Represented by a lower case letter e.g. b. |

3 possible combinations:
Homozygous dominant BB
Heterozygous dominant Bb
Homozygous recessive bb

**Using a punnet square (using mouse fur colour as an example)**

| | | |
|---|---|---|
| ***Parent phenotype*** | Black fur  | White fur  |
| ***Parent genotype*** | BB | bb |
| ***What gametes are present*** | In each egg  | In each sperm  |

| Gametes | b | b |
|---|---|---|
| B | Bb | Bb |
| B | Bb | Bb |

The probability of black fur offspring phenotype is 100%. All offspring genotypes are heterozygous (Bb).

**Crossing two heterozygous mice (Bb)**

| Gametes | B | b |
|---|---|---|
| B | BB | Bb |
| b | Bb | bb |

The probability of black fur is 75% and white fur 25%. The ratio of black to white mice is 3:1

# AQA GCSE INHERITANCE VARIATION AND EVOLUTION PART 3

## Evolution

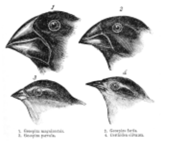
**A change in the inherited characteristics of a population over time through the process of natural selection.**

**The theory of evolution by natural selection.**

*Species of all living things have evolved from simple life forms that first developed 3 billion years ago.*

Through natural selection of variants (genotypes) that give rise to phenotypes best suited to their environment or environmental change e.g. stronger, faster. This allows for variants to pass on their genotype to the next generation.

If two populations of one species become so different in phenotype that they can no longer interbreed to produce fertile offspring they have formed two new species.

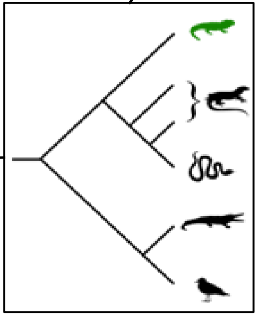

Darwin's finches

Over time this results in the formation of new species.

## Classification of living organisms

**Evolutionary trees are a method used by scientists to show how organisms are related**

Use current classification data for living organisms and fossil data for extinct organisms



## Selective breeding

**The process by which humans breed plants/animals for particular genetic characteristics**

Humans have been doing this for thousands of years since they first bred food from crops and domesticated animals.

### Selective breeding

*Choosing parents with the desired characteristics from a mixed population*

Chosen parents are bred together.

↓

From the offspring those with desired characteristics are bred together.

↓

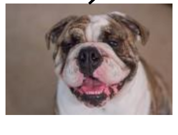
Repeat over several generations until all the offspring show the desired characteristics.

### Choosing characteristics

*Desired characteristics are chosen for usefulness or appearance*

| | |
|---|---|
| Disease resistance in food crops. |  |
| Animals which produce more meat or milk. |  |
| Domestic dogs with a gentle nature. |  |
| Large or unusual flowers. |  |

Selective breeding can lead to 'inbreeding' where some breeds are particularly prone to disease or inherited defects e.g. British Bulldogs have breathing difficulties.



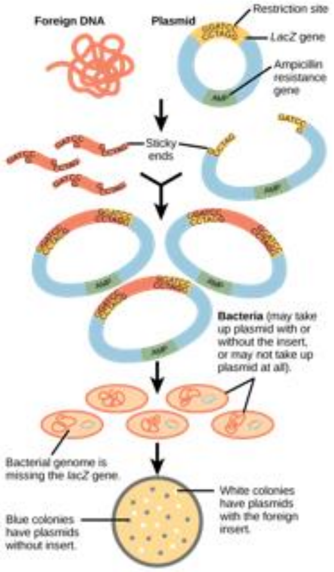
## Genetic engineering

**Genes from the chromosomes of humans or other organisms can be 'cut out' and transferred to the cells of other organisms.**

*Concern:* effect of GMO on wild populations of flowers and insects.

*Concern:* effect of GMO on human health not fully explored

Modern medical is exploring the possibility of GM to over come inherited disorders e.g. cystic fibrosis

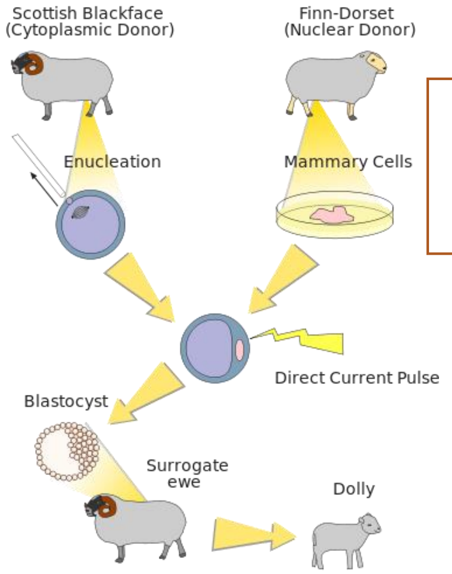


### Genetic engineering process (HT only)

1. Enzymes are used to isolate the required gene.
2. Gene is inserted into a vector – bacterial plasmid or virus.
3. Vector inserts genes into the required cells.
4. Genes are transferred to plants/animals/microbes at an early stage of development so they develop the required characteristics.

| Genetically modified crops (GMO) | *Crops that have genes from other organisms* | To become more resistant to insect attack or herbicides. |
|---|---|---|
| | | To increase the yield of the crop. |

## Cloning (Biology only)



### Adult cell cloning

1. Nucleus is removed from an unfertilised egg.
2. Nucleus from body cell is inserted into egg cell.
3. An electric shock stimulates the egg to divide into an embryo
4. Embryo cells are genetically identical to adult cells.
5. When embryo has developed into ball of cells it is inserted into host womb.

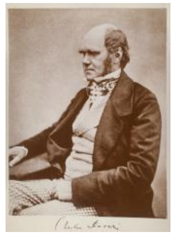
### Cloning techniques in plants/animals

| | |
|---|---|
| *Tissue culture* | Small groups of cells to grow new plants. Important for preservation of rare plants and commercially in nurseries. |
| *Cuttings* | Part of a plant is cut off and grown into full plant. |
| *Embryo transplants* | Splitting apart cells from animals embryo before they become specialised. New clone embryos are inserted into womb of adult female. |

*Concern:* some people have ethical objections to adult cell cloning e.g. welfare of the animals.

# AQA GCSE INHERITANCE VARIATION AND EVOLUTION PART 4

## Theory of evolution (Biology only)



| | | |
|---|---|---|
| **Charles Darwin** | *Theory of evolution by natural selection.* | Individual organisms within a particular species show a wide range of variation for a characteristic. |
| | | Individual most suited to the environment are more likely to breed successfully. |
| | | Characteristics enable individuals to survive are then passed on to the next generation. |

**Evidence from around the world, experimentation, geology, fossils, discussion with other scientists (Alfred Wallace) lead to:**

| | | |
|---|---|---|
| **Charles Darwin 'On the Origin of the Species' (1859)** | *Published the theory of evolution by natural selection* | Slowly accepted; challenged creation theory (God), insufficient evidence at time, mechanism of inheritance not yet known. |

Other theories e.g. Lamarckism are based on the idea that changes occur in an organism during its lifetime which can be inherited. We now know that in the vast majority of cases this cannot occur.

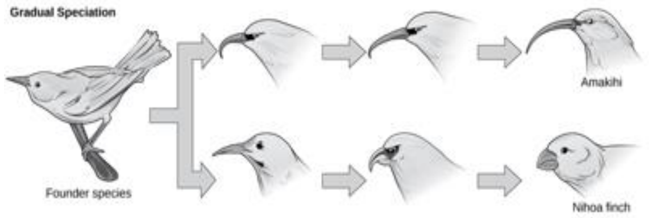
## Speciation (Biology only)

| | | |
|---|---|---|
| **Alfred Wallace** | *Independently proposed the theory of evolution by natural selection* | Published joint writings with Darwin in 1858. |
| | | Worked worldwide gathering evidence. |
| | | Best know for work on warning colouration in animals and his theory of speciation. |

Developed since its proposal from information gathered by other scientists.

Did much pioneering work on speciation but more evidence over time has lead to our current understanding.

Allows biologists to understand the diversity of species on the planet.



### Speciation

*Due to isolation of a population of a species e.g. species are split across far apart islands.*

Environmental conditions differ for populations e.g. types of food available, habitat.

⇩

Individuals in each population most suited to their environments are more likely to breed successfully.

⇩

Over long periods of time each population will have greater differences in their genotype.

⇩

If two populations of one species become so different in phenotype that they can no longer interbreed to produce fertile offspring they have formed two new species.

## Classification of living organisms

The full human classification

| Carl Linnaeus classified living things | | |
|---|---|---|
| | *Kingdom* | Animalia |
| | *Phylum* | Chordata |
| | *Class* | Mammalia |
| | *Order* | Primates |
| | *Family* | Hominidae |
| | *Genus* | *Homo* |
| | *Species* | *sapiens* |

Organisms are named by the binomial system of genus and species. Humans are *Homo sapiens*

Due to improvements in microscopes, and the understanding of biochemical processes, new models of classification were proposed.

| | |
|---|---|
| **Carl Woese** | *3 domain based on chemical analysis.* |
| | Archaea (primitive bacteria), true bacteria, eukaryota. |

## Evidence for evolution

**Fossils and antibiotic resistance in bacteria provide evidence for evolution.**

| | | |
|---|---|---|
| **Antibiotic resistant bacteria** | *Mutations produce antibiotic resistant strains which can spread* | Resistant strains are not killed. |
| | | Strain survived and reproduces. |
| | | People have no immunity to strain and treatment is ineffective. |

Evolution is widely accepted. Evidence is now available as it has been shown that characteristics are passed on to offspring in genes.

### Extinction

*When no members of a species survive*

Due to extreme geological events, disease, climate change, habitat destruction, hunting by humans.

Fossils tell scientists how much or how little different organisms have changed over time.

### Fossils

*'remains' of ancient organisms which are found in rocks*

Parts of organism that have not decayed as necessary conditions are absent.

Parts of the organism replaced by minerals as they decay.

Preserved traces of organisms such as footprints, burrows and rootlet traces.

Early forms of life were soft bodied and few traces are left behind and have been destroyed by geological activity, cannot be certain about how life began.

## The understanding of genetics (biology only)

| | | |
|---|---|---|
| **Gregor Mendel** | *In the mid 19th century carried out breeding experiments on plants* | Inheritance of each characteristic is determined by units that are passed on to descendants unchanged. |

Led to gene theory being developed but not until long after Mendel died.

### Further understanding of genetics

*Improving technology allowed new observations.*

Late 19th century: behaviour of chromosomes in cell division.

Early 20th century: chromosomes and Mendel's 'units' behave in similar ways. 'units' now called genes must be located on chromosomes.

Mid 20th century: structure of DNA determined. Mechanism of gene function worked out.

# AQA GCSE ECOLOGY PART 1

| **Ecosystem** | | |
|---|---|---|
| | ***Environment*** | The conditions surrounding an organism; abiotic and biotic. |
| | ***Habitat*** | Place where organisms live e.g. woodland, lake. |
| | ***Population*** | Individuals of a species living in a habitat. |
| | ***Community*** | Populations of different species living in a habitat. |

| **Surviving and reproducing** | | |
|---|---|---|
| | ***Competition*** | Plants in a community or habitat compete with each other for light, space, water and mineral ions. |
| | | Animals compete with each other for food, mates and territory. |
| | ***Interdependence*** | Species depend on each other for food, shelter, pollination, seed dispersal etc. Removing a species can affect the whole community |

*EXAMPLE:* Introduction of grey squirrels to UK increased competition for food for red squirrels. The greys also carry a pathogen that kills reds.

*EXAMPLE:* climate change is leading to more dissolved $CO_2$ in oceans lowering the pH of the water affecting organisms living there.

## Interdependence and competition

## Abiotic and biotic factors

| Abiotic | Biotic |
|---|---|
| ***Non-living factors that affect a community*** | ***Living factors that affect a community*** |
| Living intensity. | Availability of food. |
| Temperature. | |
| Moisture levels. | New predators arriving. |
| Soil pH, mineral content. | |
| Wind intensity and direction. | New pathogens. |
| Carbon dioxide levels for a plant. | One species outcompeting so numbers are no longer sufficient to breed |
| Oxygen levels for aquatic organisms. | |

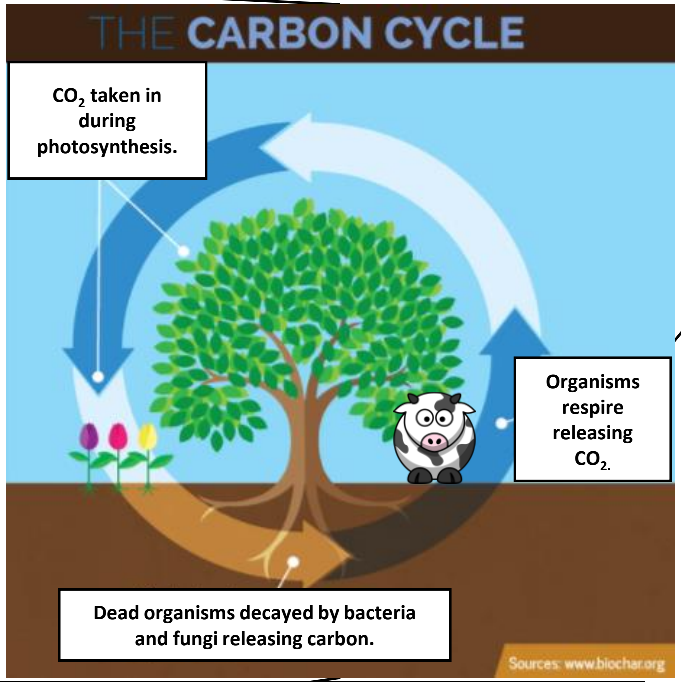
## Decomposition and material cycling

Organisms require a supply of materials from their surroundings and from the other living organisms.

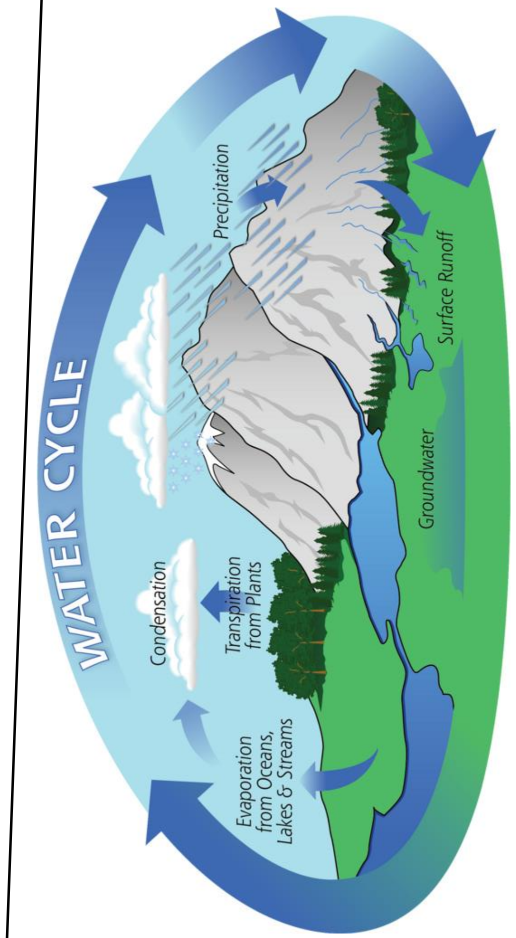
Bacteria respire when breaking down dead organisms releasing $CO_2$.

Farmers optimise conditions for making compost for use as a natural fertiliser.

Anaerobic decay in biogas generators produces methane gas, used as a fuel.



**Materials are recycled to provide the building blocks for future organisms**

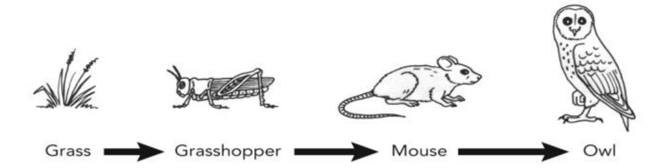


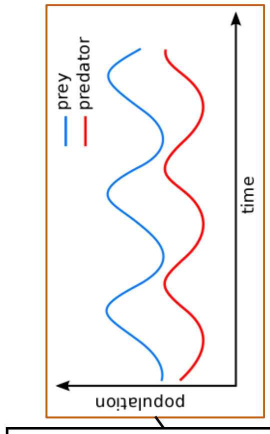
| Factors affecting rate of decay |
|---|
| ***Temperature, water, oxygen*** |
| Increase the rate of decay. In enzyme controlled reactions raising the temperature too high will denature the enzymes. |

Breakdown of dead organisms releases mineral ions into the soil.

## Levels of organisation

**Photosynthetic organisms are the producers of biomass for life on Earth**

| Food chains | | | |
|---|---|---|---|
| ***Feeding relationships in a community*** | | | |
| Producer | Primary consumer | Secondary consumer | Tertiary consumer |
|  | | | |
| All food chains begin with a producer e.g. grass that is usually a green plant or photosynthetic algae. | | Consumers that kill and eat other animals are predators and those eaten are prey. | |



In a stable community the numbers of predators and prey rise and fall in cycles.

## Adaptations

**Organisms adaptations enable them to survive in conditions where they normally live.**

Adaptations may be structural, behavioural or functional.

| Adaptations | | |
|---|---|---|
| ***Plants*** | ***Animals*** | ***Extremophiles*** |
| Cactus in dry, hot desert | Polar bear in extreme cold artic | Deep sea vent bacteria |
|  |  |  |
| No leaves to reduce water loss, wide deep roots for absorbing water. | Hollow hairs to trap layer of heat. Thick layer of fat for insulation. | Populations form in thick layers to protect outer layers from extreme heat of vent. |

# AQA GCSE ECOLOGY PART 2

## Food production (biology only)

**Factors affecting food security**

*Enough food is needed to feed a changing population*

- Increasing birth rate.
- Changing diets in developing countries.
- New pests and pathogens affecting farming.
- Environmental changes e.g. famine when rains fail.
- Cost of agriculture input.
- Conflicts (war) affecting water of food availability

### Farming techniques

*Increasing efficiency of food production*

Reduce energy waste, limiting movement, control temperature, high protein diet to increase growth.

**Sustainable fisheries**

*Fish stocks in oceans are declining*

Maintain/grow fish stocks to a sustainable level where breeding continues or certain species may disappear. By controlling net size, fishing quotas.

Some people have concerns about the treatment of animals.

### Biotechnology

*Meeting the demands of a growing population*

Fungus *Fusarium* to produce mycoprotein. Requires glucose syrup, aerobic conditions. Biomass is harvested and purified.

GM bacterium produces insulin to treat diabetes.

GM crops to provide more/nutritional food (golden rice).

Decomposers break down dead plants and animal matter by secreting enzymes. Small soluble food molecules than diffuse into the microorganism.

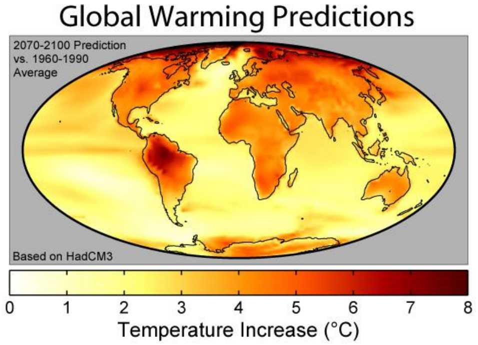
## Global warming

**Global warming**

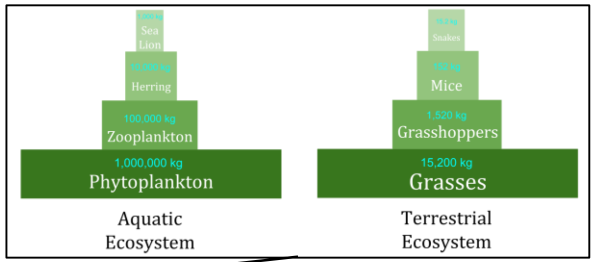
*Levels of $CO_2$ and methane in the atmosphere are increasing.*

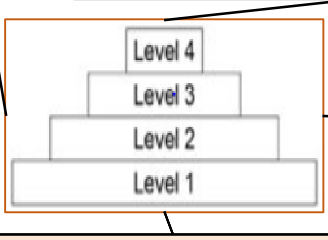
Decreased land availability from sea level rise, temperature rise damages delicate habitats, extreme weather events harm populations of plants and animals.

There is a global consensus about global warming and climate change based on systematic reviews of thousands of peer reviewed publications.



## Trophic levels and biomass (biology only)





### Transfer of biomass

*Biomass is lost between the different trophic levels*

Producers transfer about 1% of the incident energy from light for photosynthesis.

Approximately 10% of the biomass from each trophic level is transferred to the level above.

Large amounts of glucose is used in respiration, some material egested as faeces or lost as waste e.g. $CO_2$, water and urea in urine.

### Trophic levels can be represented by numbers and biomass in pyramids.

*Trophic levels are numbered sequentially according to how far the organisms is along the food chain.*

| | | |
|---|---|---|
| Level 1 | Producers | Plants and algae. |
| Level 2 | Herbivores | Primary consumers. |
| Level 3 | Carnivores | Secondary consumers. |
| Level 4 | Carnivores | Tertiary consumers. |

Apex predators are carnivores with no predators.

## Maintaining biodiversity

### Human activity can have a positive impact on biodiversity

**Scientists and concerned citizens**

*Put in place programmes to reduce the negative impacts of humans on ecosystems and biodiversity*

- Breeding programmes for endangered species.
- Protection and regeneration of rare habitats.
- Reintroduction of field margins and hedgerows in agricultural areas where farmers grow only one type of crop.
- Reduction of deforestation and $CO_2$ emissions by some governments.
- Recycling resources rather than dumping waste in landfill.

Some of the programmes potentially conflict with human needs for land use, food production and high living standards.

# AQA GCSE ECOLOGY PART 3

## Biodiversity

**Biodiversity is the variety of all different species of organisms on Earth, or within an ecosystem**

| | | |
|---|---|---|
| **Maintain a great biodiversity** | ***Ensures the stability of ecosystems*** | By reducing the dependence on one species on another for food, shelter, maintenance of the physical environment. |
| | ***Future of human species*** | Many human activities are reduction biodiversity and only recently measures have been taken to stop it. |

Experimental methods are used to determine the distribution and abundance of a species.

| | | |
|---|---|---|
| **Sampling techniques** | ***Quadrats*** | Organisms are counted within a randomly placed square |
| | ***Transects*** | Organisms are counted along a belt (transect) of the ecosystem. |

| **Processing data** | |
|---|---|
| ***Median*** | Middle value in a sample. |
| ***Mode*** | Most occurring value in a sample. |
| ***Mean*** | The sum of all the value in a sample divided by the sample number. |

## Impact of environmental change (Biology HT only)

| | | |
|---|---|---|
| **Environmental changes affect the distribution of species** | ***Temperature*** | These changes might be seasonal, geographic or caused by human interaction. |
| | ***Availability of water*** | |
| | ***Composition of atmospheric gases*** | |

***Example:*** Several species of bird migrate from cold winter conditions to warmer conditions closer to the equator.

## Biodiversity and the effect of human interaction on the ecosystem

**Human activity can have a negative impact on biodiversity**

Pollution kills plants and animals which can reduce biodiversity.

| | | |
|---|---|---|
| **Waste management** | ***Rapid growth in human population and higher standard of living*** | More resources used and more waste produced. |
| | | Pollution in water; sewage, fertiliser or toxic chemicals. |
| | | Pollution in air; smoke or acidic gases. |
| | | Pollution on land; landfill and toxic chemicals. |

## Waste, land use and deforestation

| **Land use** |
|---|
| ***Humans reduce the amount of land and habitats available for other plants, animals and microorganisms.*** |
| Building and quarrying. |
| Farming for animals and food crops. |
| Dumping waste. |
| Destruction of peat bogs to produce cheap compost for gardeners/farmers to increase food production. |

The decay or burning of peat release $CO_2$ into the atmosphere.

This conflicts with conserving peat bogs and peatlands as habitats for biodiversity and reduce $CO_2$ emissions.

| **Large scale deforestation** |
|---|
| ***In tropical areas (e.g. rain forest) has occurred to:*** |
| Provide land for cattle and rice fields, grow crops for biofuels. |

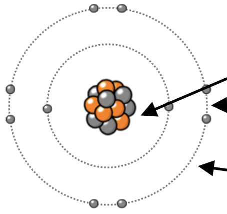
Deforestation reduces biodiversity and removes a sink for increasing the amount $CO_2$ in the atmosphere.

PiXL
Partners in excellence

# AQA GCSE Atomic structure and periodic table part 1

## Atoms, elements and compounds

| | | |
|---|---|---|
| **Atom** | *The smallest part of an element that can exist* | Have a radius of around 0.1 nanometres and have no charge (0). |
| **Element** | *Contains only one type of atom* | Around 100 different elements each one is represented by a symbol e.g. O, Na, Br. |
| **Compound** | *Two or more elements chemically combined* | Compounds can only be separated into elements by chemical reactions. |



| | |
|---|---|
| **Central nucleus** | Contains protons and neutrons |
| **Electron shells** | Contains electrons |

## Electronic structures

| Electronic shell | Max number of electrons |
|---|---|
| 1 | 2 |
| 2 | 8 |
| 3 | 8 |
| 4 | 2 |

## Relative electrical charges of subatomic particles

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

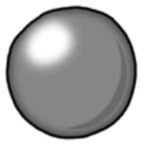
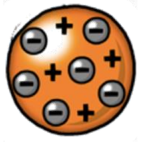
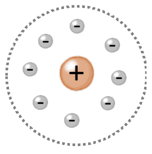
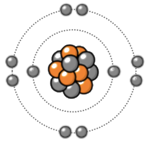
7
Li
3

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

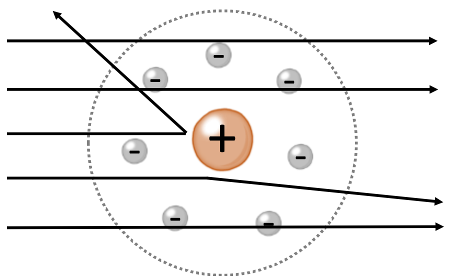
| | | |
|---|---|---|
| **Mixtures** | *Two or more elements or compounds not chemically combined together* | Can be separated by physical processes. |

| Method | Description | Example |
|---|---|---|
| **Filtration** | *Separating an insoluble solid from a liquid* | To get sand from a mixture of sand, salt and water. |
| **Crystallisation** | *To separate a solid from a solution* | To obtain pure crystals of sodium chloride from salt water. |
| **Simple distillation** | *To separate a solvent from a solution* | To get pure water from salt water. |
| **Fractional distillation** | *Separating a mixture of liquids each with different boiling points* | To separate the different compounds in crude oil. |
| **Chromatography** | *Separating substances that move at different rates through a medium* | To separate out the dyes in food colouring. |

## The development of the model of the atom

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

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

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

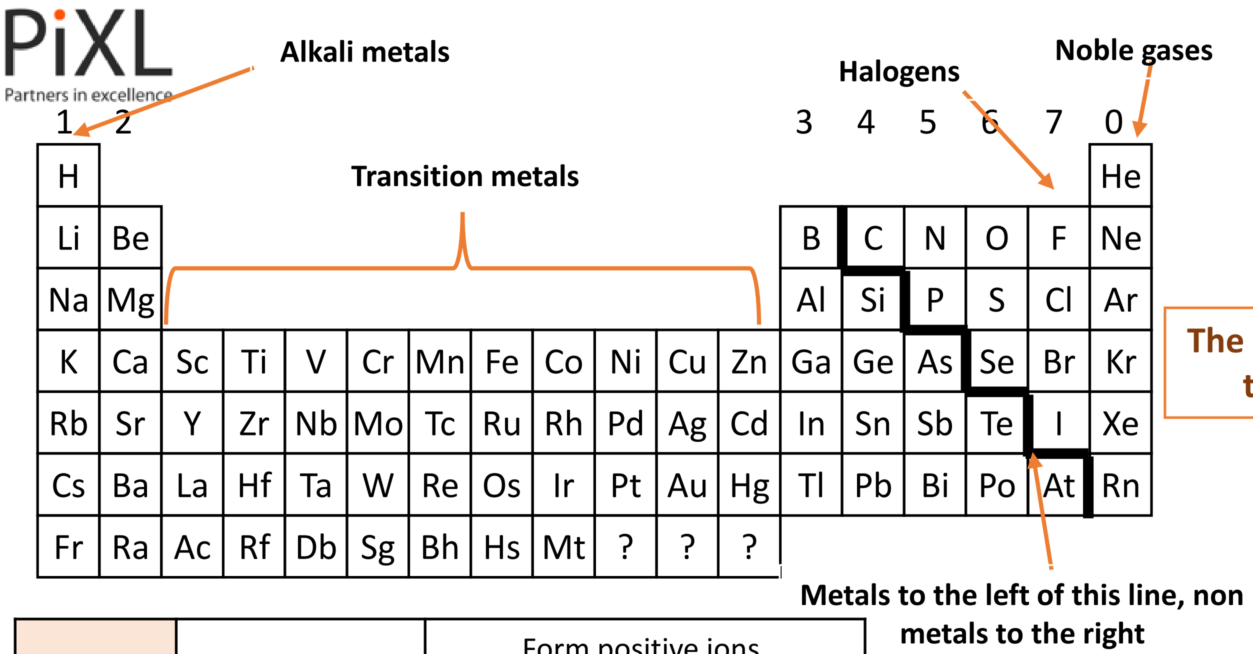
| | | |
|---|---|---|
| **Chemical equations** | *Show chemical reactions - need reactant(s) and product(s) energy always involves and energy change* | Law of conservation of mass states the total mass of products = the total mass of reactants. |

| | | |
|---|---|---|
| **Word equations** | *Uses words to show reaction*<br>**reactants → products**<br>magnesium + oxygen → magnesium oxide | Does not show what is happening to the atoms or the number of atoms. |
| **Symbol equations** | *Uses symbols to show reaction*<br>**reactants → products**<br>$2Mg + O_2 \rightarrow 2MgO$ | Shows the number of atoms and molecules in the reaction, these need to be balanced. |

## Relative atomic mass

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

# AQA GCSE Atomic structure and periodic table part 2



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

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

## The Periodic table

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

## Development of the Periodic table

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

## Metals and non metals

| | | |
|---|---|---|
| **Metals** | *To the left of the Periodic table* | Form positive ions. Conductors, high melting and boiling points, ductile, malleable. |
| **Non metals** | *To the right of the Periodic table* | Form negative ions. Insulators, low melting and boiling points. |

## Group 1

| | | |
|---|---|---|
| **Alkali metals** | *Very reactive with oxygen, water and chlorine* | Only have one electron in their outer shell. Form +1 ions. |
| | *Reactivity increases down the group* | Negative outer electron is further away from the positive nucleus so is more easily lost. |

| | | | |
|---|---|---|---|
| **With oxygen** | **Forms a metal oxide** | Metal + oxygen → metal oxide | e.g. $4Na + O_2 \rightarrow 2Na_2O$ |
| **With water** | **Forms a metal hydroxide and hydrogen** | Metal + water → metal hydroxide + hydrogen | e.g. $2Na + 2H_2O \rightarrow 2NaOH + H_2$ |
| **With chlorine** | **Forms a metal chloride** | Metal + chlorine → metal chloride | e.g. $2Na + Cl_2 \rightarrow 2NaCl$ |

## Group 7

| | | |
|---|---|---|
| **Halogens** | *Consist of molecules made of a pair of atoms* | Have seven electrons in their outer shell. Form -1 ions. |
| | *Melting and boiling points increase down the group (gas → liquid → solid)* | Increasing atomic mass number. |
| | *Reactivity decreases down the group* | Increasing proton number means an electron is more easily gained |

| | | | |
|---|---|---|---|
| **With metals** | **Forms a metal halide** | Metal + halogen → metal halide<br>e.g. Sodium + chlorine → sodium chloride | e.g. NaCl<br>metal atom loses outer shell electrons and halogen gains an outer shell electron |
| **With hydrogen** | **Forms a hydrogen halide** | Hydrogen + halogen → hydrogen halide<br>e.g. Hydrogen + bromine → hydrogen bromide | e.g. $Cl_2 + H_2 \rightarrow 2HCl$ |
| **With aqueous solution of a halide salt** | **A more reactive halogen will displace the less reactive halogen from the salt** | Chlorine + potassium bromide → potassium chloride + bromine | e.g. $Cl_2 + 2KBr \rightarrow 2KCl + Br_2$ |

## Group 0

| | | |
|---|---|---|
| **Noble gases** | *Unreactive, do not form molecules* | This is due to having full outer shells of electrons. |
| | *Boiling points increase down the group* | Increasing atomic number. |

## Transition metals (Chemistry only)

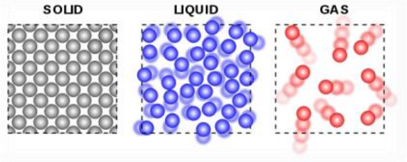
| | | |
|---|---|---|
| **Compared to group 1** | - *Less reactive*<br>- *Harder*<br>- *Denser*<br>- *Higher melting points* | - *$Cu^{2+}$ is blue*<br>- *$Ni^{2+}$ is pale green, used in the manufacture of margarine*<br>- *$Fe^{2+}$ is green, used in the Haber process*<br>- *$Fe^{3+}$ is reddish-brown*<br>- *$Mn^{2+}$ is pale pink* |
| **Typical properties** | - *Many have different ion possibilities with different charges*<br>- *Used as catalysts*<br>- *Form coloured compounds* | |

# AQA BONDING, STRUCTURE AND THE PROPERTIES OF MATTER 1

## Chemical bonds

| | | |
|---|---|---|
| **Ionic** | *Particles are oppositely charged ions* | Occurs in compounds formed from metals combined with non metals. |
| **Covalent** | *Particles are atoms that share pairs of electrons* | Occurs in most non metallic elements and in compounds of non metals. |
| **Metallic** | *Particles are atoms which share delocalised electrons* | Occurs in metallic elements and alloys. |

## The three states of matter



| | | | |
|---|---|---|---|
| **Solid, liquid, gas** | *Melting and freezing happen at melting point, boiling and condensing happen at boiling point.* | The amount of energy needed for a state change depends on the strength of forces between particles in the substance. | (HT only)<br>Limitations of simple model:<br>• There are no forces in the model<br>• All particles are shown as spheres<br>• Spheres are solid |

| | |
|---|---|
| *s* | solid |
| *l* | liquid |
| *g* | gas |

## Properties of ionic compounds

| | |
|---|---|
| *High melting and boiling points* | Large amounts of energy needed to break the bonds. |
| *Do not conduct electricity when solid* | Ions are held in a fixed position in the lattice and cannot move. |
| *Do conduct electricity when molten or dissolved* | Lattice breaks apart and the ions are free to move. |

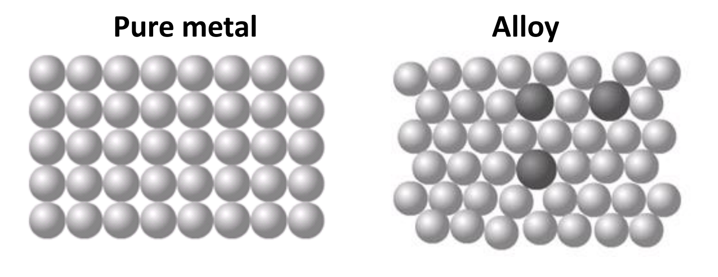
## Metals as conductors

| | |
|---|---|
| *Good conductors of electricity* | Delocalised electrons carry electrical charge through the metal. |
| *Good conductors of thermal energy* | Energy is transferred by the delocalised electrons. |

## Properties of metals and alloys

| | |
|---|---|
| *High melting and boiling points* | This is due to the strong metallic bonds. |
| *Pure metals can be bent and shaped* | Atoms are arranged in layers that can slide over each other. |

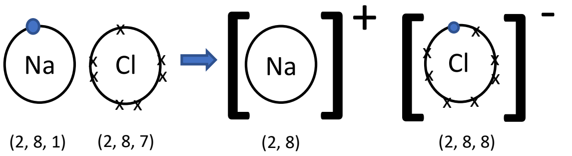
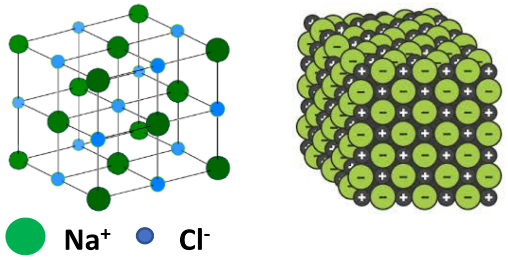
| | | |
|---|---|---|
| **Alloys** | *Mixture of two or more elements at least one of which is a metal* | Harder than pure metals because atoms of different sizes disrupt the layers so they cannot slide over each other. |



## Ionic bonding

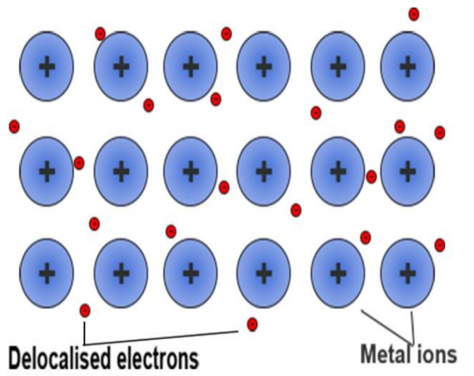
| | | |
|---|---|---|
| Electrons are transferred so that all atoms have a noble gas configuration (full outer shells). | *Metal atoms lose electrons and become positively charged ions* | Group 1 metals form +1 ions<br>Group 2 metals form +2 ions |
| | *Non metals atoms gain electrons to become negatively charged ions* | Group 6 non metals form -2 ions<br>Group 7 non metals form -1 ions |

## Ionic compounds

| | |
|---|---|
| **Dot and cross diagram** |  |
| **Giant structure** |  |

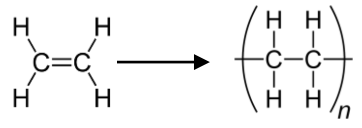
| | |
|---|---|
| **Structure** | • *Held together by strong electrostatic forces of attraction between oppositely charged ions*<br>• *Forces act in all directions in the lattice* |

## Metallic bonding

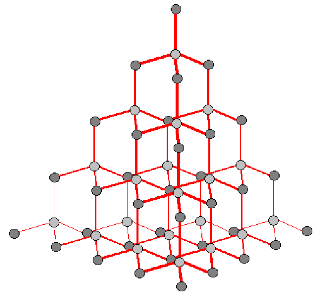
| | | |
|---|---|---|
| *Giant structure of atoms arranged in a regular pattern* |  | Electrons in the outer shell of metal atoms are delocalised and free to move through the whole structure. This sharing of electrons leads to strong metallic bonds. |

# AQA BONDING, STRUCTURE AND THE PROPERTIES OF MATTER 2

## Polymers

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

## Diamond

| | | | |
|---|---|---|---|
| *Each carbon atom is bonded to four others* |  | Very hard. | Rigid structure. |
| | | Very high melting point. | Strong covalent bonds. |
| | | Does not conduct electricity. | No delocalised electrons. |

## Giant covalent structures

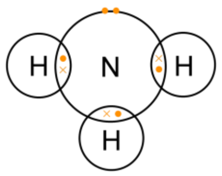
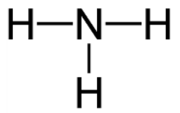
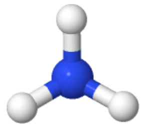
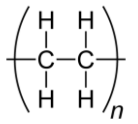
| | | |
|---|---|---|
| Diamond, graphite, silicon dioxide | *Very high melting points* | Lots of energy needed to break strong, covalent bonds. |

## Properties of small molecules

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

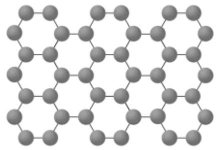
## Covalent bonding

Atoms share pairs of electrons

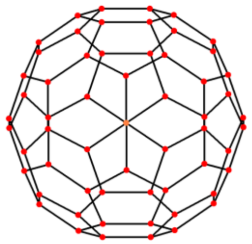
| | | |
|---|---|---|
| *Can be small molecules e.g. ammonia* |  | Dot and cross :<br>+ Show which atom the electrons in the bonds come from<br>- All electrons are identical |
| |  $H-N(-H)-H$ | 2D with bonds:<br>+ Show which atoms are bonded together<br>- It shows the H-C-H bond incorrectly at 90° |
| |  | 3D ball and stick model:<br>+ Attempts to show the H-C-H bond angle is 109.5° |
| *Can be giant covalent structures e.g. polymers* |  | |

## Graphene and fullerenes

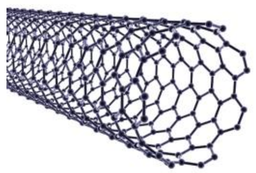
### Graphene

| | | |
|---|---|---|
|  *Single layer of graphite one atom thick* | Excellent conductor. | Contains delocalised electrons. |
| | Very strong. | Contains strong covalent bonds. |

### Fullerenes

| | | |
|---|---|---|
|  | Buckminsterfullerene, $C_{60}$<br>First fullerene to be discovered. | Hexagonal rings of carbon atoms with hollow shapes. Can also have rings of five (pentagonal) or seven (heptagonal) carbon atoms. |

### Carbon nanotubes

| | | | |
|---|---|---|---|
|  | *Very thin and long cylindrical fullerenes* | Very conductive. | Used in electronics industry. |
| | | High tensile strength. | Reinforcing composite materials. |
| | | Large surface area to volume ratio. | Catalysts and lubricants. |

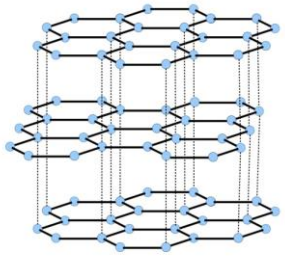
## Size of particles and their properties (Chemistry only)

| | | |
|---|---|---|
| Nanoparticles | *Between 1 and 100 nanometres (nm) in size* | 1 nanometre (1 nm) = 1 x $10^{-9}$ metres (0.000 000 001m or a billionth of a metre). |

## Use of nanoparticles

| | |
|---|---|
| *Healthcare, cosmetics, sun cream, catalysts, deodorants, electronics.* | Nanoparticles may be toxic to people. They may be able to enter the brain from the bloodstream and cause harm. |

## Graphite

| | | | |
|---|---|---|---|
| *Each carbon atom is bonded to three others forming layers of hexagonal rings with no covalent bonds between the layers* |  | Slippery. | Layers can slide over each other. |
| | | Very high melting point. | Strong covalent bonds. |
| | | Does conduct electricity. | Delocalised electrons between layers. |

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# AQA GCSE QUANTITATIVE CHEMISTRY 1

## Relative formula mass ($M_r$)

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

## Mass changes when a reactant or product is a gas

| | | |
|---|---|---|
| Mass appears to increase during a reaction | *One of the reactants is a gas* | Magnesium + oxygen → magnesium oxide |
| Mass appears to decrease during a reaction | *One of the products is a gas and has escaped* | Calcium carbonate → carbon dioxide + calcium oxide |

## Conservation of mass and balanced symbol equations

| | | |
|---|---|---|
| Conservation of mass | *No atoms are lost or made during a chemical reaction* | Mass of the products equals the mass of the reactants. |
| Balanced symbol equations | *Represent chemical reactions and have the same number of atoms of each element on both sides of the equation* | $H_2 + Cl_2 \rightarrow 2HCl$<br>Subscript<br>Normal script<br>Subscript numbers show the number of atoms of the element to its left.<br>Normal script numbers show the number of molecules. |

## Moles (HT only)

| | | |
|---|---|---|
| Chemical amounts are measured in moles (mol) | *Mass of one mole of a substance in grams = relative formula mass* | One mole of $H_2O$ = 18g (1 + 1 + 16)<br>One mole of Mg = 24g |
| Avogadro constant | *One mole of any substance will contain the same number of particles, atoms, molecules or ions.* | $6.02 \times 10^{23}$ per mole<br>One mole of $H_2O$ will contain $6.02 \times 10^{23}$ molecules<br>One mole of NaCl will contain $6.02 \times 10^{23}$ $Na^+$ ions |
| *Number of moles = $\frac{\text{mass (g)}}{A_r}$ or $\frac{\text{mass (g)}}{M_r}$* | | How many moles of sulfuric acid molecules are there in 4.7g of sulfuric acid ($H_2SO_4$)?<br>Give your answer to 1 significant figure.<br>$\frac{4.7}{98}$ = 0.05 mol<br>98 ← ($M_r$ of $H_2SO_4$) |

## Limiting reactants (HT only)

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

## Chemical measurements

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

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

## Concentration of solutions

| | | |
|---|---|---|
| Measured in mass per given volume of solution (g/dm³) | *Conc. = $\frac{\text{mass (g)}}{\text{volume (dm}^3\text{)}}$* | HT only<br>Greater mass = higher concentration.<br>Greater volume = lower concentration. |

## Using moles to balance equations (HT only)

| | |
|---|---|
| The balancing numbers in a symbol equation can be calculated from the masses of reactants and products | *Convert the masses in grams to amounts in moles and convert the number of moles to simple whole number ratios.* |

## Amounts of substances in equations (HT only)

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

# AQA QUANTITATIVE CHEMISTRY 2

## Atom economy

**A measure of the amount of starting materials that end up as useful products**

$$\text{Atom economy} = \frac{\text{Relative formula mass of desired product from equation}}{\text{Sum of relative formula mass of all reactants from equation}} \times 100$$

High atom economy is important or sustainable development and economic reasons

Calculate the atom economy for making hydrogen by reacting zinc with hydrochloric acid:

$Zn + 2HCl \rightarrow ZnCl_2 + H_2$

$M_r$ of $H_2$ = 1 + 1 = 2
$M_r$ of Zn + 2HCl = 65 + 1 + 1 + 35.5 + 35.5 = 138

Atom economy = $^{2}/_{138} \times 100$
= $^{2}/_{138} \times 100$ = 1.45%

This method is unlikely to be chosen as it has a low atom economy.

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

**Concentration of a solution is the amount of solute per volume of solution**

*Concentration (mol/dm³) = amount (mol) / volume (dm³)*

What is the concentration of a solution that has 35.0g of solute in 0.5dm³ of solution?

35/0.5 = 70 g/dm³

### Titration

*If the volumes of two solutions that react completely are known and the concentrations of one solution is known, the concentration of the other solution can be calculated.*

$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$

It takes 12.20cm³ of sulfuric acid to neutralise 24.00cm³ of sodium hydroxide solution, which has a concentration of 0.50mol/dm³.

Calculate the concentration of the sulfuric acid in mol/dm³:

0.5 mol/dm³ x (24/1000) dm³ = 0.012 mol of NaOH
The equation shows that 2 mol of NaOH reacts with 1 mol of $H_2SO_4$, so the number of moles in 12.20cm³ of sulfuric acid is (0.012/2) = 0.006 mol of sulfuric acid

Calculate the concentration of sulfuric acid in mol/ dm³
0.006 mol x (1000/12.2) dm³ =0.49mol/dm³

Calculate the concentration of sulfuric acid in g/ dm³:
$H_2SO_4$ = (2x1) + 32 + (4x16) = 98g
0.49 x 98g = 48.2g/dm³

## Percentage yield

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

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

**Yield is the amount of product obtained**

*It is not always possible to obtain the calculated amount of a product*

- The reaction may not go to completion because it is reversible.
- Some of the product may be lost when it is separated from the reaction mixture.
- Some of the reactants may react in ways different to the expected reaction.

**Percentage yield is comparing the amount of product obtained as a percentage of the maximum theoretical amount**

$$\text{\% Yield} = \frac{\text{Mass of product made}}{\text{Max. theoretical mass}} \times 100$$

A piece of sodium metal is heated in chlorine gas. A maximum theoretical mass of 10g for sodium chloride was calculated, but the actual yield was only 8g.
*Calculate the percentage yield.*

Percentage yield = 8/10 x 100 =80%

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

**Equal amounts of moles or gases occupy the same volume under the same conditions of temperature and pressure**

*The volume of one mole of any gas at room temperature and pressure (20°C and 1 atmospheric pressure) is 24 dm³*

$$\text{No. of moles of gas} = \frac{\text{vol of gas (dm}^3\text{)}}{24\text{dm}^3}$$

What is the volume of 11.6 g of butane ($C_4H_{10}$) gas at RTP?
$M_r$ : (4 x 12) + (10 x 1) = 58
11.6/58 = 0.20 mol
Volume = 0.20 x 24 = 4.8 dm³

6g of a hydrocarbon gas had a volume of 4.8 dm³. Calculate its molecular mass.
1 mole = 24 dm³, so 4.8/24 = 0.2 mol
$M_r$ = 6 / 0.2 = 30
If 6g = 0.2 mol, 1 mol equals 30 g

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

# AQA Chemical Changes 1

## Oxidation and reduction in terms of electrons (HT ONLY)

| Ionic half equations (HT only) | | |
|---|---|---|
| **For displacement reactions** | *Ionic half equations show what happens to each of the reactants during reactions* | For example:<br>The ionic equation for the reaction between iron and copper (II) ions is:<br>$Fe + Cu^{2+} \rightarrow Fe^{2+} + Cu$<br>The half-equation for iron (II) is:<br>$Fe \rightarrow Fe^{2+} + 2e^-$<br>The half-equation for copper (II) ions is:<br>$Cu^{2+} + 2e^- \rightarrow Cu$ |

## Reactions of acids

### Neutralisation of acids and salt production

| Acid name | Salt name |
|---|---|
| *Hydrochloric acid* | Chloride |
| *Sulfuric acid* | Sulfate |
| *Nitric acid* | Nitrate |

**sodium hydroxide + hydrochloric acid → sodium chloride + water**

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

| | | |
|---|---|---|
| **Neutralisation** | *Acids can be neutralised by alkalis and bases* | An **alkali** is a soluble base e.g. metal hydroxide.<br>A **base** is a substance that neutralises an acid e.g. a soluble metal hydroxide or a metal oxide. |

### Reactions of acids and metals

Acids react with some metals to produce salts and hydrogen.

| | | |
|---|---|---|
| **Reactions with acids** | *metal + acid → metal salt + hydrogen* | **magnesium + hydrochloric acid → magnesium chloride + hydrogen**<br>**zinc + sulfuric acid → zinc sulfate + hydrogen** |

**HT ONLY:** Reactions between metals and acids are redox reactions as the metal donates electrons to the hydrogen ions. This displaces hydrogen as a gas while the metal ions are left in the solution.

## Reactivity of metals

### Metal oxides

| | | |
|---|---|---|
| **Metals and oxygen** | *Metals react with oxygen to form metal oxides* | **magnesium + oxygen → magnesium oxide**<br>*$2Mg + O_2 \rightarrow 2MgO$* |
| **Reduction** | *This is when oxygen is removed from a compound during a reaction* | e.g. metal oxides reacting with hydrogen, extracting low reactivity metals |
| **Oxidation** | *This is when oxygen is gained by a compound during a reaction* | e.g. metals reacting with oxygen, rusting of iron |

### Extraction of metals and reduction

| Extraction using carbon | |
|---|---|
| *Metals less reactive than carbon can be extracted from their oxides by reduction.* | For example:<br>**zinc oxide + carbon → zinc + carbon dioxide** |

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

### The reactivity series

| | Reactions with water | Reactions with acid |
|---|---|---|
| **Group 1 metals** | *Reactions get more vigorous as you go down the group* | *Reactions get more vigorous as you go down the group* |
| **Group 2 metals** | *Do not react with water* | *Observable reactions include fizzing and temperature increases* |
| **Zinc, iron and copper** | *Do not react with water* | *Zinc and iron react slowly with acid. Copper does not react with acid.* |

| | | |
|---|---|---|
| **Metals form positive ions when they react** | *The reactivity of a metal is related to its tendency to form positive ions* | The reactivity series arranges metals in order of their reactivity (their tendency to form positive ions). |
| **Carbon and hydrogen** | *Carbon and hydrogen are non-metals but are included in the reactivity series* | These two non-metals are included in the reactivity series as they can be used to extract some metals from their ores, depending on their reactivity. |
| **Displacement** | *A more reactive metal can displace a less reactive metal from a compound.* | Silver nitrate + Sodium chloride →<br>Sodium nitrate + Silver chloride |

| | | |
|---|---|---|
| potassium | most reactive | K |
| sodium | ↑ | Na |
| calcium | | Ca |
| magnesium | | Mg |
| aluminium | | Al |
| carbon | | C |
| zinc | | Zn |
| iron | | Fe |
| tin | | Sn |
| lead | | Pb |
| hydrogen | | H |
| copper | | Cu |
| silver | | Ag |
| gold | ↓ | Au |
| platinum | least reactive | Pt |

# AQA Chemical Changes 2

## Electrolysis

| | | |
|---|---|---|
| **Process of electrolysis** | *Splitting up using electricity* | When an ionic compound is melted or dissolved in water, the ions are free to move. These are then able to conduct electricity and are called electrolytes. Passing an electric current though electrolytes causes the ions to move to the electrodes. |
| **Electrode** | *Anode*<br>*Cathode* | The positive electrode is called the anode.<br>The negative electrode is called the cathode. |
| **Where do the ions go?** | *Cations*<br>*Anions* | Cations are positive ions and they move to the negative cathode.<br>Anions are negative ions and they move to the positive anode. |

### Electrolysis of aqueous solutions

The ions discharged when an aqueous solution is electrolysed using inert electrodes depend on the relative reactivity of the elements involved.

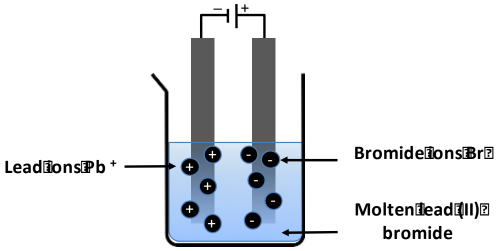
| | |
|---|---|
| **At the negative electrode** | Metal will be produced on the electrode if it is less reactive than hydrogen. Hydrogen will be produced if the metal is more reactive than hydrogen. |
| **At the positive electrode** | Oxygen is formed at positive electrode. If you have a halide ion ($Cl^-$,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

### Extracting metals using electrolysis

*Metals can be extracted from molten compounds using electrolysis.*

*This process is used when the metal is too reactive to be extracted by reduction with carbon.*

*The process is expensive due to large amounts of energy needed to produce the electrical current.*
*Example: aluminium is extracted in this way.*



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

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

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

## Reactions of acids

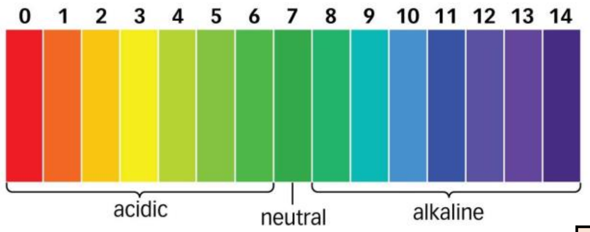
### Strong and weak acids (HT ONLY)

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

### Soluble salts

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

### The pH scale and neutralisation



You can use universal indicator or a pH probe to measure the acidity or alkalinity of a solution against the pH scale.

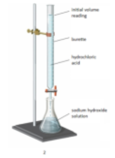
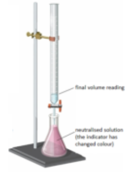
| | |
|---|---|
| **Acids** | *Acids produce hydrogen ions ($H^+$) in aqueous solutions.* |
| **Alkalis** | *Aqueous solutions of alkalis contain hydroxide ions ($OH^-$).* |

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

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

### Titrations (Chemistry only)

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

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

**Calculating the chemical quantities in titrations involving concentrations in mol/dm³ and in g/dm³ (HT ONLY):**

**$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$**

It takes 12.20$cm^3$ of sulfuric acid to neutralise 24.00$cm^3$ of sodium hydroxide solution, which has a concentration of 0.50mol/$dm^3$.

*Calculate the concentration of the sulfuric acid in g/dm³*

**0.5 mol/$dm^3$ x (24/1000) $dm^3$ = 0.012 mol of NaOH**

The equation shows that 2 mol of NaOH reacts with 1 mol of $H_2SO_4$, so the number of moles in 12.20$cm^3$ of sulfuric acid is **(0.012/2) = 0.006 mol of sulfuric acid**

*Calculate the concentration of sulfuric acid in mol/ dm³*

**0.006 mol x (1000/12.2) $dm^3$ =0.49mol/$dm^3$**

*Calculate the concentration of sulfuric acid in g/ dm³*

**$H_2SO_4$ = (2x1) + 32 + (4x16) = 98g**
**0.49 x 98g = 48.2g/$dm^3$**

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# AQA GCSE Energy changes

## Types of reaction

| | | |
|---|---|---|
| **Endothermic** | *Energy is taken in from the surroundings so the temperature of the surroundings decreases* | - Thermal decomposition<br>- Sports injury packs |
| **Exothermic** | *Energy is transferred to the surroundings so the temperature of the surroundings increases* | - Combustion<br>- Hand warmers<br>- Neutralisation |

## The energy change of reactions (HT only)

| | |
|---|---|
| **Reaction profiles** | *Show the overall energy change of a reaction* |

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

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

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

## Cells and batteries (Chemistry only)

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

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

## Fuel cells (Chemistry only)

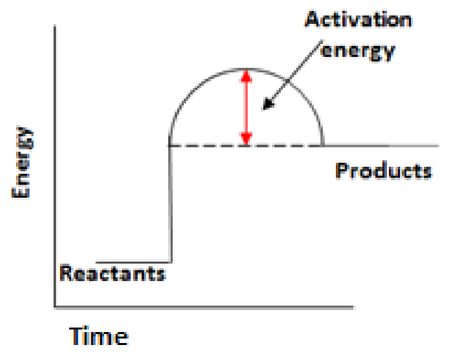
| | | |
|---|---|---|
| **Ionic half equations** | Negative electrode:<br>$2H_2\ (g) + 4OH^-\ (aq) \rightarrow 4H_2O\ (l) + 4e^-$ | Positive electrode:<br>$O_2\ (g) + 2H_2O\ (l) + 4e^- \rightarrow 4OH^-\ (aq)$ |

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

## Reaction profiles

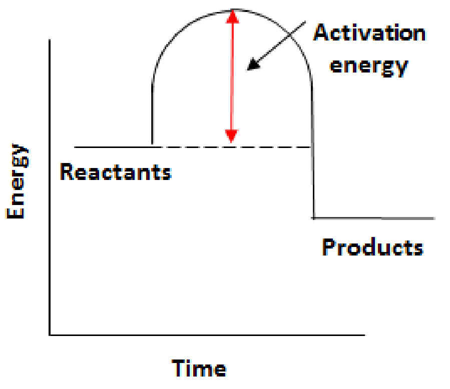
| | | |
|---|---|---|
| **Activation energy** | *Chemical reactions only happen when particles collide with sufficient energy* | The minimum amount of energy that colliding particles must have in order to react is called the activation energy. |

**Endothermic**



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

**Exothermic**



Products are at a lower energy level than the reactants. When the reactants form products, energy is transferred to the surroundings. The temperature of the surroundings increases because energy is released during the reaction.

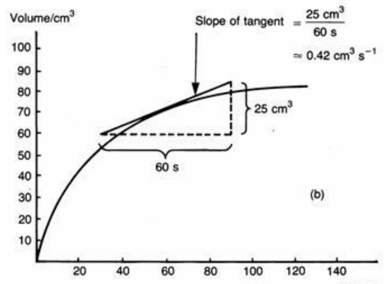
# AQA GCSE The rate and extent of chemical change

## Rate of reaction

### Calculating rates of reactions

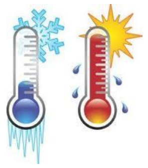
| | | |
|---|---|---|
| Rate of chemical reaction | *This can be calculated by measuring the quantity of reactant used or product formed in a given time.* | $\text{Rate} = \frac{\text{quantity of reactant used}}{\text{time taken}}$<br>$\text{Rate} = \frac{\text{quantity of product formed}}{\text{time taken}}$ |

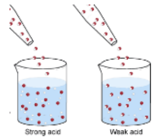
| Quantity | Unit |
|---|---|
| *Mass* | Grams (g) |
| *Volume* | cm$^3$ |
| *Rate of reaction* | Grams per cm$^3$ (g/cm$^3$)<br>HT: moles per second (mol/s) |

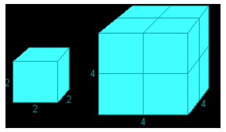


### Factors affecting rates

| Factors affecting the rate of the reaction | |
|---|---|
| Temperature | *The higher the temperature, the quicker the rate of reaction.* |
| Concentration | *The higher the concentration, the quicker the rate of reaction.* |
| Surface area | *The larger the surface area of a reactant solid, the quicker the rate of reaction.* |
| Pressure (of gases) | *When gases react, the higher the pressure upon them, the quicker the rate of reaction.* |



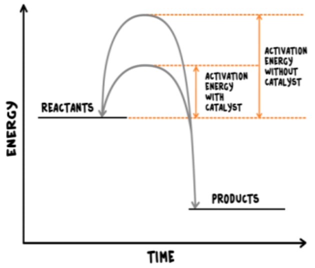




### Collision theory and activation energy

| | | |
|---|---|---|
| Collision theory | *Chemical reactions can only occur when reacting particles collide with each other with sufficient energy.* | Increasing the temperature increases the frequency of collisions and makes the collisions more energetic, therefore increasing the rate of reaction.<br>Increasing the concentration, pressure (gases) and surface area (solids) of reactions increases the frequency of collisions, therefore increasing the rate of reaction. |
| Activation energy | *This is the minimum amount of energy colliding particles in a reaction need in order to react.* | |

### Catalysts



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

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

## Reversible reactions and dynamic equilibrium

### Reversible reactions

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

### Energy changes and reversible reactions

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

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

### Equilibrium

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

### Changing conditions and equilibrium (HT)

The relative amounts of reactants and products at equilibrium depend on the conditions of the reaction.

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

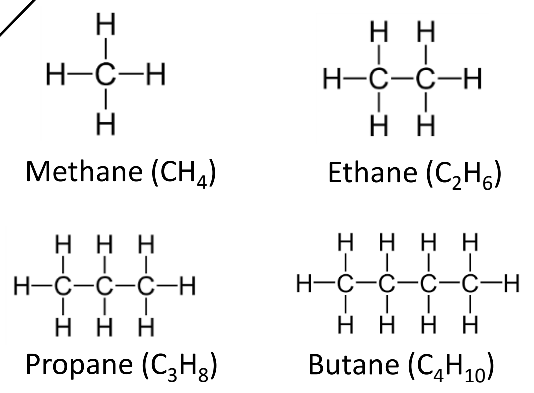
# AQA GCSE
# Organic chemistry 1

# Carbon compounds as fuels and feedstock

## Crude oil, hydrocarbons and alkanes

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

Display formula for first four alkanes



Methane ($CH_4$)

Ethane ($C_2H_6$)

Propane ($C_3H_8$)

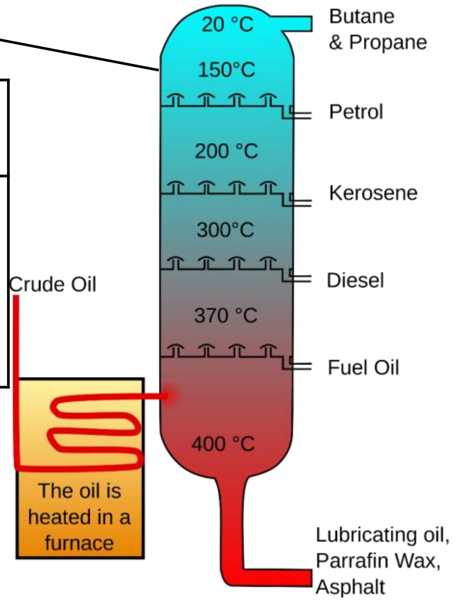
Butane ($C_4H_{10}$)

## Fractional distillation and petrochemicals

| | | |
|---|---|---|
| **Fractions** | *The hydrocarbons in crude oil can be split into fractions* | Each fraction contains molecules with a similar number of carbon atoms in them. The process used to do this is called fractional distillation. |
| **Using fractions** | *Fractions can be processed to produce fuels and feedstock for petrochemical industry* | We depend on many of these fuels; petrol, diesel and kerosene.<br>Many useful materials are made by the petrochemical industry; solvents, lubricants and polymers. |

**Hydrocarbon chains**

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



# Carbon compounds as fuels and feedstock

## Cracking and alkenes

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

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

Decane → pentane + propene + ethane

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

| | |
|---|---|
| **Alkenes and uses as polymers** | *Used to produce polymers. They are also used as the starting materials of many other chemicals, such as alcohol, plastics and detergents.* |
| **Why do we crack long chains?** | *Without cracking, many of the long hydrocarbons would be wasted as there is not much demand for these as for the shorter chains.* |

## Properties of hydrocarbons

| | |
|---|---|
| **Combustion** | During the complete combustion of hydrocarbons, the carbon and hydrogen in the fuels are oxidised, releasing carbon dioxide, water and energy. |

Complete combustion of methane:

Methane + oxygen → carbon dioxide + water + energy

$$CH_4\ (g) + 2O_2\ (g) \rightarrow CO_2\ (g) + 2\ H_2O\ (l)$$

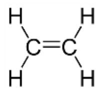
| | |
|---|---|
| **Boiling point (temperature at which liquid boils)** | *As the hydrocarbon chain length increases, boiling point increases.* |
| **Viscosity (how easily it flows)** | *As the hydrocarbon chain length increases, viscosity increases.* |
| **Flammability (how easily it burns)** | *As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

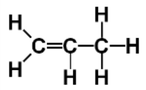
# AQA GCSE Organic chemistry 2 (CHEMISTRY ONLY)

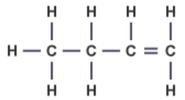
## Reactions of alkenes and alcohols

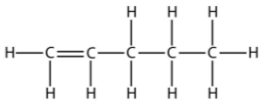
### Structure and formula of alkenes

| | | |
|---|---|---|
| **Alkenes** | *Hydrocarbons with a double carbon-carbon bond.* |
| **Unsaturated** | *Alkenes are unsaturated because they contain two fewer hydrogen atoms than their alkane counterparts.* |
| **General formula for alkenes** | *$C_nH_{2n}$* |


Ethene $C_2H_4$


Propene $C_3H_6$

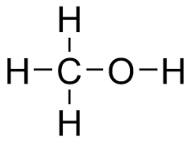

Butene $C_4H_8$

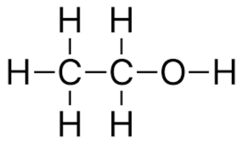

Pentene $C_5H_{10}$

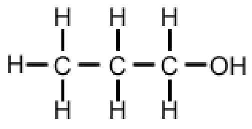
### Reactions of alkenes

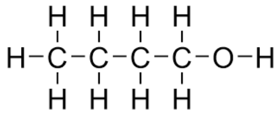
| | | |
|---|---|---|
| **Functional group** | *Alkenes are hydrocarbons in the functional group C=C.* | The functional group of an organic compound determined their reactions. |
| **Alkene reactions** | *Alkenes react with oxygen in the same way as other hydrocarbons, just with a smoky flame due to incomplete combustion.* | Alkenes also react with hydrogen, water and the halogens. The C=C bond allows for the addition of other atoms. |

### Alcohols


Methanol


Ethanol


Propanol


Butanol

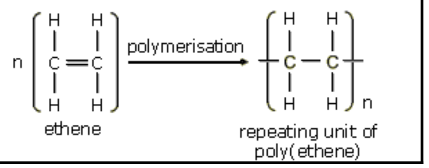
| | | |
|---|---|---|
| **Functional group** | *-OH*<br>*For example: $CH_3CH_2OH$* | Methanol, ethanol, propanol and butanol are the first four of the homologous series. |
| **Alcohol reactions** | *Alcohols react with sodium, air and water.* | Alcohols and sodium:<br>bubbling, hydrogen gas given off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

### Carboxylic acids

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

## Synthetic and naturally occurring polymers

### Addition polymerisation

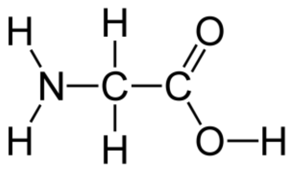
| | | |
|---|---|---|
| **Polymers** | *Alkenes are used to make polymers by addition polymerisation.* | Many small molecules join together to form polymers (very large molecules). |
| **Displaying polymers** | *In addition polymers, the repeating unit has the same atoms as the monomer.* | It can be displayed like this:<br> |

### Condensation polymerisation (HT only)

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

### Amino acids

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


Glycine

### DNA and naturally occurring polymers

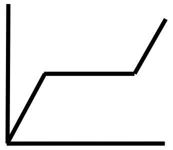
| | |
|---|---|
| **DNA** | *Deoxyribonucleic acid is a large molecule essential for life. DNA gives the genetic instructions to ensure development and functioning of living organisms and viruses.* |
| **DNA structure** | *Most DNA molecules are two polymer chains made from four different monomers, called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

# AQA Chemical analysis

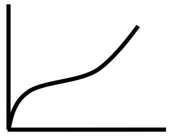
## Purity, formulations and chromatography

### Pure substances

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



*Melting point of a pure substance*

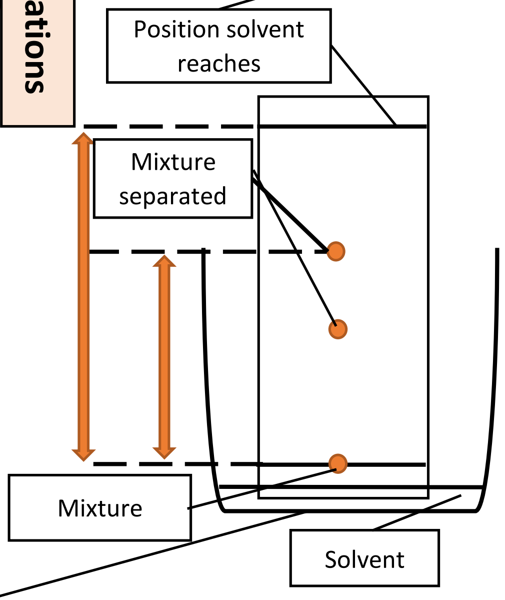


*Melting point of an impure substance*

### Formulations

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

### Chromatography



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

## Identification of common gases

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

## Identification of ions (CHEMISTRY ONLY)

### Flame tests (chem only)

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

### Metal hydroxides (chem only)

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

### Carbonates, halides and sulfates (chem only)

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

### Instrumental methods

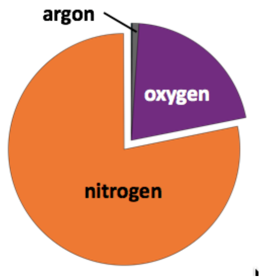
| | | |
|---|---|---|
| **Instrumental methods** | *Methods that rely on machines* | Can be used to identify elements and compounds. These methods are accurate, sensitive and rapid. |

### Flame emission spectroscopy

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

# AQA GCSE Chemistry of the atmosphere

## Composition and evolution of the atmosphere



### Proportions of gases in the atmosphere

| Gas | *Percentage* |
|---|---|
| Nitrogen | *~80%* |
| Oxygen | *~20%* |
| Argon | *0.93%* |
| Carbon dioxide | *0.04%* |

### How oxygen increased

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

### How carbon dioxide decreased

| | | |
|---|---|---|
| Reducing carbon dioxide in the atmosphere | *Algae and plants* | These gradually reduced the carbon dioxide levels in the atmosphere by absorbing it for photosynthesis. |
| Formation of sedimentary rocks and fossil fuels | *These are made out of the remains of biological matter, formed over millions of years* | Remains of biological matter falls to the bottom of oceans. Over millions of years layers of sediment settled on top of them and the huge pressures turned them into coal, oil, natural gas and sedimentary rocks. The sedimentary rocks contain carbon dioxide from the biological matter. |

### The Earth's early atmosphere

| | | |
|---|---|---|
| Volcano activity 1st Billion years | *Billions of years ago there was intense volcanic activity* | This released gases (mainly $CO_2$) that formed to early atmosphere and water vapour that condensed to form the oceans. |
| Other gases | *Released from volcanic eruptions* | Nitrogen was also released, gradually building up in the atmosphere. Small proportions of ammonia and methane also produced. |
| Reducing carbon dioxide in the atmosphere | *When the oceans formed, carbon dioxide dissolved into it* | This formed carbonate precipitates, forming sediments. This reduced the levels of carbon dioxide in the atmosphere. |

## Common atmospheric pollutants

### Atmospheric pollutants from fuels

| | |
|---|---|
| Combustion of fuels | *Source of atmospheric pollutants. Most fuels may also contain some sulfur.* |
| Gases from burning fuels | *Carbon dioxide, water vapour, carbon monoxide, sulfur dioxide and oxides of nitrogen.* |
| Particulates | *Solid particles and unburned hydrocarbons released when burning fuels.* |

### Properties and effects of atmospheric pollutants

| | |
|---|---|
| Carbon monoxide | *Toxic, colourless and odourless gas. Not easily detected, can kill.* |
| Sulfur dioxide and oxides of nitrogen | *Cause respiratory problems in humans and acid rain which affects the environment.* |
| Particulates | *Cause global dimming and health problems in humans.* |

## $CO_2$ and methane as greenhouse gases

### Greenhouse gases

| | |
|---|---|
| Carbon dioxide, water vapour and methane | *Examples of greenhouse gases that maintain temperatures on Earth in order to support life* |
| The greenhouse effect | *Radiation from the Sun enters the Earth's atmosphere and reflects off of the Earth. Some of this radiation is re-radiated back by the atmosphere to the Earth, warming up the global temperature.* |

### Carbon footprints

The total amount of greenhouse gases emitted over the full life cycle of a product/event. This can be reduced by reducing emissions of carbon dioxide and methane.

### Global climate change

| Effects of climate change |
|---|
| Rising sea levels |
| Extreme weather events such as severe storms |
| Change in amount and distribution of rainfall |
| Changes to distribution of wildlife species with some becoming extinct |

### Human activities and greenhouse gases

| | |
|---|---|
| Carbon dioxide | *Human activities that increase carbon dioxide levels include burning fossil fuels and deforestation.* |
| Methane | *Human activities that increase methane levels include raising livestock (for food) and using landfills (the decay of organic matter released methane).* |
| Climate change | *There is evidence to suggest that human activities will cause the Earth's atmospheric temperature to increase and cause climate change.* |

# Using the Earth's resources and obtaining potable water

## AQA GCSE Using resources 1

## Life cycle assessment and recycling

### Using the Earth's resources and sustainable development

| | | |
|---|---|---|
| **Earth's resources** | *Used to provide warmth, shelter, food and transport for humans* | Natural resources and resources from agriculture provide: timber, food, clothing and fuels. |
| | | Finite resources from the Earth, oceans and atmosphere are processed to provide energy and materials. |
| **Chemistry and resources** | *Research and techniques improve agricultural and industrial processes* | These improvements provide new products and improve sustainability. |
| **Plastics** | *Normally made using ethene from crude oil* | However, the raw material ethene can also be obtained from ethanol, which can be produced during fermentation. Industries are now starting to use a renewable crop for this process. |

### Potable water

Sterilising agents include chlorine, ozone and UV light.

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

### Waste water treatment

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

### Alternative methods of extracting metals (HT)

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

### Life cycle assessment

| | | |
|---|---|---|
| **LCAS** | *Life cycle assessments are carried out to assess the environmental impact of products* | They are assessed at these stages:<br>- Extraction and processing raw materials<br>- Manufacturing and packaging<br>- Use and operation during lifetime<br>- Disposal |
| **Values** | *Allocating numerical values to pollutant effects is difficult* | Value judgments are allocated to the effects of pollutants so LCA is not a purely objective process. |

### Ways of reducing the use of resources

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

# AQA GCSE Using resources 2 (CHEM ONLY)

## Using materials

### Corrosion and its prevention

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

### Alloys are useful materials

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

### Ceramics, polymers and composites

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

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

## The Haber process and the use of NPK fertilisers

### Production and uses of NPK fertilisers

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

**Phosphate rock**

| Treatment | *Products* |
|---|---|
| **Nitric acid** | *The acid is neutralised with ammonia to produce ammonium phosphate, a NPK fertiliser.* |
| **Sulfuric acid** | *Calcium phosphate and calcium sulfate (a single superphosphate).* |
| **Phosphoric acid** | *Calcium phosphate (a triple superphosphate).* |

### The Haber process

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

**The Haber process – conditions and equilibrium**

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

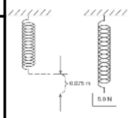
# AQA ENERGY – part 1

## Energy stores and changes

**Energy pathways**

| | |
|---|---|
| Mechanical | *Force acts upon an object* |
| Electrical | *Electric current flow* |
| Heat | *Temperature difference between objects* |
| Radiation | *Electromagnetic waves or sound* |

| | | |
|---|---|---|
| Kinetic energy | *Energy stored by a moving object* | ½ X mass X (speed)$^2$<br>½ mv$^2$ |
| Elastic Potential energy | *Energy stored in a stretched spring, elastic band* | ½ X spring constant X (extension)$^2$<br>½ ke$^2$<br>(Assuming the limit of proportionality has not been exceeded) |
| Gravitational Potential energy | *Energy gained by an object raised above the ground* | Mass X gravitational field strength X height<br>mgh |



| | | |
|---|---|---|
| System | *An object or group of objects that interact together* | EG: Kettle boiling water. |
| Energy stores | *Kinetic, chemical, internal (thermal), gravitational potential, elastic potential, magnetic, electrostatic, nuclear* | Energy is gained or lost from the object or device. |
| Ways to transfer energy | *Light, sound, electricity, thermal, kinetic are ways to transfer from one store to another store of energy.* | EG: electrical energy transfers chemical energy into thermal energy to heat water up. |
| Unit | *Joules (J)* | |

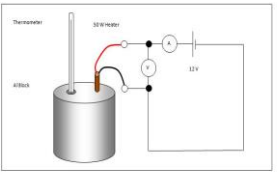
| | | | |
|---|---|---|---|
| Work | *Doing work transfers energy from one store to another* | By applying a force to move an object the energy store is changed. | Work done = Force X distance moved<br>W = Fs |
| Power | *The rate of energy transfer* | 1 Joule of energy per second = 1 watt of power | Power = energy transfer ÷ time<br>P = E ÷ t<br>Power = work done ÷ time,<br>P = W ÷ t |

| | Units |
|---|---|
| Specific Heat Capacity | *Joules per Kilogram degree Celsius (J/Kg°C)* |
| Temperature change | *Degrees Celsius ( °C)* |
| Work done | *Joules (J)* |
| Force | *Newton (N)* |
| Distance moved | *Metre (m)* |
| Power | *Watts (W)* |
| Time | *Seconds (s)* |

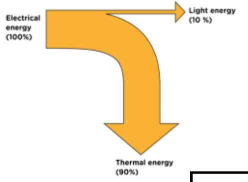
Change in thermal energy = mass **X** specific heat capacity **X** temperature change

$\Delta E = m \; X \; c \; X \; \Delta\theta$

| | | |
|---|---|---|
| Specific Heat Capacity | *Energy needed to raise 1kg of substance by 1°C* | Depends on: mass of substance, what the substance is and energy put into the system. |



| | |
|---|---|
| Closed system | *No change in total energy in system* |
| Open system | *Energy can dissipate* |



| | |
|---|---|
| Useful energy | *Energy transferred and used* |
| Wasted energy | *Dissipated energy, stored less usefully* |

| Prefix | *Multiple* | Standard form |
|---|---|---|
| Kilo | *1000* | $10^3$ |
| Mega | *1000 000* | $10^6$ |
| Giga | *100 000 000* | $10^9$ |

## Energy Conservation and Dissipation

**HIGHER:** efficiency can be increased using machines.

Efficiency = $\frac{\text{Useful power output}}{\text{Total power input}}$

Efficiency = $\frac{\text{Useful output energy transfer}}{\text{Total input energy transfer}}$

| | | |
|---|---|---|
| Efficiency | *How much energy is usefully transferred* | |
| Dissipate | *To scatter in all directions or to use wastefully* | When energy is 'wasted', it dissipates into the surroundings as internal (thermal) energy. |

| | | |
|---|---|---|
| Ways to reduce 'wasted' energy | *Energy transferred usefully* | Insulation, streamline design, lubrication of moving parts. |
| Principle of conservation of energy | *The amount of energy always stays the same.* | Energy cannot be created or destroyed, only changed from one store to another. |

| | Units |
|---|---|
| Energy (KE, EPE, GPE, thermal) | *Joules (J)* |
| Velocity | *Metres per second (m/s)* |
| Spring constant | *Newton per metre (N/m)* |
| Extension | *Metres (m)* |
| Mass | *Kilogram (Kg)* |
| Gravitational field strength | *Newton per kilogram (N/Kg)* |
| Height | *Metres (m)* |

**HIGHER:** When an object is moved, energy is transferred by doing work.

Work done = Force X distance moved

Frictional forces cause energy to be transferred as thermal energy. This is wasted.

Reducing friction - using wheels, applying lubrication. Reducing air resistance – travelling slowly, streamlining.

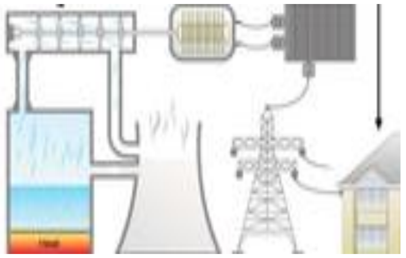
# AQA ENERGY – part 2

## Global Energy Resources

## National Grid

**Power station – NB: You need to understand the principle behind generating electricity. An energy resource is burnt to make steam to drive a turbine which drives the generator.**

|  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|
| Power station | ***Generates electricity*** | Fuel burnt releasing thermal energy | Water boils into steam | Steam turns turbine | Turbine turns generator | Generator induces voltage |
| National Grid | ***Transports electricity across UK*** | Power station | Step-up transformer | Pylons | Step-down transformer | House, factory |



## Using fuels

|  |  |  |
|---|---|---|
| Transport | ***Petrol, diesel, kerosene produced from oil*** | Used in cars, trains and planes. |
| Heating | ***Gas and electricity*** | Used in buildings. |
| Electricity | ***Most generated by fossil fuels*** | Used to power most devices. |

Using renewable energy will need to increase to meet demand.

Renewable energy makes up about 20% of energy consumption.

Fossil fuel reserves are running out.

Energy demand is increasing as population increases.

## Energy resources

|  |  |  |
|---|---|---|
| Non-renewable energy resource | ***These will run out. It is a finite reserve. It cannot be replenished.*** | e.g. Fossil fuels (coal, oil and gas) and nuclear fuels. |
| Renewable energy resource | ***These will never run out. It is an infinite reserve. It can be replenished.*** | e.g. Solar, Tides, Waves, Wind, Geothermal, Biomass, Hydroelectric |

| Energy resource | ***How it works*** | Uses | Positive | Negative |
|---|---|---|---|---|
| Fossil Fuels (coal, oil and gas) | ***Burnt to release thermal energy used to turn water into steam to turn turbines*** | Generating electricity, heating and transport | Provides most of the UK energy. Large reserves. Cheap to extract. Used in transport, heating and making electricity. Easy to transport. | Non-renewable. Burning coal and oil releases sulfur dioxide. When mixed with rain makes acid rain. Acid rain damages building and kills plants. Burning fossil fuels releases carbon dioxide which contributes to global warming. Serious environmental damage if oil spilt. |
| Nuclear | ***Nuclear fission process*** | Generating electricity | No greenhouse gases produced. Lots of energy produced from small amounts of fuel. | Non-renewable. Dangers of radioactive materials being released into air or water. Nuclear sites need high levels of security. Start up costs and decommission costs very expensive. Toxic waste needs careful storing. |
| Biofuel | ***Plant matter burnt to release thermal energy*** | Transport and generating electricity | Renewable. As plants grow, they remove carbon dioxide. They are ‘carbon neutral’. | Large areas of land needed to grow fuel crops. Habitats destroyed and food not grown. Emits carbon dioxide when burnt thus adding to greenhouse gases and global warming. |
| Tides | ***Every day tides rise and fall, so generation of electricity can be predicted*** | Generating electricity | Renewable. Predictable due to consistency of tides. No greenhouse gases produced. | Expensive to set up. A dam like structure is built across an estuary, altering habitats and causing problems for ships and boats. |
| Waves | ***Up and down motion turns turbines*** | Generating electricity | Renewable. No waste products. | Can be unreliable depends on wave output as large waves can stop the pistons working. |
| Hydroelectric | ***Falling water spins a turbine*** | Generating electricity | Renewable. No waste products. | Habitats destroyed when dam is built. |
| Wind | ***Movement causes turbine to spin which turns a generator*** | Generating electricity | Renewable. No waste products. | Unreliable – wind varies. Visual and noise pollution. Dangerous to migrating birds. |
| Solar | ***Directly heats objects in solar panels or sunlight captured in photovoltaic cells*** | Generating electricity and some heating | Renewable. No waste products. | Making and installing solar panels expensive. Unreliable due to light intensity. |
| Geothermal | ***Hot rocks under the ground heats water to produce steam to turn turbine*** | Generating electricity and heating | Renewable. Clean. No greenhouse gases produced. | Limited to a small number of countries. Geothermal power stations can cause earthquake tremors. |

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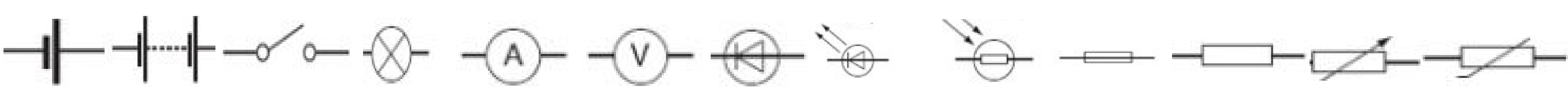
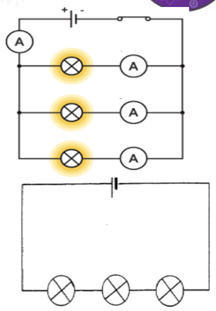


Electrons carry current. Electrons are free to move in metal.

| Cell | Battery | Switch | Lamp | Ammeter | Volt meter | Diode | LED | LDR | Fuse | Resistor | Variable resistor | Thermistor |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Store of chemical energy* | *Two or more cells in series* | *Breaks circuit, turning current off* | *Lights when current flows* | *Measures current* | *Measures potential difference* | *Current flows one way* | *Emits light when current flows* | *Resistance low in bright light* | *Melts when current is too high* | *Affects the size of current flowing* | *Allows current to be varied* | *Resistance low at high temp* |



# AQA Electricity

## Circuit symbols

## Current, potential difference and resistance

### Current and Charge

| | | |
|---|---|---|
| Current | *Flow of electrical charge* | Ampere (A) |
| Potential difference (p.d.) | *How much electrical work is done by a cell* | Volts (V) |
| Charge | *Amount of electricity travelling in a circuit* | Coulombs (C) |

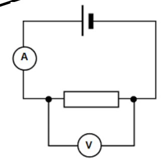
Charge = Current X time

Q = I X t

### Controlling current

| | |
|---|---|
| Changing current | *Change the p.d. of the cells* |
| | *Add more components* |

| | |
|---|---|
| Ammeter | *Set up in series with components* |
| Voltmeter | *Set up parallel to components* |



R = V ÷ I

Resistance = Potential difference ÷ Current

| | |
|---|---|
| Resistance (Ω) | *A measurement of how much current flow is reduced* |

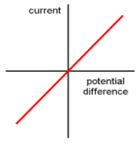
The higher the resistance, the more difficult it is for current to flow.

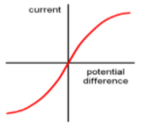
Increasing resistance, reduces current.

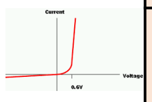
Increasing voltage, increases current.

| Thermistor | LDR |
|---|---|
| *Resistance varies with temperature* | *Resistance varies with light intensity* |
| Resistance decreases as temperature increases. | Resistance decreases as light increases. |

### Current – Potential difference graphs







| | |
|---|---|
| Ohmic conductor | *At a constant temperature, current is directly proportional to the p.d. across the resistor.* |
| Filament lamp | *As current increases, the resistance increases. The temperature increases as current flows.* |
| Diode | *Current flows when p.d. flows forward. Very high resistance in reverse.* |

## Series and parallel circuits

| | | | |
|---|---|---|---|
| Series circuit | Current is the same in all components. | Total p.d. from battery is shared between all the components. | Total resistance is the sum of each component's resistance. |
| Parallel circuit | Total current is the sum of each component's current. | p.d. across all components is the same. | Total resistance is less than the smallest resistance value of the smallest individual resistor. |

| Series | Parallel |
|---|---|
| *A circuit with one loop* | *A circuit with two or more loops* |

| | |
|---|---|
| Total p.d | *If cells are joined in series, add up individual cell values* |

## Energy transfers

Work is done when charge flowing.

Power (W) = potential difference X current

R = V X I

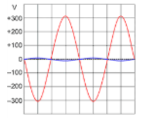
Power = $(\text{current})^2$ X resistance

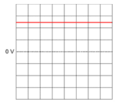
$P = I^2 X R$

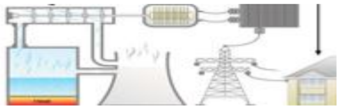
Energy transferred = Power X time

E = P X t

## Domestic uses and safety







| | |
|---|---|
| National Grid | *Distributes electricity generated in power stations around UK* |

| Step-up transformers | Step-down transformers |
|---|---|
| *Increase voltage, decrease current* | *Decrease voltage, increase current* |
| Increases efficiency, reduces heat loss. | Makes safer for houses. |

| Alternating current | Direct current |
|---|---|
| *p.d. switches direction many times a second, current switches direction* | *p.d. remains in one direction, current flows the same direction* |
| Generator. | Cell or battery. |

'Earthing' a safety device; Earth wire joins the metal case.

| Mains supply |
|---|
| *Frequency 50Hz, 230V* |

| 3 pin plug | | |
|---|---|---|
| *Live - Brown* | Carries p.d from mains supply. | p.d between live and earth = 230V |
| *Neutral - Blue* | Completes the circuit. | p.d. = OV |
| *Earth – Green and Yellow stripes* | Only carries current if there is a fault. | p.d. = 0V |

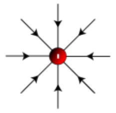
## Static electricity

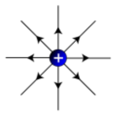
**PHYSICS only**

| | | |
|---|---|---|
| Static electricity | *Electrical charge is stationary* | When two insulating material are rubbed together, electrons move from one material to the other. |

| | |
|---|---|
| Like charges | *Repel* |
| Unlike charges | *Attract* |

| | |
|---|---|
| Shocks | Walking on carpet causes friction. Electrons move to the person and charge builds up. When the person touches a metal object, the electrons conduct away, making a spark. |

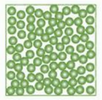




| | |
|---|---|
| Electric fields | Charged objects create electric fields around them. Strongest closest to the object. The field direction is the direction of force on a positive charge. Add more charge increases field strength. |

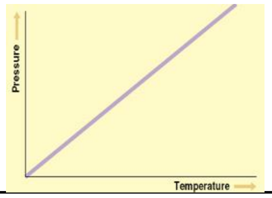
# AQA PARTICLE MODEL OF MATTER

## Particle model



| State | *Particle arrangement* | Properties |
|---|---|---|
| Solid | *Packed in a regular structure. Strong forces hold in place so cannot move.* | Difficult to change shape. |
| Liquid | *Close together, forces keep contact but can move about.* | Can change shape but difficult to compress. |
| Gas | *Separated by large distances. Weak forces so constantly randomly moving.* | Can expand to fill a space, easy to compress. |

### Kinetic theory of gases



- Pressure of a fixed volume of gas increases as temperature increases (temperature increases, speed increases, collisions occur more frequently and with more force so pressure increases).
- Temperature of gas is linked to the average kinetic energy of the particles.
- If kinetic energy increases so does the temperature of gas.
- No kinetic energy is lost when gas particles collide with each other or the container.
- Gas particles are in a constant state of random motion.

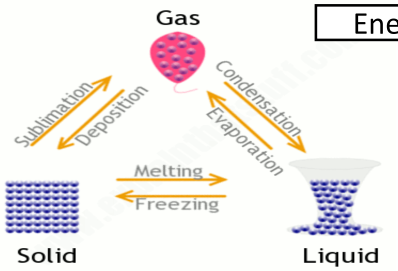
$P = m \div V$

Density = mass ÷ volume.

| Density | *Mass of a substance in a given volume* |
|---|---|

## Change of state

| | |
|---|---|
| Freezing | Liquid turns to a solid. Internal energy decreases. |
| Melting | Solid turns to a liquid. Internal energy increases. |
| Boiling / Evaporating | Liquid turns to a gas. Internal energy increases. |
| Condensation | Gas turns to a liquid. Internal energy decreases. |
| Sublimation | Solid turns directly into a gas. Internal energy increases. |
| Conservation of mass | When substances change state, mass is conserved. |
| Physical change | No new substance is made, process can be reversed. |



## Pressure

| **PHYSICS ONLY:** when you do work the temperature increases e.g. pump air quickly into a ball, the air gets hot because as the piston in the pump moves the particles bounce off increasing kinetic energy, which causes a temperature rise. | Reducing the volume of a fixed mass of gas increases the pressure. |
|---|---|
| | Halving the volume doubles the pressure. |

PV = constant.

$P_1V_1 = P_2V_2$

## Internal energy and energy transfers

| Specific Heat Capacity | *Energy needed to raise 1kg of substance by 1°C* | Depends on:<br>• Mass of substance<br>• What the substance is<br>• Energy put into the system. |
|---|---|---|

Change in thermal energy = mass **X** specific heat capacity **X** temperature change.

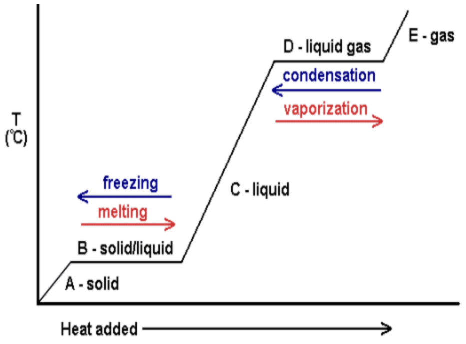
$\Delta E = m \textbf{ X } c \textbf{ X } \Delta\theta$

| Internal energy | | |
|---|---|---|
| | *Energy stored inside a system by particles* | Internal energy is the total kinetic and potential energy of all the particles (atoms and molecules) in a system. |
| | *Heating changes the energy stored within a system* | Heating causes a change in state. As particles separate, potential energy stored increases. Heating increases the temperature of a system. Particles move faster so kinetic energy of particles increases. |

| | |
|---|---|
| Specific Latent Heat | *Energy needed to change 1kg of a substance's state* |
| Specific Latent Heat of Fusion | *Energy needed to change 1kg of solid into 1 kg of liquid at the same temperature* |
| Specific Latent Heat of Vaporisation | *Energy needed to change 1kg of liquid into 1 kg of gas at the same temperature* |

Energy needed = mass **X** specific latent heat.

$\Delta E = m \text{ X } L$



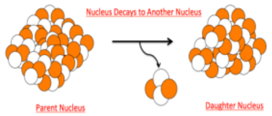
| | *Units* |
|---|---|
| Density | *Kilograms per metre cubed (kg/m³)* |
| Mass | *Kilograms (kg)* |
| Volume | *Metres cubed (m³)* |
| Energy needed | *Joules (J)* |
| Specific latent heat | *Joule per kilogram (J/kg)* |
| Change in thermal energy | *Joules (J)* |
| Specific heat capacity | *Joule per kilogram degrees Celsius (J/kg°C)* |
| Temperature change | *Degrees Celsius ( °C)* |
| Pressure | *Pascals (Pa)* |

# AQA ATOMIC STRUCTURE

Radius of an atom
1 X $10^{-10}$m

*Electrons gained* – Negative ion

*Electrons lost* – Positive ion

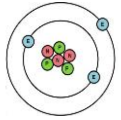
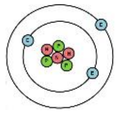


## Atom structure

| | |
|---|---|
| Atom | *Same number of protons and electrons* |
| Ion | *Unequal number of electrons to protons* |
| Mass number | *Number of protons and neutrons* |
| Atomic number | *Number of protons* |

| Particle | *Charge* | *Size* | *Found* |
|---|---|---|---|
| Neutron | *None* | *1* | *In the nucleus* |
| Proton | *+* | *1* | |
| Electron | *-* | *Tiny* | *Orbits the nucleus* |

## Atoms and Isotopes

| Isotope | $^6_3Li$ |  | $^7_3Li$ |  |
|---|---|---|---|---|

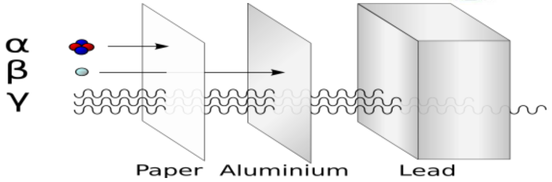
*Different forms of an element with the same number of protons but different number of neutrons*

## Discovery of the nucleus

| | |
|---|---|
| Democritus | Suggested idea of atoms as small spheres that cannot be cut. |
| J J Thomson (1897) | Discovered electrons– emitted from surface of hot metal. Showed electrons are negatively charged and that they are much less massive than atoms. |
| Thomson (1904) | Proposed *'plum pudding'* model – atoms are a ball of positive charge with negative electrons embedded in it. |
| Geiger and Marsden (1909) | Directed beam of alpha particles ($He^{2+}$)at a thin sheet of gold foil. Found some travelled through, some were deflected, some bounced back. |
| Rutherford (1911) | Used above evidence to suggest alpha particles deflected due to electrostatic interaction between the very small charged nucleus, nucleus was massive. Proposed mass and positive charge contained in nucleus while electrons found outside the nucleus which cancel the positive charge exactly. |
| Bohr (1913) | Suggested modern model of atom – electrons in circular orbits around nucleus, electrons can change orbits by emitting or absorbing electromagnetic radiation. His research led to the idea of some particles within the nucleus having positive charge; these were named protons. |
| Chadwick (1932) | Discovered neutrons in nucleus – enabling other scientists to account for mass of atom. |

## Atoms and Nuclear Radiation

| Decay | *Range in air* | *Ionising power* | *Penetration power* |
|---|---|---|---|
| Alpha | Few cm | Very strong | Stopped by paper |
| Beta | Few m | Medium | Stopped by Aluminium |
| Gamma | Great distances | Weak | Stopped by thick lead |



| | |
|---|---|
| Radioactive decay | *Unstable atoms randomly emit radiation to become stable* |
| Detecting | *Use Geiger Muller tube* |
| Unit | *Becquerel* |
| Ionisation | *All radiation ionises* |

| Decay | *Emitted from nucleus* | *Changes in mass number and atomic number* | |
|---|---|---|---|
| Alpha (α) | *Helium nuclei ($^4_2He$)* | *-4* | *-2* |
| Beta (β) | *Electron ($^0_{-1}e$)* | *0* | *+1* |
| Gamma (γ) | *Electromagnetic wave* | *0* | *0* |
| Neutron | *Neutron* | *-1* | *0* |

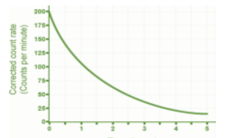
$$^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^4_2He$$

$$^{14}_6C \rightarrow {}^{14}_7N + {}^0_{-1}e$$

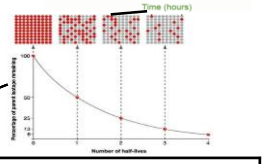
$$^{99}_{43}Tc \rightarrow {}^{99}_{43}Tc + \gamma$$

## PHYSICS ONLY: Hazards and uses of Radioactive emissions and of background radiation

| | |
|---|---|
| Contamination | *Unwanted presence of radioactive atoms* |
| Irradiation | *Person is in exposed to radioactive source* |



| | |
|---|---|
| Half life | *The time taken to lose half of its initial radioactivity* |



| | |
|---|---|
| Sievert | *Unit measuring dose of radiation* |
| Background | *Constant low level environmental radiation, e.g. from nuclear testing, nuclear power, waste* |

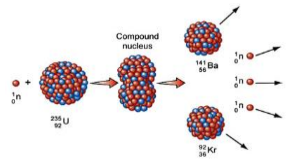
| | | |
|---|---|---|
| Uses | *Different isotopes have different half lives* | Short half-lives used in high doses, long half lives used in low doses. |
| Tracers | *Used within body* | Isotope with short half life injected, allowed to circulate and collect in damaged areas. PET scanner used to detect emitting radiation. Must be beta or gamma as alpha does not penetrate the body. |
| Radiation therapy | *Used to treat illnesses e.g. cancer* | Cancer cells killed by gamma rays. High dose used to kill cells. Damage to healthy cells prevented by focussed gamma ray gun. |

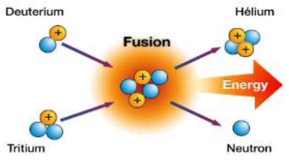
## Nuclear fission and fusion

| | |
|---|---|
| Fuel rods | Made of U-238, 'enriched' with U-235 (3%). Long and thin to allow neutrons to escape, hitting nuclei. |
| Control rods | Made of Boron. Controls the rate of reaction. Boron absorbs excess neutrons. |
| Concrete | Neutrons hazardous to humans – thick concreate shield protects workers. |

## PHYSICS ONLY: Nuclear energy

| | | | |
|---|---|---|---|
| Nuclear fission | *One large unstable nucleus splits to make two smaller nuclei* | Neutron hits U-235 nucleus, nucleus absorbs neutron, splits emitting two or three neutrons and two smaller nuclei. Process also releases energy. | Process repeats, chain reaction formed<br>Used in nuclear power stations |
| Nuclear fusion | *Two small nuclei join to make one larger nucleus* | Difficult to do on Earth – huge amounts of pressure and temperature needed. | Occurs in stars |





# AQA FORCES – part 1

## Forces and their interactions

Each Kg has a gravitational pull of 9.8N.

| | | |
|---|---|---|
| Gravitational field strength | *Gravity exerted around an object.* | Earth's gfs = 9.8N/kg |

Weight = mass X gravitational field strength

W = m X g

### Gravity

| | | |
|---|---|---|
| Weight | *Force acting upon an object due to gravity* | Newton (N) |
| Mass | *How much matter* | Kilograms (Kg) |

| | | |
|---|---|---|
| Unit | *Newton (N)* | 1N |
| Kilo | *Kilonewton (KN) = 1000* | 1X $10^3$ |
| Mega | *Meganewton (MN) = 1000,000* | 1 X $10^6$ |

| | |
|---|---|
| Centre of mass | *The weight of an object acts through a single point* |

## Scalar and vector quantities

| | | |
|---|---|---|
| Scalar | *A quantity that only has magnitude (size)* | e.g. mass, time, speed, temperature, energy, |
| Vector | *A quantity that only has magnitude and direction* | e.g. force, velocity, momentum |

| | |
|---|---|
| An arrow can be used to show vectors | *Length of arrow = magnitude of vector* |
| | *Direction of arrow = direction of vector* |

| | | |
|---|---|---|
| Velocity | *Speed + direction* | The speed of a car is 30m/s. A car moves forward with a velocity of 30m/s |
| Distance | *How far* | The table is 1m long |
| Displacement | *Distance + direction* | The beach is 1km due east of the town |

| | |
|---|---|
| Area | *Metres squares ($m^2$)* |
| Weight | *Newton (N)* |
| Mass | *Kilograms (kg)* |
| Gravitational field strength | *Newton per kilogram (N/Kg)* |
| Force | *Newton (N)* |
| Work done | *Joules (J)* |
| Distance | *Metres (m)* |
| Moment | *Newton-metres (Nm)* |

## Contact and Resultant forces

| | | |
|---|---|---|
| Force | *Push or pull* | Stretch, squash, turn. |
| Contact force | *Exerted between two objects when they touch* | Friction, air resistance, tension. |
| Non-contact force | *Exerted between two objects without touching* | Gravity, electrostatic forces, magnetic forces. |

| | | |
|---|---|---|
| Resultant force | *The overall effect of all of the forces acting upon an object* | Two forces acting in the same direction are added. |
| | | Two forces acting in the opposite direction are taken away. |

| | | |
|---|---|---|
| Resolving forces | *An object pulled with a force at an angle* | A single force can be split into two components acting at right angles to each other. |

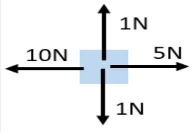
The component forces combined have the same effect.

### HIGHER ONLY

Work done against frictional forces, temperature of object rises.

| | |
|---|---|
| Free body diagram | *Show magnitude and direction of all forces upon an object* |

Object moves left with a force of 5N



If force is at right angles to direction of movement, NO work is done.

## Work done and energy transfer

| | | |
|---|---|---|
| Work done | *When work is done, energy is transferred* | Work done = force X distance moved<br>W = F X s |
| | 1J of work is done when 1N of force moves an object through a distance of 1m, in the direction of the force. | |

## Moments, levers and gears

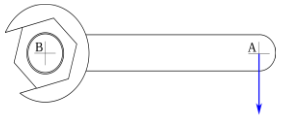
### PHYSICS ONLY

M = F X d

Moment = force X distance

| | |
|---|---|
| Moment | *Turning effect of a force about a pivot* |
| Lever | *A small force exerted with a long lever applies a large force* |

| |
|---|
| Principle of moments |
| *In a balanced system, the sum of the clockwise moments = the sum of the anti-clockwise moments* |



| | |
|---|---|
| Gears | *Increase or decrease the rotational effect of a force* |

## Forces and elasticity

| | |
|---|---|
| One force | *The object changes speed or direction* |
| More than one force | *The object changes shape* |

Two balanced forces can stretch a object.

Two balanced forces can compress an object.

Three balanced forces can bend an object.

| | |
|---|---|
| Elastic deformation | *The object has been stretched but returns to its original length* |
| Inelastic deformation | *The object has been stretched but does not return to its original length* |
| Extension | *The difference between stretched and unstretched lengths* |

| |
|---|
| Limit of proportionality |
| *Beyond this point the spring is permanently deformed* |

| | |
|---|---|
| Stretching a spring | Force = spring constant X extension, F = k X e |
| | EPE = ½ X spring constant X $(\text{extension})^2$, EPE = ½ $ke^2$ |

| | |
|---|---|
| Elastic Potential energy (EPE) | *Energy stored in a stretched spring* |

| | |
|---|---|
| Force | *Newton (N)* |
| Spring constant | *Newton per metre (N/m)* |
| Extension | *Metres (m)* |
| EPE | *Joules (J)* |

## Pressure

### HIGHER ONLY

Pressure = Force ÷ Area

P = F ÷ A

| |
|---|
| Pressure and depth |
| *Pressure on divers depends on weight of water above* |

Pressure = height X density X gfs

| |
|---|
| Upthrust |
| *Resultant force exerted by a fluid* |

| | |
|---|---|
| Fluid | *A liquid or gas* |
| Flows and changes shape to fill a container. | |

| | |
|---|---|
| Hydraulic machine | *Use liquids to transmit pressure* |

| |
|---|
| Atmospheric pressure |
| *Caused by billions of air particles colliding with a surface.* |

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# AQA FORCES – part 2

# Observing and recording motion

## Describing motion

|  |  |
|---|---|
| Aeroplane banks to change direction | Velocity changes. |
| Car travelling around a bend | Constant speed, direction changes. |
| Satellite orbiting the Earth | Constant speed, direction changes. |

| | |
|---|---|
| Changing velocity | ***Objects in a circular motion, change direction but keep a constant speed*** |

**HIGHER ONLY**

| | | |
|---|---|---|
| Velocity | ***The speed of an object with direction*** | Vector |

Speed of sound 330m/s.

Speed = distance ÷ time

v = s ÷ t

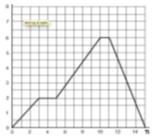
| | | |
|---|---|---|
| Speed | ***How fast an object moves*** | Scalar |
| Displacement | ***Includes the distance and direction an object moves*** | vector |
| Distance | ***How far an object moves*** | scalar |

| | |
|---|---|
| Car on motorway | ***30m/s*** |
| Train | ***60m/s*** |
| Jet plane | ***200m/s*** |

| | |
|---|---|
| Walking | ***1.5m/s*** |
| Running | ***3m/s*** |
| Cycling | ***6m/s*** |

Speed is rarely constant.

| | |
|---|---|
| Distance-time graph | ***Shows how far an object moves along a straight line*** |
| Speed of object | ***Use the gradient of graph*** |



Gradient = vertical ÷ horizontal

| | | |
|---|---|---|
| Accelerating objects | ***It takes time for objects to reach top speed*** | Draw a tangent to the curve, work out gradient. |

**HIGHER ONLY**

| | |
|---|---|
| Distance travelled | ***Area under the graph shape*** |

**HIGHER ONLY**

| | |
|---|---|
| Velocity-time graph | ***Shows speed of an object*** |
| Accelerating | ***Object getting faster*** |
| Decelerating | ***Object slowing down*** |

Acceleration = change in velocity ÷ time taken

| | | |
|---|---|---|
| Acceleration | ***Change in velocity*** | Vector |

Constant acceleration

(final velocity) $^2$ – (initial velocity) $^2$ = 2 X acceleration X distance

$V^2 – u^2 = 2 X a X s$

**Falling objects**

| | | |
|---|---|---|
| Falling objects accelerate due to gravity. | In no air resistance, objects accelerate at 9.8m/s$^2$ | Air resistance slows falling objects down. |

| | | |
|---|---|---|
| Terminal velocity | ***Weight of an object is balanced by resistive forces*** | Object moves at a constant velocity. Resultant force = 0. |

**PHYSICS ONLY**

| | |
|---|---|
| Parachuting | ***Size of air resistance depends on area of object and speed*** |

Larger the area, the larger the air resistance.

Larger the speed, the larger the air resistance.

## Forces, acceleration and Newton's Laws of motion

| | |
|---|---|
| Inertia | ***When objects continue in the same state of motion*** |

**HIGHER ONLY**

Speed or direction only changes if a resultant force acts on the object

| | | |
|---|---|---|
| Newton's first Law | ***Balanced forces*** | When the resultant force on an still object = 0, the object is stationary.<br>When the resultant force on a moving object = 0, the object is at a constant speed. |
| Newton's second Law | ***Unbalanced forces*** | When the resultant force is greater than 0, the object accelerates. It could speed up, slow down or change direction. |
| Newton's third Law | ***Equal and opposite forces*** | When two objects interact the forces exerted are equal and in an opposite direction. |

Acceleration is proportional to resultant force.

Acceleration is inversely proportional to mass.

Force = mass X acceleration

F = m X a

**HIGHER ONLY**

| | |
|---|---|
| Inertial mass | ***How difficult it is to change the velocity of an object*** |

Inertial mass = force ÷ acceleration

If the mass is large, to change velocity a big force is needed.

## Forces and braking

Frictional forces decelerate a moving object and bring it to rest.

Speed affects both thinking and braking distances.

Typical reaction time = 0.7s

| | |
|---|---|
| Thinking distance | ***Distance travelled whilst the driver reacts*** |
| Braking distance | ***Distance travelled whilst the car is stopped by the brakes*** |
| Stopping distance | ***Total thinking and braking distances*** |

| | | |
|---|---|---|
| Factors affecting stopping distances | ***Drivers reaction times*** | Drinking alcohol, taking drugs, tired. |
| | ***Braking distances*** | Weather conditions, worn brakes or tyres, road surface, size of braking force. |
| Braking and kinetic energy | ***Work done by braking force, reduces kinetic energy*** | Kinetic energy decreases, temperature of brakes increases due to frictional forces. |

## Momentum

Is a vector

**HIGHER ONLY**

p = m X v

Momentum = mass X velocity

**HIGHER ONLY**

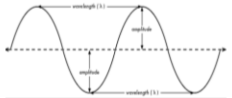
| |
|---|
| Conservation of momentum |
| ***When two objects collide, the momentum they have before the collision = the momentum they have after the collision*** |
| Closed system = no external forces acting on it. |

| | |
|---|---|
| Crumple zones | Changes in momentum |
| | ***Force is applied to stop momentum*** |
| | If momentum changes slowly, the force applied is small so less damage. |

**PHYSICS HIGHER ONLY**

| | |
|---|---|
| Speed / velocity | ***Metres per second (m/s)*** |
| Distance | ***Metres (m)*** |
| Time | ***Seconds (s)*** |
| Acceleration | ***Metres per second squared (m/s$^2$)*** |
| Force | ***Newton (N)*** |
| Mass | ***Kilogram (Kg)*** |
| Momentum | ***Kilograms metres per second (Kgm/s)*** |

# AQA Waves



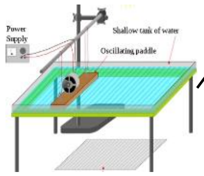
| | | |
|---|---|---|
| Wave speed | Wave speed = frequency X wavelength | V = f X λ |
| Wave period | Wave period = 1 ÷ frequency | T = 1 ÷ f |
| Speed | Speed = distance ÷ time | v = d ÷ t |

| | |
|---|---|
| Wavelength | *Distance from one point on a wave to the same point of the next wave* |
| Amplitude | *The maximum disturbance from its rest position* |
| Frequency | *Number of waves per second* |
| Period | *Time taken to produce 1 complete wave* |

## Waves in air, fluids and solids

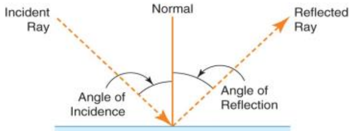
**Properties**

Measuring speed



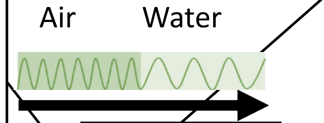
In water, use a ripple tank.

In air, use echoes.



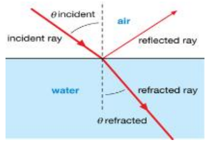
Angle of incidence = angle of reflection (i) = (r)

Sound waves travelling through different mediums, the frequency stay constant.



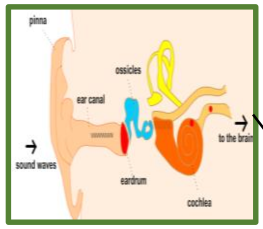
**PHYSICS ONLY**

| | |
|---|---|
| Reflection | Wave bounces off the surface. |
| Refraction | Waves changes direction at boundary. |
| Transmitted | Passes through the object. |
| Absorbed | Passes into but not out of, transfers energy and heats up the object. |



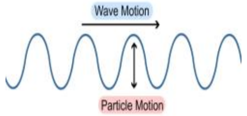
Light refracts as it slows down in a denser substance

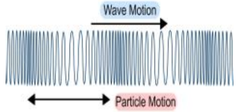
**PHYSICS HIGHER ONLY**



| | | |
|---|---|---|
| Hearing | *Frequencies between 20 – 20,000 Hz* | Longitudinal waves cause ear drum to vibrate, amplified by three ossicles which creates pressure in the cochlea. |

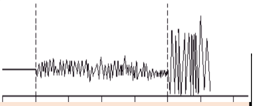
## Transverse and Longitudinal waves



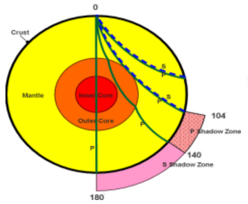


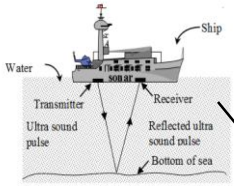
| | | | |
|---|---|---|---|
| Transverse wave | *Vibration causing the wave is at right angles to the direction of energy transfer* | Energy is carried outwards by the wave. | Water and light waves, S waves. |
| Longitudinal wave | *Vibration causing the wave is parallel to the direction of energy transfer* | Energy is carried along the wave. | Sound waves, P waves. |

## Seismic waves



| P wave | S wave | Seismograph |
|---|---|---|
| *Longitudinal* | *Transverse* | *Shows P and S waves arriving at different times.* |
| *Fast* | *Slow* | |
| *Travel through solids and liquids* | *Travels through solids* | By using the times the waves arrive at the monitoring centres, the epicentre of earthquake can be found. (v = x ÷ t). |
| Produced by earthquakes. | | |

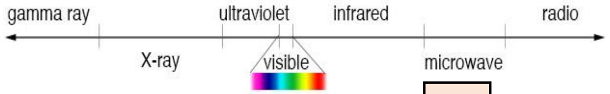




| | | |
|---|---|---|
| Ultra sound | *Partially reflected off boundary* | Used for medical and foetal scans. |
| Sonar | *Reflected off objects* | Used to determine depth of objects under the sea. |

## Electromagnetic waves

| | |
|---|---|
| Electromagnetic wave | *Continuous spectrum of transverse waves* |



e.g. Gamma

Short wavelengths have high frequency and high energy.

Absorbed light changes into thermal energy store.

| | |
|---|---|
| Black surfaces | *Good emitters, good absorbers* |
| White surfaces | *Poor emitters, poor absorbers* |
| Shiny surfaces | *Good reflectors* |

EM waves refract

| EM wave | Danger | Use |
|---|---|---|
| Radio | Safe. | Communications, TV, radio. |
| Microwave | Burning if concentrated. | Mobile phones, cooking, satellites. |
| Infrared | | Heating, remote controls, cooking. |
| Visible | Damage to eyes. | Illumination, photography, fibre optics. |
| Ultra violet | Sunburn, cancer. | Security marking, disinfecting water. |
| X-ray | Cell destruction, mutation, cancer. | Broken bones, airport security. |
| Gamma | | Sterilising, detecting and killing cancer. |

Low frequency, long wavelength.

| | |
|---|---|
| White | Wave lengths reflected |
| Black | Wave lengths absorbed |

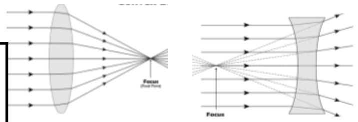
High frequency, short wavelength

## HIGHER: Properties

**PHYSICS ONLY**

Magnification = image size ÷ object size

**HIGHER: Lenses**



| | |
|---|---|
| Convex | Real or virtual images. |
| Concave | Only virtual images. |

| | |
|---|---|
| 2F | Image same size, upside down, real. |
| 2F - F | Image larger, upside down, real. |
| < F | Image bigger, right way, virtual. |

| | |
|---|---|
| Specular | Flat surface reflection. |
| Diffuse | Rough surface reflection. |

## Black body radiation

**PHYSICS ONLY**

### Earth and Global warming

Ultraviolet, visible light, infra-red radiation penetrate atmosphere and heat up Earth's surface.

Longer wavelengths are radiated back, trapped by atmosphere.

Energy lost is not at the same rate as energy being absorbed so Earth heats up.

| | | |
|---|---|---|
| Black body radiation | *All objects absorb or reflect infrared radiation* | Hotter objects emit more infrared radiation. |
| Constant temperature | *Rate of absorption = rate of radiation* | Intensity and wavelength of energy affects temperature. |

| | Units |
|---|---|
| Distance | *Metres (m)* |
| Wave speed | *Metres per second (m/s)* |
| Wavelength | *Metres (m)* |
| Frequency | *Hertz (Hz)* |
| Period | *Seconds (s)* |

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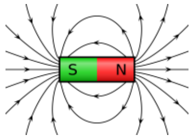
# AQA MAGNETISM AND ELECTROMAGNETISM

## Permanent and Induced Magnetism



### Magnets

| | | |
|---|---|---|
| Magnetic | *Materials attracted by magnets* | Uses non-contact force to attract magnetic materials. |
| North seeking pole | *End of magnet pointing north* | Compass needle is a bar magnet and points north. |
| South seeking pole | *End of magnet pointing south* | Like poles (N – N) repel, unlike poles (N – S) attract. |
| Magnetic field | *Region of force around magnet* | Strong field, force big. Weak field, force small. Field is strongest at the poles. |
| Permanent | *A magnet that produces its own magnetic field* | Will repel or attract other magnets and magnetic materials. |
| Induced | *A temporary magnet* | Becomes magnet when placed in a magnetic field. |

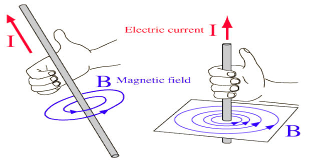
### Magnetic field around a wire

Electric current flowing in a wire produces a magnetic field around it.

- If current is small, magnetic field is very weak.
- Current large enough, iron filings show circular magnetic field.
- Further away from the wire, magnetic field is weaker.
- Reverse current, magnetic field direction reverses.

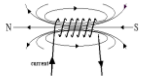
### Right hand rule

| | |
|---|---|
| Thumb | Direction of current. |
| Fingers | Direction of magnetic field. |



### Solenoid

| | |
|---|---|
| Solenoid | *A long coil of wire* | Magnetic field from each loop adds to the next. |



### Electromagnet

| | |
|---|---|
| Electromagnet | *Lots of turns of wire increase the magnetising effect when current flows* |
| | Turn current off, magnetism lost. |

| Increase strength of magnetic field |
|---|
| *Use larger current* |
| *Use more turns of wire* |
| *Put turns of wire closer together* |
| *Use iron core in middle* |

### Relay

| | | |
|---|---|---|
| Relay | *A device using a small current to control a larger current in another circuit* | Solenoid is wound around an iron core. Small current magnetises the solenoid. This attracts to electrical contacts, making a complete circuit. Current flows from battery to starter motor. |

## Motor effect

**HIGHER only**

Magnetic fields from the permanent magnet and current in the foil interact. This is called the motor effect.

- Reverse the current , foil moves upwards.
- Aluminium foil placed between two poles of a strong magnet, will move downwards when current flows through the foil.
- Size of force acting on foil depends on magnetic flux density between poles, size of current, length of foil between poles.

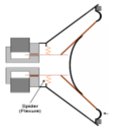
F = B X I X l

Force = magnetic flux density X current X length

If current and magnetic field are parallel to each other , no force on wire.

| | | |
|---|---|---|
| Magnetic flux | *Lines drawn to show magnetic field* | Lots of lines = stronger magnets. |
| Magnetic flux density | *Number of lines of magnetic flux in a given area* | Measures the strength of magnetic force. |

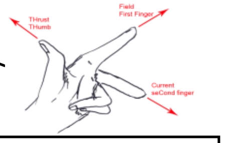
| | | |
|---|---|---|
| Electric motor | *Coil of wire rotates about an axle* | Current flows through the wire causing a downward movement on one side and an upward movement on the other side. |
| Split-ring commutator | *Split ring touching two carbon brush contacts* | |
| Generators | *Coil of wire rotating inside a magnetic field. The end of the coil is connected to slip rings.* | Produces altering current. |
| Loud speakers | *Converts variations in electrical current into sound waves .* | Varying current flows through a coil that is in a magnetic field. A force on the wire moves backwards and forwards as current varies. Coil connected to a diaphragm. Diaphragm movements produce sound waves. |
| Microphones | *Converts pressure variations in sound waves into variations in current in electrical circuits.* | |



### Fleming's left-hand rule

To predict the direction a straight conductor moves in a magnetic field.

| | |
|---|---|
| Thumb | Direction of movement. |
| First finger | Direction of magnetic field. |
| Second finger | Direction of current. |



## Induced potential, transformers and National Grid

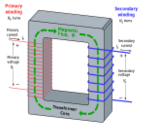
| | |
|---|---|
| National Grid | *Distributes electricity generated in power stations around UK* |

**PHYSICS HIGHER only**

| | |
|---|---|
| Induced potential | *When a conducting wire moves through a magnetic field, p.d. is produced* |
| Generator effect | *Generates electricity by inducing current or p.d.* |
| Uses of the generator effect | *Dynamo, Microphones* |

| | | |
|---|---|---|
| Transformer | *Two coils of wire onto an iron core* | Alternating current supplied to primary coil, making magnetic field change. Iron core becomes magnetised, carries changing magnetic field to secondary coil. This induces p.d. |

| Step-up transformers | Step-down transformers |
|---|---|
| *Increase voltage, decrease current* | *Decrease voltage, increase current* |
| Increases efficiency by reducing amount of heat lost from wires. | Makes safer value of voltage for houses and factories. |



Power lost = Potential difference X Current

Power supplied to primary coil = power supplied to secondary coil

$V_p \times I_p = V_s \times I_s$

Voltage across the coil X number of coils (primary) = Voltage across the coil X number of coils (secondary)

$V_p \div V_s = n_p \div n_s$

| | |
|---|---|
| Force | *Newton (N)* |
| Magnetic flux density | *Tesla (T)* |
| Current | *Amperes (A)* |
| Length | *Metres (m)* |
| Power | *Watts (W)* |
| p.d. | *Voltage (V)* |

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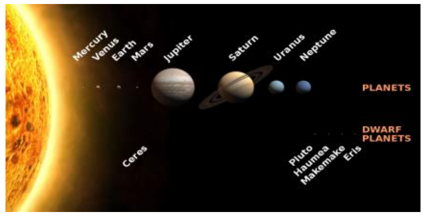
# AQA
# SPACE PHYSICS
# PHYSICS ONLY

## Solar system

Milky Way our galaxy.

| | |
|---|---|
| Planet | *A large body orbiting the Sun* |
| Moon | *A natural satellite orbiting a planet* |
| Dwarf planet | *A body large enough to have its own gravity which caused a spherical shape* |
| Solar system | *Any object orbiting the Sun due to gravity* |
| Galaxy | *Collection of billions of stars* |
| Universe | *Collection of galaxies* |



Other objects.
Comets, asteroids, satellites.

### Effect of gravity.

Gravity causes moons to orbit planets, planets to orbit the Sun, stars to orbit galaxy centres.

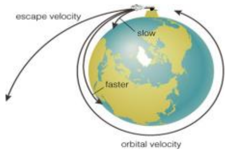
Force of gravity changes the moon's direction not its speed.

Gravity pulls objects towards the ground.

## Orbital motions

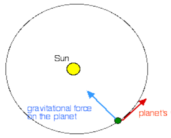
### Speed of Orbit.

Too fast = disappears into Space.
Correct speed = steady orbit around Earth.
Too slow = falls to Earth.



### HIGHER: Circular orbits.

To calculate speed of Orbit: distance object moves in 1 orbit, Distance = 2∏r, then average speed = distance ÷ time.



Planets close to the Sun, gravity pull is strong. Planets move quickly.

Planets further away from the Sun, gravity pull is weaker. So speed of planet is slower.

### HIGHER:

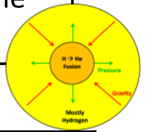
Velocity = a vector.

A planet's velocity changes but speed remains constant.

Due to the Sun's gravity, planets accelerate towards the Sun and so changes direction.

## The life cycle of a star.

| | | |
|---|---|---|
| Nebula | *A cloud of cold hydrogen gas and dust* | Cloud collapses due to gravity, particles move very fast colliding with each other, kinetic energy transfers into internal energy and the temperature increases. |
| Protostar | *The large ball of gas contracts to form a star* | High temperature causes Hydrogen nuclei to collide and nuclear fusion begins. A star is 'born'. |
| Main sequence | *Stable period of star* | Gravity tries to collapse the star but enormous pressure of fusion energy expands and balances the inward force. |



### Stars the same size as our Sun.

| | | |
|---|---|---|
| Red giant | *A large star that fuses Helium into heavier elements* | Hydrogen runs out, star becomes unstable, pressure inside drops causing star to collapse. Atoms now closer together results in atoms fusing and temperature increases. This increase in temperature causes the core to swell. |
| White dwarf | *Star collapses* | Nuclear fuel runs out, fusion stops, dense very hot core. |
| Black dwarf | *Cold dark star* | White dwarf cools down. |

### Stars larger than our Sun.

| | | |
|---|---|---|
| Red super giant | *Star swells greatly* | Nuclear fuel begins to run out and star swells (more matter = bigger size). |
| Supernova | *Gigantic explosion due to run away fusion reactions* | Rapid collapse, heats to very high temperatures causing run away nuclear reactions, star explodes, flinging remnants out into space. Large gravitational forces collapse the core into a tiny space.<br>Remains of supernova form heavier elements (Iron and above) |
| Neutron star | *Very dense star* | Made out of neutrons. |

### OR if collapse is into a really tiny space.

| | | |
|---|---|---|
| Black hole | *No light escapes* | Gravitational forces so strong everything is pulled in. |

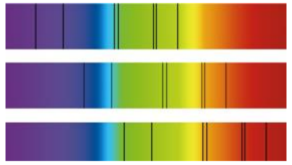
## Red shift

When ambulances go past the sound changes from a high pitch to a low pitch.

Frequency of sound wave decreases, wavelength increases.

### Understanding models.

| | |
|---|---|
| Red-shift | *The observed increase in wavelength of light from most distance galaxies. Light moves towards the red end of the spectrum.* |
| Hubble (1929) | *He studied light from distant galaxies; found as frequency decreases, wavelength increases.* |



Light from star in our galaxy.
Light from star in nearby galaxy.
Light from star in distant galaxy.

Galaxies are moving away from us in all directions.

Light from distant galaxies is red-shifted, so galaxy is moving away from us.

Galaxies further away have bigger red-shift so are moving faster away.

| | |
|---|---|
| The Big Bang | *Universe began 13.8 billion years ago* |
| All matter and space expanded violently from a single point. | Red—shift provides evidence for expansion. |

| | |
|---|---|
| Aristotle (ancient Greek) | *Earth at the centre, other heavenly bodies move around the Earth.* |
| Copernicus (1473 - 1543) | *Sun at the centre, other heavenly bodies move around the Sun.* |
| Galileo (1610) | *Made a telescope, looked at Jupiter, found four moons rotating around planet.* |

Planets and moons moved at different speeds to stars = reason for different positions.