KS3: Genetics

Key Words

Gametes - sex cells. In humans this is the sperm and egg.
Genome - all of the genetic material of an organism.
Gene - small section of DNA on a chromosome. Each gene codes for a particular amino acid, to make a specific protein.
Polymer - very long chain molecule made from small repeating units called monomers.
Protein - a polymer made up of a long chain of amino acids.
Allele - different versions of a gene.
Genotype - the set of alleles of an individual. Their genetic material.
Homozygous dominant - two dominant alleles.
Homozygous recessive - two recessive alleles.
Heterozygous - one recessive and one dominant allele.
Inherited disease - genetic conditions that are passed down from generation to generation.
Polydactyly - a dominant inherited disease that causes a person to have extra finger or toes.
Carrier - a person who has the ability to pass down a characteristic without physically expressing it.
Cystic fibrosis -a recessive inherited disease that results in the production of thick, sticky mucus in different organs.

Sexual and Asexual Reproduction

You should be able to describe the differences and advantages/disadvantages of sexual and asexual reproduction.

Asexual Reproduction:

Involves one parent. The parent divides (using mitosis) to produce offspring that are **exact copies** of the parent.

- Bacteria, Fungi and some Plants use asexual reproduction.

Advantages	Disadvantages
• Population can be increased rapidly when conditions are right. • Can exploit suitable environments quickly. • More time and energy efficient. • Reproduction is completed much faster than sexual reproduction.	• Limited genetic variation in population, offspring are genetically identical to their parents. • Population is vulnerable to changes in conditions and may only be suited for one habitat. • Disease is likely to affect the whole population as there is no genetic variation

Sexual Reproduction:

Involves two parent. The gametes of two parents which fuse together (fertilisation) to form one cell.

- Plants and animals use sexual reproduction.

Advantages	Disadvantages
• Increases genetic variation. • The species can adapt to new environments due to variation, giving them a survival advantage. • Disease is less likely to affect population (due to variation)	• Takes time and energy to find mates. • Difficult for isolated members of the species to reproduce.

Developing Gene Theory

You should be able to name key scientists and their contribution to our understanding of genes and DNA.

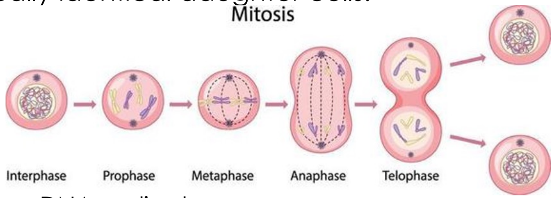
- mid 19th century - Gregor **Mendel** carried out breeding experiments on plants
- early 20th century - Walter **Sutton** observed chromosomes in grasshopper.
- mid 20th century - Rosalind **Franklin** discovered the structure of DNA, and a model was developed by **Watson and Crick.**

Cell Division

You should be able to describe the stages of mitosis, and compare and contrast with meiosis.

Mitosis

Cell division used for growth and repair. It produces two genetically identical daughter cells.



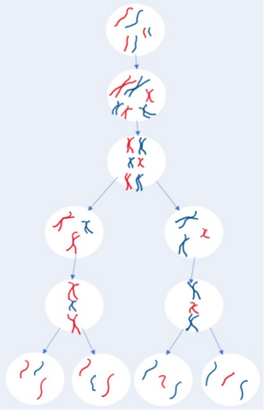
Prophase - DNA replicates.
Metaphase - Pairs of chromosomes (one from each parent) line up down the equator of the cell.
Anaphase - One set of chromosomes are pulled to each end of the cell.
Telophase - Cytoplasm and cell membrane divides to form two cells.

Meiosis

You should be able to describe the general process of meiosis, and compare and contrast with mitosis.

Meiosis

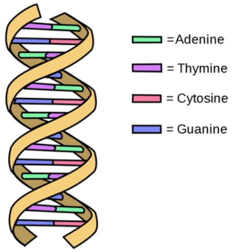
Cell division that produces four gametes (sex cells) that are not genetically identical to each other.



1. Copies of the chromosomes are made. (Remember: cells contain two copies of each chromosome – one from each parent)
2. Chromosomes line up in pairs in the centre of the cell and then get pulled to opposite ends for the **first division.**
3. The cell prepares for a **second division.** Chromosomes line up in the centre of the cell again and are pulled to opposite poles.

DNA

You should be able to describe the structure of DNA.



A and T bind together
G and C bind together

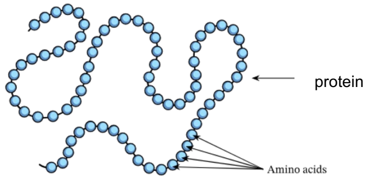
Deoxyribonucleic acid (DNA) is:

- **polymer** (made of many monomers).
- It has a double helix structure.
- There are four nucleotide bases that make up DNA (adenine, thymine, cytosine and guanine)

DNA and Proteins

You should be able to understand how DNA codes for proteins.

Each **gene** has a unique sequence of nucleotide bases which codes for a sequence of **amino acid** in a **protein**.



Proteins are made in ribosomes of cells.

Proteins are needed for growth, replacement and repair of damaged cells.

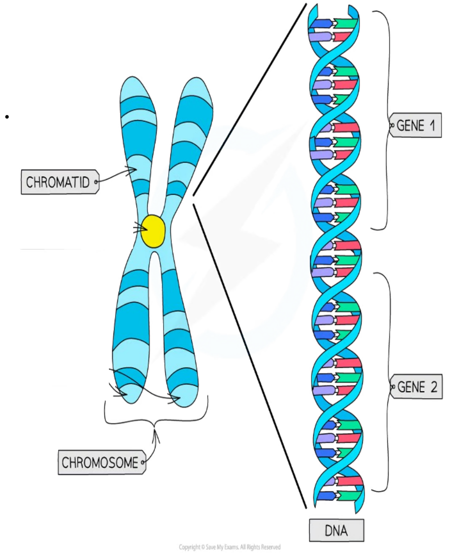
DNA is stored in the nucleus of plant and animal cells.

Whereas, in bacterial cells it is found in the cytoplasm as ‘naked DNA’ because it is not in the nucleus.

KS3: Genetics

Chromosomes, Genes, Alleles

You should be able to define, identify and explain the difference between the three terms.



Every chromosome is formed of two **chromatids**, so there are two copies of each gene in every genome.

One of the chromosomes come from the biological father and the other from the biological mother.

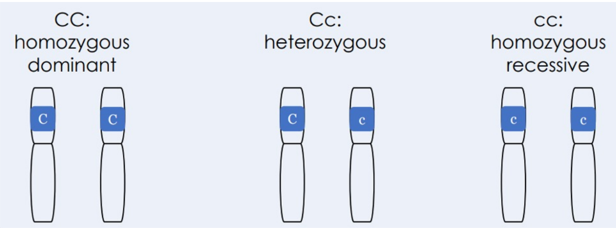
Sometimes an individual inherits two different versions of the gene, sometimes an individual inherits two of the same version. These different versions are called **alleles**.

Alleles can either be **dominant** or **recessive**.

A **dominant** allele is one that will always be expressed. It is represented with a capital letter. For example, F.

A **recessive** allele is one that will only be expressed if the individual has two of the same versions of the gene (two copies of the allele). For example, f.

There are three possible combinations of alleles:



Punnett Squares

You should be able to draw a punnett square and be able to calculate the probability that an offspring has a specific trait.

What do you get when you cross a purple pea plant with a white pea plant?

Phenotype: Purple flowers | White flowers

Genotype: PP | pp

Gametes: (P) (P) | (p) (p)

Cross:

	P	P
p	Pp	Pp
p	Pp	Pp

Ratio: 4 purple: 0 white

Percentage: 100% purple flowers (Pp - heterozygous)

1. Determine genotype of both parents.
2. Draw a Punnett Square.
3. Write the alleles for parent 1 on the left side of the Punnett Square.
4. Write the alleles for parent 2 above the Punnett Square.
5. Fill in the boxes by taking one allele from each parent.

If there is a ¼ ratio = 25%
If there is a 2/4 ratio = 50%
If there is a ¾ ratio = 75%

A man with dimples in their cheeks (genotype: Cc) had a baby with a woman with no dimples (genotype: cc). What is the chance that their child will have dimples?

Phenotype: Dimples | No dimples

Genotype: Cc | cc

Gametes: (C) (c) | (c) (c)

Cross:

	C	c
c	Cc	cc
c	Cc	cc

Ratio: 1 dimples (Cc): 1 no dimples (cc)

There is a 50% chance that their child will have dimples in their cheeks.

Sex Determination

You should be able to describe the genotype of females and males and determine the probability that an offspring will be male or female.

Female gametes \ Male gametes	X	Y
X	XX	XY
X	XX	XY

Humans have 23 pairs of chromosomes. Each pair of chromosome is responsible for certain characteristics.

The 23rd pair controls your sex: female or male. It is called **sex chromosome.**

Males have **XY** sex chromosomes.
Females have **XX** sex chromosomes.

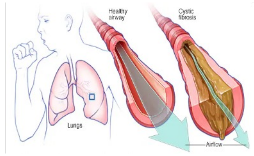
There is a 50% change a child is born male or female using a punnett square.

Inherited Disease

You should be able to define what an inherited disease and discuss polydactyly and cystic fibrosis.

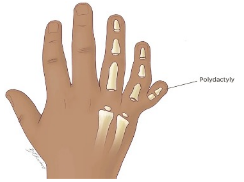
Cystic Fibrosis

- Inherited disease.
- Caused by a recessive allele.
- Results in the production of thick, sticky mucus in different organs.



Polydactyly

- Inherited disease.
- Caused by a dominant allele.
- Disease that causes a person to have extra finger or toes.

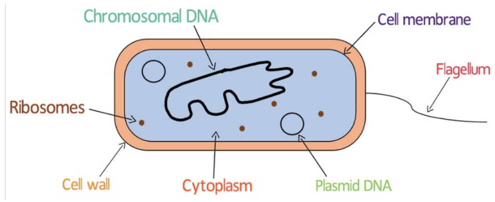


AQA Biology B1: Cells

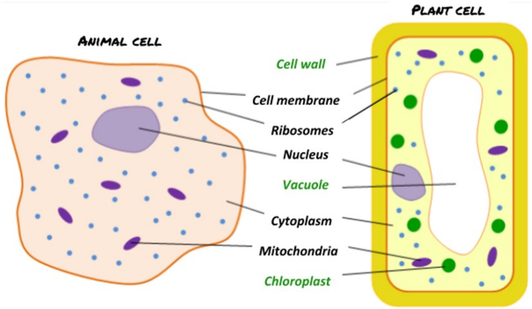
Key Words

Eukaryotic - plant or animal cell with a membrane bound nucleus.
Prokaryotic - bacterial cell without a nucleus.
Plasmid - circular strand of DNA found in bacteria
Flagella - tail-like projection used for movement.
Magnification - enlarging an image so details can be seen.
Mitosis - asexual cell division that produces two genetically identical cells.
Meiosis - cell division that produces four cells with half the number of chromosomes. These cells are called gametes (sex cell).
Stem cell - Undifferentiated cell capable of becoming any cell type.
Specialised cell - cell that is adapted to carry out a specific function.
Haploid - cells that contain half the number of chromosomes.
Diploid - cells containing pairs of chromosomes.
Enucleated cell - egg cell with the nucleus removed.
Therapeutic cloning - use of stem cells from an embryo to treat disease.

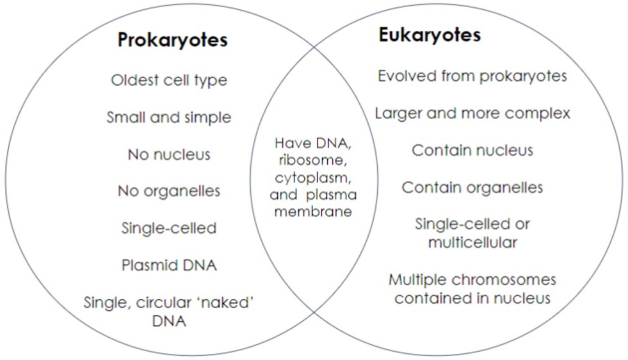
Prokaryotic and Eukaryotic Cells



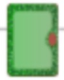
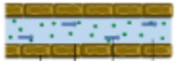
Prokaryotic cells have no nucleus. They have 'naked' DNA and plasmids.



Eukaryotic cells contain membrane bound organelles (cell membrane, ribosome, cytoplasm, mitochondria) and a nucleus. Plant cells contain cell wall, vacuole, and chloroplasts which are not present in animal cells.



Cell Specialisation

	**Sperm Cell**	Long tail for swimming Pointed head to enter egg Lots of mitochondria for respiration
	**Egg Cell**	Very large cell. Contains large cytoplasm.
	**Nerve Cell**	These are extremely long cells so they can reach different locations. They have many branches at both ends to connect to other nerve cells.
	**Red Blood Cell**	No nucleus - more space for oxygen Large surface area Contains haemoglobin which binds to oxygen
	**Root Hair Cell**	Large surface area. Large vacuole to store water and sap.
	**Leaf Palisade Cell**	Lots of chloroplast for photosynthesis.
	**Xylem Cell**	Hollow so it can conduct water. Strong cell walls to manage water pressure

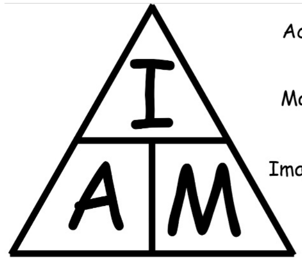
Light Microscopes and Estimating Size

You should be able to describe how microscopy techniques have changed over time. You should also be able to calculate magnification, actual size and image size
.

An electron microscope has much higher magnification and resolving power. It can be used to study cells in finer details.

Light microscope	Electron microscope
Beam of light (longer wavelength)	Beam of electrons (shorter wavelength)
Small	Large and non portable
Relatively inexpensive	Expensive
Not a lot of training required to use	Training required
See colour images	Black and white images
Specimen can be alive and unharmed	Specimen must be dead
Lower resolving power	Greater resolution
Lower magnification	Greater magnification

The equation can be used to calculate magnification.
Magnification unit - X
Size unit - micrometer (μm)



$$\text{Actual Image} = \frac{\text{Image Size}}{\text{Magnification}}$$

$$\text{Magnification} = \frac{\text{Image Size}}{\text{Actual Image}}$$

$$\text{Image Size} = \text{Actual} \times \text{Magnification}$$

AQA Biology B1: Cells

Key Words

Spindle - protein thread used to help separate chromatids during cell division.
Chromatids - single chromosome of a chromosome pair.
Partially permeable - contains pores that allow small substances to pass through.

Stem Cells

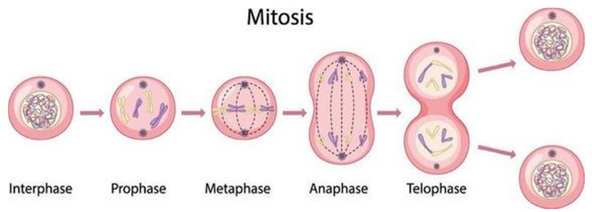
A stem cell is an undifferentiated cell of an organism capable of giving rise to many different types of cells. Stem cells can be used in cloning, preventing extinction, curing disease, research.
Therapeutic cloning - an embryo is produced with the same genes as the parent and used to cure disease (e.g. diabetes)
Adult cell cloning - nucleus removed from individual to be cloned and placed in an enucleated egg cell. Cell stimulated to divide and placed in surrogate.

Cell Division

You should be able to describe the stages of mitosis, and compare and contrast with meiosis.

Mitosis

Cell division used for growth and repair. It produces two genetically identical daughter cells.



Prophase - DNA replicates.
Metaphase - Pairs of chromosomes (one from each parent) line up down the equator of the cell.
Anaphase - One set of chromosomes are pulled to each end of the cell.
Telophase - Cytoplasm and cell membrane divides to form two cells.

Meiosis

Cell division that produces four gametes (sex cells) that are not genetically identical to each other.

Types of Stem Cells

You should be able to describe where the stem cells are derived from and the pros and cons of each.

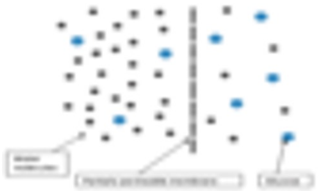
Embryonic Stem Cell	Adult Stem Cell	Meristem Cells
• Human • Taken from embryo • Able to differentiate into any type of cell • Ethical issues • Painless extraction • Can treat a variety of diseases	• Human • Taken from blood marrow • Able to differentiate into blood cells only • No ethical issues • Painful extraction • Well tested	• Plant • Found in the tips of roots and shoots • Able to differentiate into any type of cell

Modes of Transport

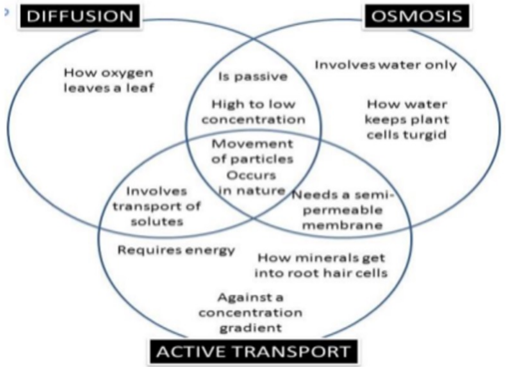
You should be able to define, describe and give examples of each of these transport types.

Diffusion: The movement of substances from an area of high concentration to low concentration down a gradient. It is a passive process. It can be affected by concentration, temperature and surface area.

Osmosis: The diffusion of water from a dilute to a concentrated solution through a partially permeable membrane. This is a passive process.

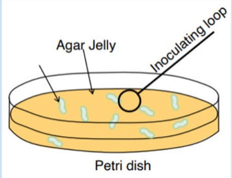


Active transport: Substances move from a dilute to a concentrated solution, against a concentration gradient. This is an active process and required energy from respiration.



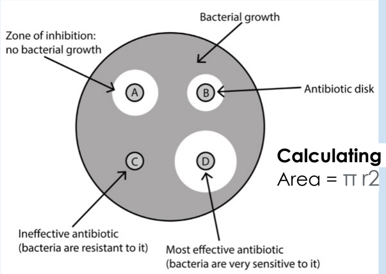
Culturing Microorganisms

You should be able to describe the equipment and method used.



Bacteria replicate through binary fission (asexual).

STEPS	EXPLANATION
1. WHENEVER WORKING ASEPTICALLY, ALL WORK SHOULD BE CARRIED OUT IN FRONT OF A LIT BUNSEN BURNER WITH A YELLOW FLAME.	THE FLAME CREATES A CONVECTION CURRENT ABOVE THE BENCH, PREVENTING CONTAMINATION OF ANY MICROORGANISMS IN THE AIR.
2. HOT AGAR JELLY IS POURED INTO A STERILISED PETRI DISH. THE AGAR IS LEFT TO COOL AND SET.	THE PETRI DISH AND CULTURE MEDIUM ARE HEATED TO A HIGH TEMPERATURE TO KILL ANY POTENTIAL MICROORGANISMS THAT COULD CONTAMINATE THE EXPERIMENT.
3. AN INOCULATING LOOP IS PASSED THROUGH A HOT FLAME BEFORE IT IS USED TO TRANSFER BACTERIA TO THE CULTURE MEDIUM.	ANY MICROORGANISMS ON THE LOOP ARE KILLED TO PREVENT CONTAMINATION.
4. PETRI DISHES SHOULD ONLY BE OPENED AS LITTLE AS POSSIBLE, AT THE SIDE FACING THE BUNSEN BURNER.	THIS DECREASES THE RISK OF MICROORGANISMS CONTAMI– NATING THE DISH.
5. THE LID OF THE PETRI DISH SHOULD BE SECURED WITH TAPE AT INTERVALS AROUND THE DISH AND STORED UPSIDE DOWN.	THIS PREVENTS DROPS OF CONDENSATION (ANOTHER SOURCE OF CONTAMINATION) FROM DROPPING ONTO THE SURFACE OF THE AGAR.
6. THE CULTURES SHOULD NOT BE INCUBATED ABOVE 25℃ IN A SCHOOL LABORATORY.	THIS RESTRICTS THE GROWTH OF HARMFUL PATHOGENS (WHICH ARE MORE LIKELY TO GROW AT HIGHER TEMPERATURES).



Calculating Zone of Inhibition
Area = πr^2

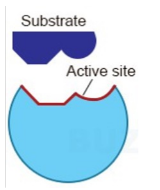
AQA Biology B2: Organisation

Key Words

Cells - smallest unit that makes up all living things.
Tissue - a group of cells with a similar structure and function.
Organs - tissues working together to perform a specific function.
Organ system- Group of organs working together.
Protein - a large molecule made up of a chain of amino acids.
Carbohydrates - a large molecule made up of a chain of simple sugars.
Lipids - a large molecule made up of three fatty acids and glycerol.
Denature - when an enzyme loses its shape, no longer allowing the substrate to bind to the active site.
Diffusion- The movement of particles from a high concentration to a low concentration, down a concentration gradient.
Enzyme- a biological catalyst
Xylem- Vessel in the plant that transports water from the roots to the leaf.
Phloem- Vessel in the leaf that transports glucose around the plant.
Transpiration- Loss of water from a leaf.
Translocation- process of glucose being transported around the plant.

Enzymes

You should be able to describe the structure of enzymes and use 'lock and key' theory to describe the function of enzymes

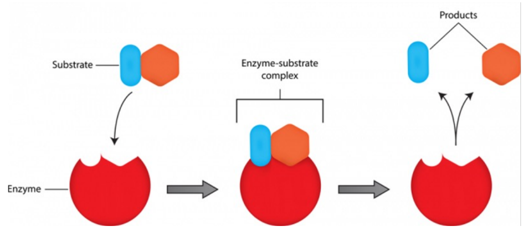


Enzymes can either break something down or join things together.

The **active site** is the point where the substrate binds. It is complementary in shape to the substrate.

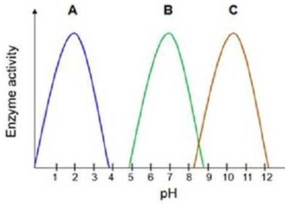
Lock and Key

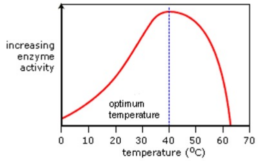
The substrate fits perfectly (complementary) to the active site. The substrate binds to the active site. It is broken down and the released from the active site. The enzyme is unchanged and can be reused.



Lipase - enzyme that breaks down lipids into fatty acids and glycerol.
Protease - enzyme that breaks down lipids into proteins into amino acids.
Amylase - enzyme that breaks down starch into glucose.

Factors Affecting Enzymes: pH and Temperature





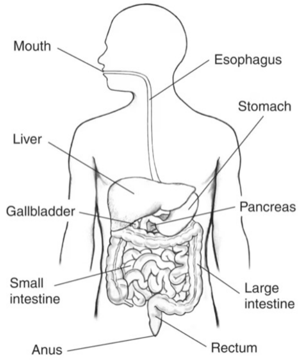
Different enzymes have a different pH and temperatures at which they work best at.

This is called **optimum pH** and **optimum temperature.**

Enzymes denature if the pH is too low or high or if temperature is too high. So enzyme activity decreases.

The Digestive System

You should be able to label the parts of the digestive system and their function.



Mouth - food is broken down through chewing, carbohydrate digestion begins.-
Stomach - food is churned with stomach acids, protein digestion begins.
Small intestine - absorption and digestion of protein, lipids, and carbohydrates.
Large intestine - absorption of water.

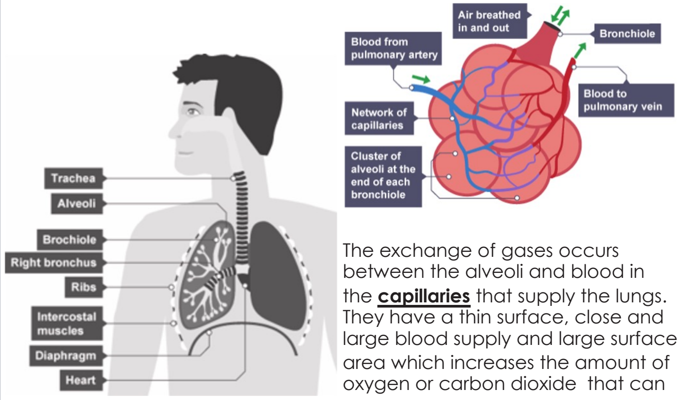
Pancreas - produces digestive enzymes.
Liver - produces bile.
Gallbladder - stores bile.

Bile - emulsifies lipids (breaking them down into tiny droplets). Bile is alkali so it neutralises the stomach acid.

Amylase	Produced in salivary glands, pancreas, and small intestine
Protease	Produced in stomach, pancreas, and small intestine
Lipase	Produced in pancreas

The Respiratory System

You should be able to label the parts of the respiratory system and the steps involved in inspiration and expiration.



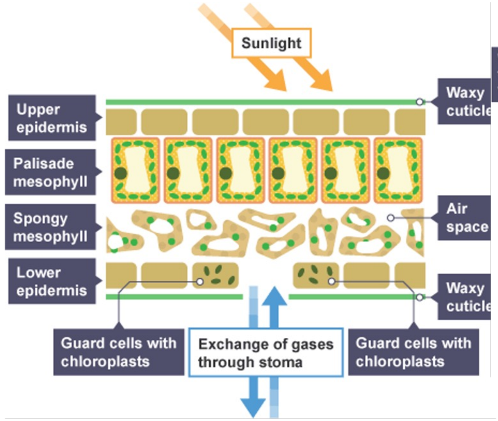
The exchange of gases occurs between the alveoli and blood in the __capillaries__ that supply the lungs. They have a thin surface, close and large blood supply and large surface area which increases the amount of oxygen or carbon dioxide that can diffuse

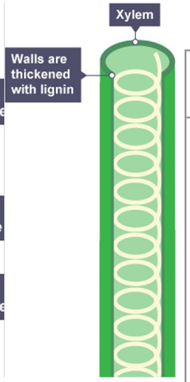
Inspiration (Breathing In)	Expiration (Breathing Out)
• Intercostal muscles contract - the ribs move up and outwards. • Diaphragm contracts moving downwards, increasing space for lungs to expand. • Volume of lungs increases so pressure decreases and air diffuses into the lungs.	• Intercostal muscles relax- the ribs move down and outwards. • Diaphragm relaxes and moves up. • Volume of lungs decreases so pressure increases and air diffuses out of the lungs.

Plant Tissue and Organs

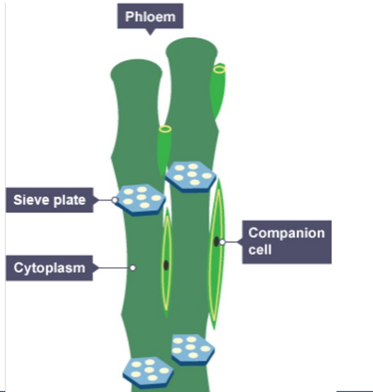
You should be able to label the parts of the leaf and state their functions.

Transpiration is water loss through a leaf, **Translocation** is the movement of sugar around a plant





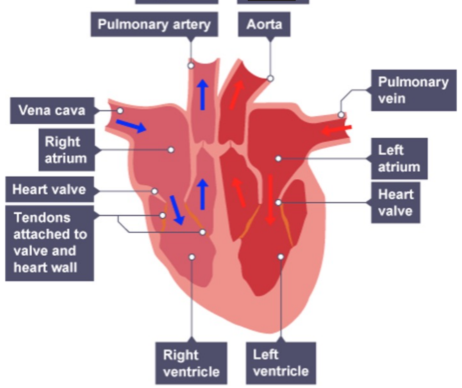
Xylem	Phloem
Dead, hollow cells Contains lignin for strength Transports water one way	Live cells Sieve cells distribute glucose Companion cells provide energy Transports glucose both ways



Substance transported	From	To
Oxygen	The lungs	All the body's cells
Carbon dioxide	All the body's cells	Lungs
Glucose	Digestive system	The liver, then all the body's cells
Urea	Liver cells	Kidneys

The heart

Blood is pumped around the body by the heart.



Blood enters the heart through the atria. Blood from two **vena cava** enters the right atrium. Blood from the **pulmonary veins** enters the left atrium.The atria fill, followed by the **ventricles**. Blood is prevented from flowing back into the atria by heart valves.

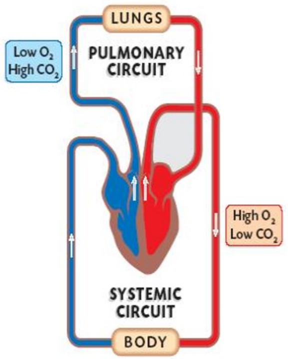
Blood leaves the heart in the body's main artery - the **aorta** - from the left side, and the **pulmonary artery**, from the right.

Double circulation

Humans have a double circulatory system.

The heart pumps blood through two circuits:

- the **pulmonary circulation**
- the **systemic circulation**



The pulmonary circulation transports blood to the lungs. At the lungs:

- **Oxygen diffuses** into the blood from the **alveoli** - the blood becomes oxygenated
- **carbon dioxide** diffuses from the blood into the lungs

Blood passes through the heart twice in one complete circulation of the body.

CHD

The **heart** is a muscular pump. Like all muscles, it needs **oxygen** for **aerobic respiration** to contract. The **coronary arteries** supply blood, and therefore oxygen, to the heart muscle.

The coronary arteries may become blocked by a build-up of fatty material, caused by certain kinds of 'bad' **cholesterol**. As the fatty material increases, one or more coronary arteries narrow, and can become blocked.

If a blockage builds up, the amount of oxygen reaching the heart muscle is reduced. A person will develop chest pain, and if left untreated, a heart attack is the result. This can cause damage to, or death of the heart muscle. Part of the heart muscle, or the whole heart, will die.

Drugs and surgery can help to control coronary heart disease.

Statins

Statins are drugs that help to lower cholesterol in the blood. They do this by lowering its production in the **liver**.

Statins are prescribed for people with heart disease or who have a high risk of developing it. They need to be taken long-term. **Cholesterol** levels will rise again if a person stops taking them.

Some studies have raised concerns regarding the side effects of statin use, while others believe they can bring additional positive benefits.

Statins are not suitable for everyone - they should not be prescribed for people with liver disease, or pregnant or breastfeeding women.

Some patients taking statins often experience side-effects such as headaches and memory loss. There have been reports of statins being linked with type 2 **diabetes** and liver damage.

Faulty heart valves

Heart valves may become faulty. A valve may not:

- open as wide as it should, restricting blood flow through the heart - this means less blood reaches the body, pressure builds up and the lungs can swell with fluid
- close properly and allow blood to leak back through into the atrium

A patient will not always have symptoms. A scan of the heart can diagnose the problem. When symptoms are present, these are shortness of breath, dizziness, rapid heart rate and chest pain. The problem can lead to **heart failure**.

If the condition is severe, the patient will require surgery.

Faulty heart valves can be replaced:

- with a biological valve from a human donor or made from animal tissue from a pig or cow
- with a mechanical valve made from strong, durable materials

The operation is usually successful. Mechanical valves last longer, but blood can clot on them. A patient may need long-term medication that prevents blood clots developing. Biological valves are more likely to wear out.

The heart beat

Specialised cells in the right **atrium** generate electrical signals that make the heart contract independently of the **nervous system**. These specialised cells act as a **natural pacemaker**.

A wave of contraction spreads across the heart - to the left atrium and then to the ventricles. This enables the ventricles to contract together.

Artificial pacemakers

Sometimes, the rhythm of the heart's natural pacemaker process becomes disrupted - a person's heart beats abnormally. It can be abnormally slow or fast, or irregular.

An **artificial pacemaker** is a small, battery-operated electronic device implanted in a person's chest that sends out regular, adjustable electrical impulses to produce normal contractions of the heart.

There are several types of artificial pacemaker, which have electrical leads connected to different chambers of the heart.

Wires are guided along a vein to the chamber of the heart that needs to be stimulated. The lead extends to the pacemaker, which is fitted between the skin of the upper chest and the chest muscle.

Arteries	Veins
Always carry blood **away** from the heart	Always carry blood **to** the heart
Carry oxygenated blood, except for the pulmonary artery	Always carry deoxygenated blood, except for the pulmonary vein
Carry blood under high pressure	Carry blood under low or negative pressure
Have thick muscular and elastic walls to pump and accommodate blood	Have thin walls - have less muscular tissue than arteries
A type of supporting tissue called connective tissue provides strength	Have less connective tissue than arteries
The channel in the blood vessel that carries blood - the **lumen** - is narrow	Have a wide lumen

Capillaries:

The walls of capillaries are just one cell thick. Capillaries therefore allow the exchange of molecules between the blood and the body's cells - molecules can **diffuse** across their walls. This exchange of molecules is not possible across the walls of other types of blood vessel.

Stents

Coronary arteries that are blocked or have become narrow can be stretched open and a **stent** inserted to restore and maintain blood flow.

They can be used in instances where drugs are less effective, and offer a longer term solution. Stents are made from metal **alloys** and do not lead to an immune response in the patient.

The operation is safe as it does not involve surgery, but there is a risk of bleeding, heart attack or stroke.

Component	Function(s)
Plasma	Transporting carbon dioxide, digested food molecules, urea and hormones; distributing heat
Red blood cells	Transporting oxygen
White blood cells	Ingesting pathogens and producing antibodies
Platelets	Involved in blood clotting

Heart transplants

A **heart transplant** is required in cases of **heart failure**. **Coronary heart disease** can lead to heart failure. The heart fails to pump sufficient blood and **organs** are starved of **oxygen**. There are different degrees of severity of heart failure.

AQA Biology B3: Infection and Response

Key Words

Antibody - chemical released from white blood cells (lymphocytes) that aid in the immune response.
Antibiotics: drug that can 'kill' bacteria
Blind trial - doctor is aware of what treatment/ placebo a participant is receiving
Chlorosis - lack of chlorophyll caused by a magnesium deficiency
Double blind trial - doctor and patient do not know if the participant is receiving a placebo or the drug
Hybridoma cell - cell produced when a lymphocyte is combined with a tumour cell in making monoclonal antibodies
Monoclonal antibody - immune cells clones from on parent cell
Painkiller - drug that treats the symptoms of infection
Pathogen - microorganism that causes disease
Phagocytosis - ingesting and digesting microorganisms by white blood cells (phagocytes) during the immune response
Placebo - 'dummy' pill or fake drug that does not contain the active ingredient in drug trials
Vaccinations - drug treatments that use fake/ dead microorganisms to trigger the immune responses

Communicable (infectious) disease

The main types of pathogens are:

- Viruses
- Bacteria
- Fungi
- Protists

Bacteria and viruses reproduce rapidly inside the body.
Bacteria produce poisons that damage tissue, and viruses live and reproduce inside cells, causing damage.

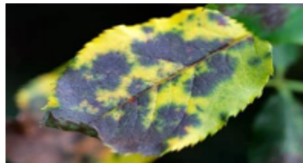
Bacterial diseases

	Salmonella	Gonorrhoea
Symptom	Fever, cramps, vomiting	Yellow/Green discharge, painful urination
Transmission (Spread)	Food, surfaces	Sexual contact
Treatment	Poultry are vaccinated	Antibiotics

Viral diseases

	Measles	HIV	TMV
Symptom	Fever and red skin rash	Flu- like	''Mosaic' leaf pattern
Transmission (Spread)	Inhalation of droplets from coughs/ sneezes	Sexual contact or exchange body fluid	Contact
Treatment	Vaccination	Anti-retroviral drug	

Fungal diseases



Rose Black Spot

Rose black spot is a fungal disease that causes purple/blacks spots to develop on leaves. As photosynthesis is reduced, the plant will not be able to grow as much. It is spread by wind or water. It can be prevented by fungicides of removing infected leaves.

Athlete's foot is a rash caused by a fungus that is usually found between people's toes. It causes dry, red and flaky or white, wet and cracked skin. It is often found in communal areas like swimming pool changing rooms or gyms. It is transmitted by touching infected skin or surfaces that have been previous contaminated. It is treated by **antifungal medication**.

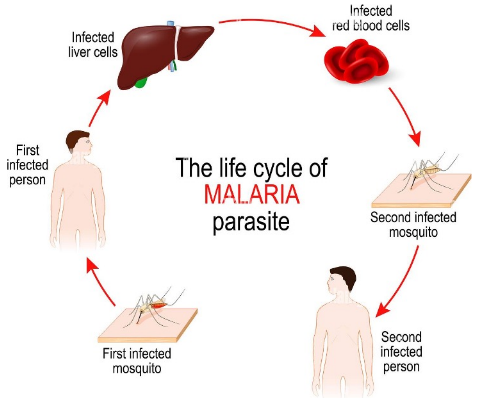
Athletes foot

Protist

Protists are a group of microorganisms that have features that belong to animals, plants and **fungi**. Some are like animals, others more like plants and some, called moulds are closest to fungi. They are all **eukaryotic**, which means they have a **nucleus**

Malaria

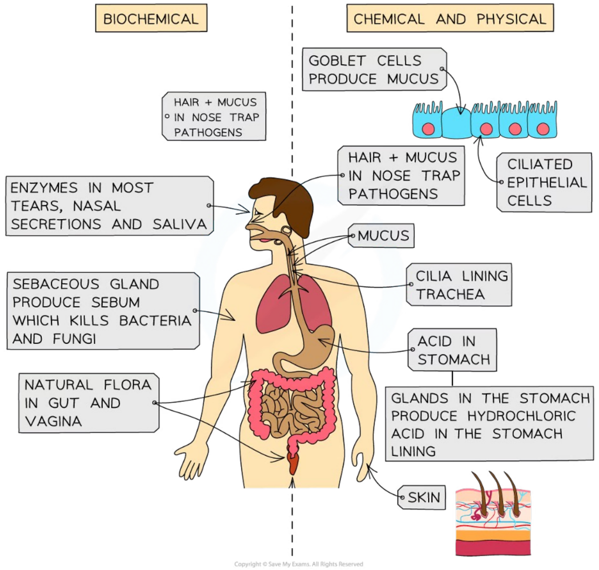
Malaria is spread by mosquitoes which carry the Plasmodium protist. These are often found in areas with higher temperatures like Africa, Asia, and South and Central America, but not the UK. Mosquitos suck blood containing the protists from an infected person. They pass the protist, to other people they suck blood from. The mosquitos do not become ill and are called '**vectors**' because they transmit the disease.



The symptoms of malaria include a fever, sweats and chills, headaches, vomiting and **diarrhoea**. Of the 200 million people infected each year, up to half die from this disease. There is no **vaccination** for malaria. Infection can only be prevented by stopping individuals from being bitten. People sleep under mosquito nets and wear insect repellent to avoid bites. **Antimalarial drugs** are also taken, which treat the symptoms and can prevent infection.

Human defence systems

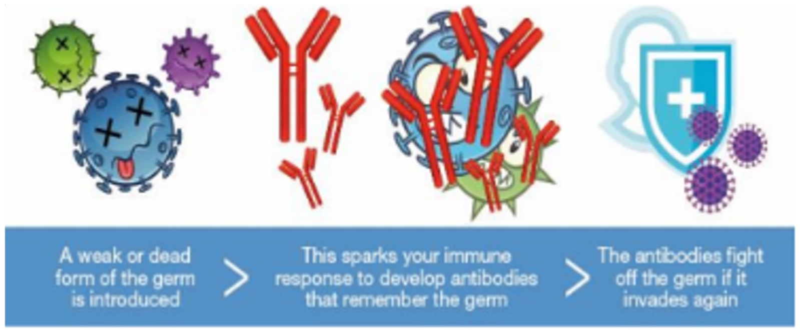
Humans have non-specific defence systems against pathogens



White blood cells defend against pathogens by phagocytosis (ingesting and digesting the pathogen), antibody production (immunity) and antitoxin production

Vaccinations

Small quantities of a dead/weakened/inactive pathogen is injected into the body to trigger an immune response. Lymphocytes produce specific antibodies to tackle the pathogen. If the pathogen re-enters the body at a later date, the antibodies are quickly produced to fight infection.



Antibiotics and painkillers

Discovered by A.Flemming, antibiotics kill infective bacteria inside the body. Antibiotics cannot kill viral pathogens.

Overuse of antibiotics has led to some resistant strains forming. This means that the antibiotics will no longer work against the bacteria- so the bacteria survives and reproduces. This can cause superbugs to form and when they spread they are are difficult to control

Painkillers do not treat a disease, they only treat the symptoms.

Drugs

Preclinical trials and testing is done on using computer simulations, on cells, tissues and animals.
Clinical trials are completed on healthy volunteers first then moves on to unhealthy patients.

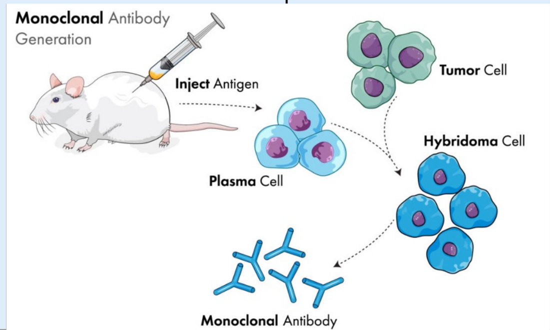
A placebo is a fake version of the drug that is given in a double blind trial- this is when the test subjects or the person giving the drug does not know whether they have the trialled drug or the placebo so that there is no bias in the results.
We test new drugs because:

Toxicity	Identify if it is safe and any side effects
Dosage	To see how much should be taken and how often
Efficacy	To see if the drug is fit for purpose

Monoclonal antibodies (Bio only)

Monoclonal antibodies are produced from a single clone of cells and are highly specific. The can be used for pregnancy tests, to measure hormone levels etc.

Monoclonal antibodies are produced by stimulating mouse lymphocytes (white blood cells) to make a particular antibody. The lymphocytes are combined with tumour cells to make a hybridoma cell. When this cell divides/cloned large amounts of the antibody is made and can be collected and purified.



Plant diseases (Bio only)

Plants can be infected by viruses (TMV), fungi (Rose Black Spot) and insects (aphids). Symptoms of plant diseases include stunted growth, discolouration, presence of pests and areas of decay.

Plants can be damaged by a range of ion deficiencies too. These include lack of nitrates which causes stunted growth or lack of magnesium which causes chlorosis which is a lack of chlorophyll in the leaf so they become yellow.

AQA Biology B4: Bioenergetics

Key words

Carbon dioxide- compound of carbon and oxygen which is a product of respiration, but essential for photosynthesis
Chlorophyll- The green chemical inside the chloroplasts of plant cells where photosynthesis takes place
Chloroplast- Contains chlorophyll
Endothermic- reaction where energy is taken in (photosynthesis)
Exothermic- reaction where energy is released (respiration)
Glucose- Simple sugar used for respiration
Humidity- the amount of water vapour in the atmosphere measured as a %
Limiting factor- a factor that can reduce the rate of photosynthesis
Metabolism- the sum of all chemical reactions
Mitochondria- the site of aerobic respiration
Oxygen- an element that makes up 20% of the atmosphere, which is needed for aerobic respiration and a product of photosynthesis
Phloem- the tube that carries sugar around the plant
Photosynthesis- Is a chemical reaction that makes glucose and oxygen, using carbon dioxide and water in the presence of light.
Respiration- Chemical reaction that takes place in living cells where glucose and oxygen produce carbon dioxide and water whilst releasing energy
Stomata- Tiny holes in the epidermis of the leaf that helps control water loss and gas exchange
Xylem- the tube that carries water from the roots to the leaf

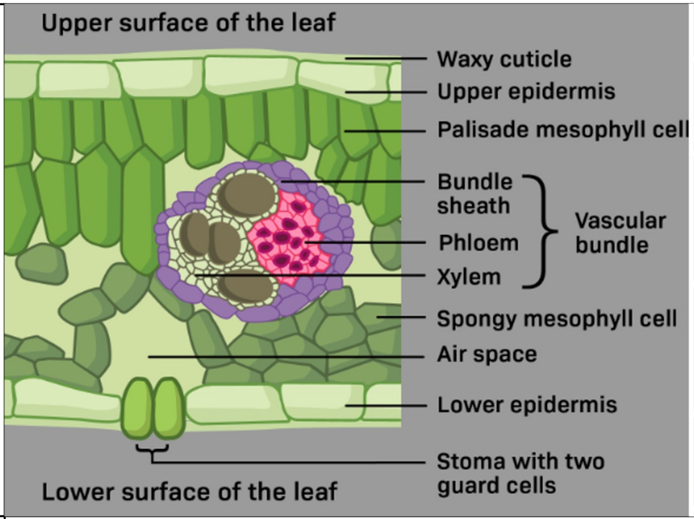
Photosynthesis

Plants, unlike animals, can make their own food. They do this using a process called **photosynthesis**.
During photosynthesis, plants produce **glucose** from simple **inorganic** molecules – **carbon dioxide** and water – using light energy.
The word and symbol equations for photosynthesis are:

Carbon dioxide + Water —Light / Chlorophyll→ Glucose + Oxygen

$$6CO_2 + 6H_2O \xrightarrow[\text{Chlorophyll}]{\text{Light}} C_6H_{12}O_6 + 6O_2$$

Some of the glucose produced by photosynthesis is used for **respiration**.
Glucose is the starting point for the **biosynthesis** of materials that plants need to live.



Feature
Large surface area
A thin, flattened blade - though there are exceptions
Vascular tissue in the midrib and veins
Air spaces between cells within the leaf

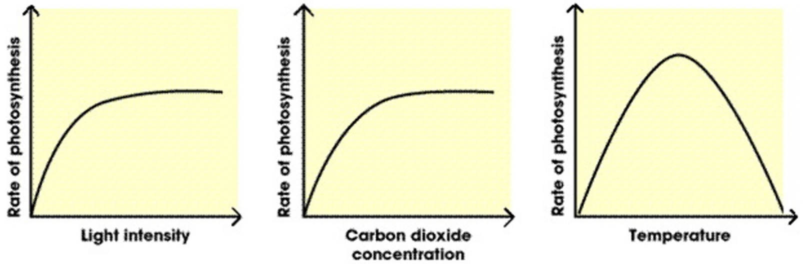
Limiting factors

A limiting factor is something that will reduce the rate of photosynthesis if it is in short supply.
Several factors can affect the rate of photosynthesis:

- light intensity
- carbon dioxide concentration
- temperature

The amount of **chlorophyll** also affects the rate of photosynthesis:

- plants in lighting conditions unfavourable for photosynthesis synthesise more chlorophyll, to absorb the light required
- the effects of some plant diseases affect the amount of chlorophyll, and therefore the ability of a plant to photosynthesise



The light intensity is **inversely proportional** to the square of the distance – this is the inverse square law.

Calculating $\frac{1}{d^2}$:

Plant transport tissues - xylem and phloem

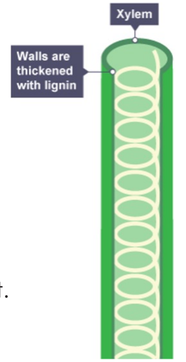
Xylem

The **xylem** transports water and minerals from the roots up the plant stem and into the leaves.
In a mature flowering plant or tree, most of the cells that make up the xylem are specialised cells called vessels.

Vessels

- Lose their end walls so the xylem forms a continuous, hollow tube.
- Become strengthened by a chemical called **lignin**. The cells are no longer alive. Lignin gives strength and support to the plant. We call lignified cells wood.

Transport in the xylem is a physical process. It does not require energy.



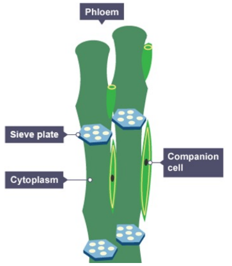
Phloem

The **phloem** moves food substances that the plant has produced by photosynthesis to where they are needed for processes such as:

- growing parts of the plant for immediate use
- storage organs such as bulbs and **tubers**
- developing seeds.

Transport in the phloem is therefore both up and down the stem.
Transport of substances in the phloem is called **translocation**.
Phloem consists of living cells. The cells that make up the phloem are adapted to their function:

- **Sieve tubes** - specialised for transport and have no **nuclei**. Each sieve tube has a perforated end so its **cytoplasm** connects one cell to the next.
- **Companion cells** - transport of substances in the phloem requires energy. One or more companion cells attached to each sieve tube provide this energy. A sieve tube is completely dependent on its companion cell(s).



AQA Biology B4: Bioenergetics

Respiration releases energy – it is an **exothermic** process.

All organisms need energy to live. This energy is used:

- to drive the chemical reactions needed to keep organisms alive – the reactions to build complex **carbohydrates**, **proteins** and **lipids** from the products of **photosynthesis** in plants, and the products of **digestion** in animals, require energy
- movement – in animals, energy is needed to make muscles contract, while in plants, it is needed for transport of substances in the **phloem**

Energy is also used:
for **cell division**
to **maintain constant conditions in cells and the body – homeostasis**
to **move molecules against concentration gradients in active transport**
for the transmission of **nerve impulses**

	Aerobic	Anaerobic
Presence of oxygen	Present.	Absent or in short supply.
Oxidation of glucose	Complete	Incomplete. The products of respiration still contain energy.
Products of respiration	Carbon dioxide and water. The products do not contain stored chemical energy.	Mammalian muscle: lactic acid. Yeast: ethanol and carbon dioxide. Some plants: ethanol and carbon dioxide. The products still contain stored chemical energy.
Amount of energy released	Relatively large amount.	Small amount, but quickly.

Metabolism is the term used for all the chemical reactions that go on inside an organism's body.

These reactions build up molecules, and break them down. They are controlled by enzymes.

Response to exercise

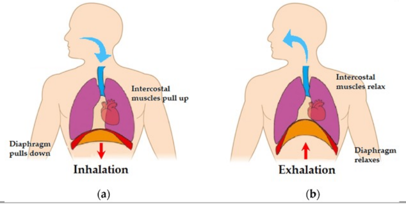
Muscles need energy to contract. While exercising, the muscles need additional energy as:

- the breathing rate and volume of each breath increases to bring more oxygen into the body and remove the carbon dioxide produced
- the heart rate increases, to supply the muscles with extra oxygen and remove the carbon dioxide produced

If insufficient oxygen is available to the muscles, for instance the exercise is vigorous and/or prolonged, the heart and lungs are unable to supply sufficient oxygen. Muscles begin to respire anaerobically. Lactic acid is produced from glucose, instead of carbon dioxide and water. Muscles continue to contract, but less efficiently.
During long periods of vigorous activity:

- lactic acid levels build up
- **glycogen** reserves in the muscles become low as more glucose is used for respiration, and additional glucose is transported from the liver.

This build-up of lactic acid produces an **oxygen debt**.
As body stores of glycogen become low, the person suffers from muscle fatigue.



Key equations:

The word equation for **aerobic respiration** is:
glucose + oxygen → carbon dioxide + water + energy released
You need to be able to recognise the chemical symbols:
$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + energy released

Anaerobic respiration in humans and animals:
glucose → lactic acid + energy released

Anaerobic respiration in plants:
glucose → ethanol + carbon dioxide + energy released

Anaerobic respiration in yeast

Yeast is used to make alcoholic drinks. When yeast cells are reproducing rapidly during beer or wine production, the oxygen runs out. The yeast switches to anaerobic respiration. Ethanol and carbon dioxide are produced.

Yeast can also be used to produce bread. Yeast respires using sugar added to the dough. Bubbles of carbon dioxide make the bread rise. The alcohol that's produced **evaporates** as the bread is baked.

Oxygen debt

When a period of exercise is over, lactic acid must be removed. The body's tolerance of lactic acid is limited.
Lactic acid is taken to the liver by the blood, and either:

- oxidised to carbon dioxide and water, or
- converted to glucose, then glycogen - glycogen levels in the liver and muscles can then be restored

These processes require oxygen. This is why, when the period of activity is over, a person's breathing rate and heart rate do not return to normal straightaway.
The amount of oxygen required to remove the lactic acid, and replace the body's reserves of oxygen, is called the **oxygen debt**.
When someone who has been exercising pays back an oxygen debt, it can take from a few hours for normal exercise, to several days after a marathon.

AQA Biology B5: Homeostasis

Key words

Homeostasis- Regulation of the internal conditions to maintain optimum conditions in response to internal and external changes
Receptors- cells that detect a stimuli
Stimuli- change in the environment
Effectors- muscles or glands which bring about responses to restore optimum levels
CNS- central nervous system made up of the brain and spine
Medulla (brain)- unconscious activities eg breathing
Cerebellum (brain)- muscle coordination
Cerebrum (brain)- memory and intelligence
Accommodation (eyes)- use of the ciliary muscles and suspensory ligaments to adjust vision to see far and close objects
Endocrine system- glands that secrete hormones directly into the bloodstream
Insulin- hormone released from the pancreas that trigger lowering in blood glucose levels
Glucagon- hormone released from the pancreas that triggers blood glucose levels to rise

Homeostasis

Homeostasis maintains optimal conditions for **enzyme** action throughout the body, as well as all cell functions.

In the human body, these include the control of:

- **blood glucose** concentration
- body temperature
- water levels

These automatic control systems may involve nervous responses (**nervous system**) or chemical responses (endocrine system).

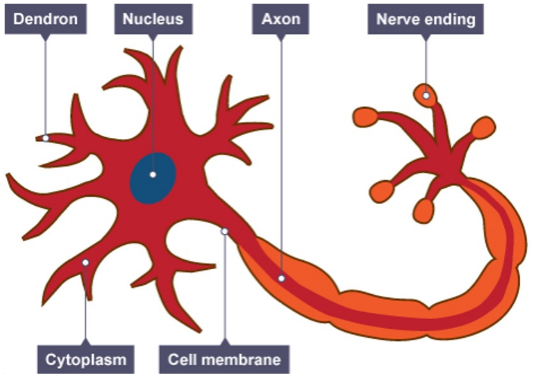
Control systems include:
- Receptors which detect stimuli such as pain receptors
- Coordination centres that receive and process information
- Effectors which bring about responses which restore optimum levels (eg muscles)

Neurones

There are three main types of neurone: sensory, motor and relay.

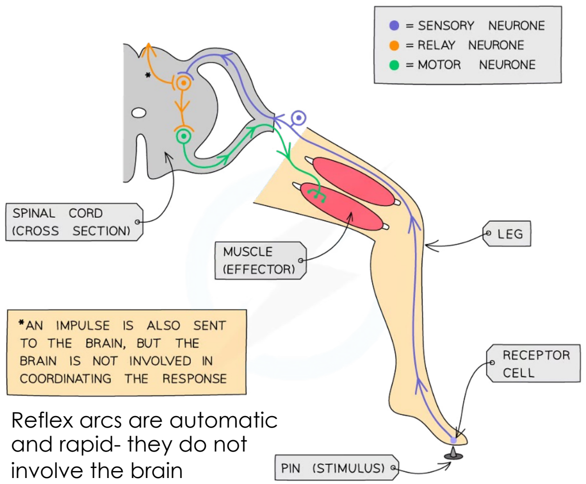
They have some features in common:
A long fibre (axon) which is insulated by a fatty (myelin) sheath. They are long so they can carry messages up and down the body.

Tiny branches (dendrons) which branch further as dendrites at each end. These receive incoming impulses from other neurones.



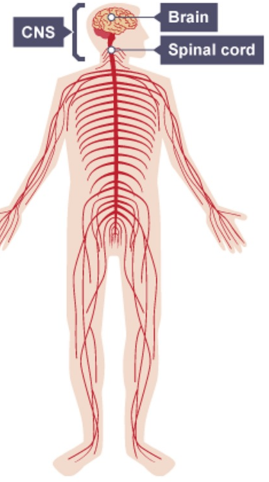
Nervous system

The human nervous system consists of:
- the **central nervous system** – the brain and spinal cord
- the peripheral nervous system – nerve cells that carry information to or from the CNS

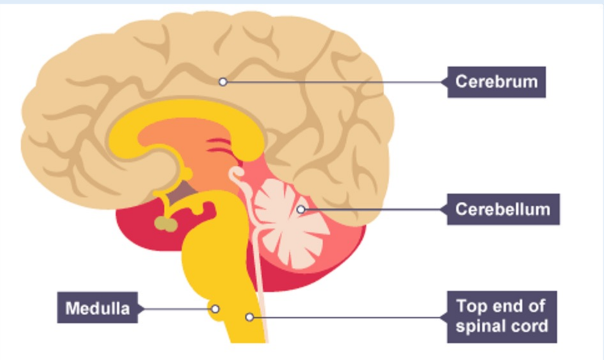


Reflex arcs are automatic and rapid- they do not involve the brain

Information from receptors pass along neurones as electrical impulses to the CNS. This coordinates responses to effectors which bring about responses.



The Brain (Bio only)



The **brain** controls complex behaviour. It is made of billions of interconnected **neurones** and has different regions that carry out different functions.

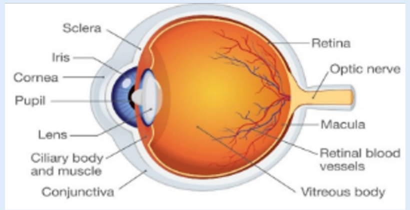
The **cerebrum** is the large folded area of the brain and is responsible for conscious thoughts, reasoning, memory and emotions.

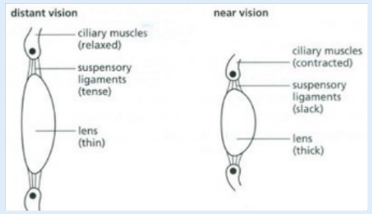
The **cerebellum** is found at the rear of the brain below the cerebrum and controls balance and coordinated movement.

The **medulla** is found at the top of the spinal cord and contains groups of neurons that transmit electrical impulses to the heart and lungs to control heart rate, breathing rate and peristalsis.

The **hypothalamus**, which is the regulating centre for temperature and water balance within the body.

The eye (Bio only) relate the structure of the eye to its function





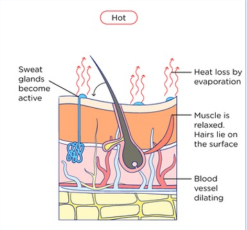
Common eye defects are myopia (short sightedness) and hyperopia (long sightedness) in which rays of light do not focus on the retina. Both can be treated with spectacles, contact lenses, laser surgery or lens replacement surgery

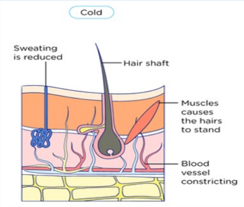
Body temperature (Bio only)

(describe how mechanisms lower or raise body temperature in a given context)

Body temperature is controlled by thermoregulatory centres in the brain. The skin contains temperature receptors and send nervous impulses to the centre.

- If body temperature is too high, vasodilation and sweating occurs
- . If body temperature is too low, vasoconstriction and skeletal muscles contract (shiver) occurs and sweating stops



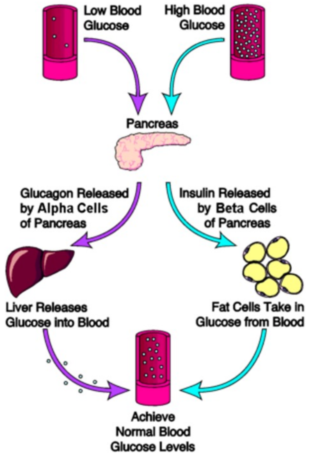


Endocrine System

(describe the principles of hormonal coordination and control)

Endocrine system is composed of glands which secrete hormones into the bloodstream. The blood carries the hormone to the target organ where is produces an effect. Much slower than the nervous system.

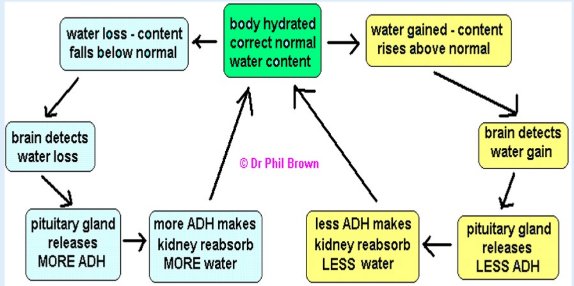
Pituitary gland is the master gland and produces several hormones that trigger the action of others



Blood glucose control

Type 1 diabetes- occurs if the pancreas fails to produce sufficient insulin. It is characterised by uncontrollably high blood glucose levels and treated with insulin injections.

Type 2 diabetes- occurs if the body no longer responds to insulin produced. A controlled diet and exercise are treatments and obesity is a risk factor.



Water control

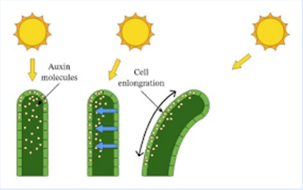
The kidneys are vital in maintaining water balance in the body

- Water leaves the body via the lungs during exhalation
- Water, ions and urea are lost from the skin in sweat
- Both the above can not be controlled

- The kidneys produce urine by filtration of the blood and selective reabsorption of useful substances such as glucose, some ions and water. The hormone ADH helps this to occur.

Hormone	Action
Auxins	Influence cell division, cell elongation, cell differentiation affecting apical dominance, tropisms, flowering, abscission and senescence.
Gibberellins	Increases elongation growth- e.g. they cause the rapid growth of internodes in stems making the plant grow taller.
Ethylene	Promoted ripening of fruits and abscission (falling) of leaves.
Cytokinins	Regulate cell division.
Abscisic Acid	Inhibits other hormones—promoting dormancy in plants and seeds.

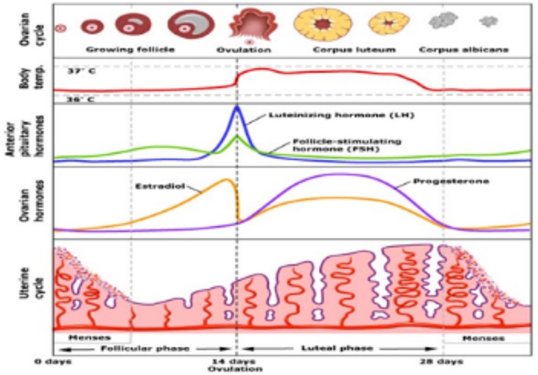
Plant hormones



Tropisms are a response or orientation of a plant or certain lower animals to a stimulus that acts with greater intensity from one direction than another

Human Reproduction

(describe the roles of hormones in human reproduction, including the menstrual cycle)



Contraception

(evaluate the different hormonal and non-hormonal methods of contraception)

- Oral contraceptives contain hormones to inhibit FSH
- Injection, implant or skin patch to release progesterone to inhibit the maturation and release of eggs
- Barrier methods e.g. condoms
- Spermicide agents that kill sperm
- Surgical methods of male and female sterilisation

Infertility (Higher only)

IVF:

- Mother is given FSH and LH to stimulate the maturation of several eggs
- Eggs are collected and fertilised by sperm in a petri dish
- The fertilised eggs are incubated and develop into embryos
- Embryos are inserted into the mothers uterus

IVF is emotionally and physically stressful, not always successful, expensive and can lead to multiple births

AQA Biology B6: Inheritance, genetics and variation

Key Words

Gametes - sex cells. In humans this is the sperm and egg.
Genome - all of the genetic material of an organism.
Gene - small section of DNA on a chromosome. Each gene codes for a particular amino acid, to make a specific protein.
Polymer - very long chain molecule made from small repeating units called monomers.
Protein - a polymer made up of a long chain of amino acids.
Allele - different versions of a gene.
Genotype - the set of alleles of an individual. Their genetic material.
Homozygous dominant - two dominant alleles.
Homozygous recessive - two recessive alleles.
Heterozygous - one recessive and one dominant allele.
Inherited disease - genetic conditions that are passed down from generation to generation.
Polydactyly - a dominant inherited disease that causes a person to have extra finger or toes.
Carrier - a person who has the ability to pass down a characteristic without physically expressing it.
Cystic fibrosis -a recessive inherited disease that results in the production of thick, sticky mucus in different organs.

Sexual and Asexual Reproduction

You should be able to describe the differences and advantages/disadvantages of sexual and asexual reproduction.

Asexual Reproduction:

Involves one parent. The parent divides (using mitosis) to produce offspring that are **exact copies** of the parent.

- Bacteria, Fungi and some Plants use asexual reproduction.

Advantages	Disadvantages
• Population can be increased rapidly when conditions are right. • Can exploit suitable environments quickly. • More time and energy efficient. • Reproduction is completed much faster than sexual reproduction.	• Limited genetic variation in population, offspring are genetically identical to their parents. • Population is vulnerable to changes in conditions and may only be suited for one habitat. • Disease is likely to affect the whole population as there is no genetic variation

Sexual Reproduction:

Involves two parent. The gametes of two parents which fuse together (fertilisation) to form one cell.

- Plants and animals use sexual reproduction.

Advantages	Disadvantages
• Increases genetic variation. • The species can adapt to new environments due to variation, giving them a survival advantage. • Disease is less likely to affect population (due to variation)	• Takes time and energy to find mates. • Difficult for isolated members of the species to reproduce.

Developing Gene Theory

You should be able to name key scientists and their contribution to our understanding of genes and DNA.

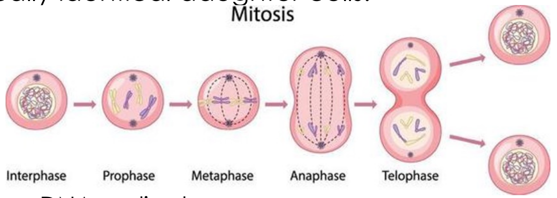
- mid 19th century - Gregor **Mendel** carried out breeding experiments on plants
- early 20th century - Walter **Sutton** observed chromosomes in grasshopper.
- mid 20th century - Rosalind **Franklin** discovered the structure of DNA, and a model was developed by **Watson and Crick.**

Cell Division

You should be able to describe the stages of mitosis, and compare and contrast with meiosis.

Mitosis

Cell division used for growth and repair. It produces two genetically identical daughter cells.



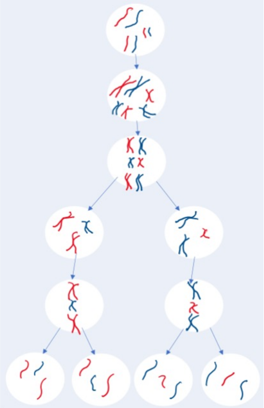
Prophase - DNA replicates.
Metaphase - Pairs of chromosomes (one from each parent) line up down the equator of the cell.
Anaphase - One set of chromosomes are pulled to each end of the cell.
Telophase - Cytoplasm and cell membrane divides to form two cells.

Meiosis

You should be able to describe the general process of meiosis, and compare and contrast with mitosis.

Meiosis

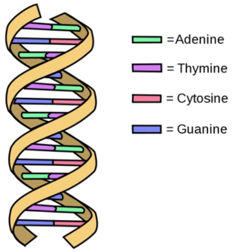
Cell division that produces four gametes (sex cells) that are not genetically identical to each other.



1. Copies of the chromosomes are made. (Remember: cells contain two copies of each chromosome – one from each parent)
2. Chromosomes line up in pairs in the centre of the cell and then get pulled to opposite ends for the **first division.**
3. The cell prepares for a **second division.** Chromosomes line up in the centre of the cell again and are pulled to opposite poles.

DNA

You should be able to describe the structure of DNA.



A and T bind together
G and C bind together

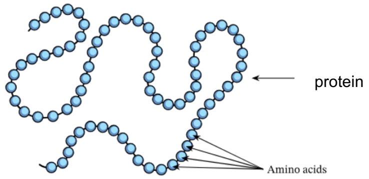
Deoxyribonucleic acid (DNA) is:

- **polymer** (made of many monomers).
- It has a double helix structure.
- There are four nucleotide bases that make up DNA (adenine, thymine, cytosine and guanine)

DNA and Proteins

You should be able to understand how DNA codes for proteins.

Each **gene** has a unique sequence of nucleotide bases which codes for a sequence of **amino acid** in a **protein**.



Proteins are made in ribosomes of cells.

Proteins are needed for growth, replacement and repair of damaged cells.

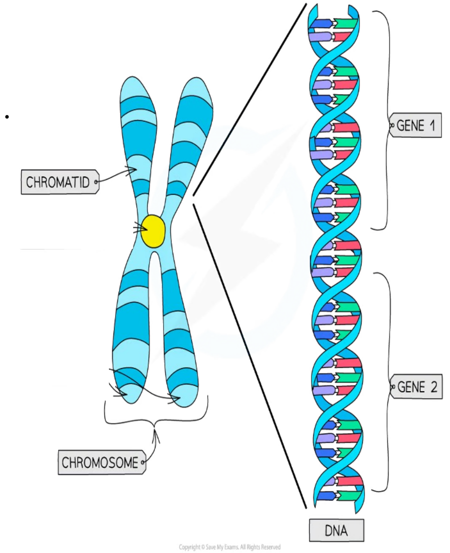
DNA is stored in the nucleus of plant and animal cells.

Whereas, in bacterial cells it is found in the cytoplasm as 'naked DNA' because it is not in the nucleus.

AQA Biology B6: Inheritance, genetics and variation

Chromosomes, Genes, Alleles

You should be able to define, identify and explain the difference between the three terms.



Every chromosome is formed of two **chromatids**, so there are two copies of each gene in every genome.

One of the chromosomes come from the biological father and the other from the biological mother.

Sometimes an individual inherits two different versions of the gene, sometimes an individual inherits two of the same version. These different versions are called **alleles**.

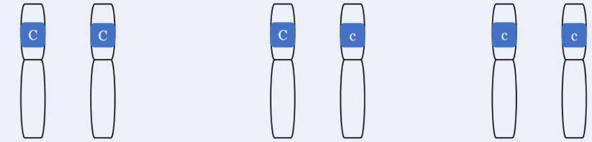
Alleles can either be **dominant** or **recessive**.

A **dominant** allele is one that will always be expressed. It is represented with a capital letter. For example, F.

A **recessive** allele is one that will only be expressed if the individual has two of the same versions of the gene (two copies of the allele). For example, f.

There are three possible combinations of alleles:

CC: homozygous dominant	Cc: heterozygous	cc: homozygous recessive



Punnett Squares

You should be able to draw a punnett square and be able to calculate the probability that an offspring has a specific trait.

What do you get when you cross a purple pea plant with a white pea plant?

Phenotype: Purple flowers | White flowers

Genotype: PP | pp

Gametes: P P | p p

Cross:

	P	P
p	Pp	Pp
p	Pp	Pp

Ratio: 4 purple: 0 white

Percentage: 100% purple flowers (Pp - heterozygous)

1. Determine genotype of both parents.
2. Draw a Punnett Square.
3. Write the alleles for parent 1 on the left side of the Punnett Square.
4. Write the alleles for parent 2 above the Punnett Square.
5. Fill in the boxes by taking one allele from each parent.

If there is a ¼ ratio = 25%
If there is a 2/4 ratio = 50%
If there is a ¾ ratio = 75%

A man with dimples in their cheeks (genotype: Cc) had a baby with a woman with no dimples (genotype: cc). What is the chance that their child will have dimples?

Phenotype: Dimples | No dimples

Genotype: Cc | cc

Gametes: C c | c c

Cross:

	C	c
c	Cc	cc
c	Cc	cc

Ratio: 1 dimples (Cc): 1 no dimples (cc)

There is a 50% chance that their child will have dimples in their cheeks.

Sex Determination

You should be able to describe the genotype of females and males and determine the probability that an offspring will be male or female.

Female gametes \ Male gametes	X	Y
X	XX	XY
X	XX	XY

Humans have 23 pairs of chromosomes. Each pair of chromosome is responsible for certain characteristics.

The 23rd pair controls your sex: female or male. It is called **sex chromosome.**

Males have **XY** sex chromosomes.
Females have **XX** sex chromosomes.

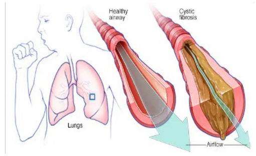
There is a 50% change a child is born male or female using a punnett square.

Inherited Disease

You should be able to define what an inherited disease and discuss polydactyly and cystic fibrosis.

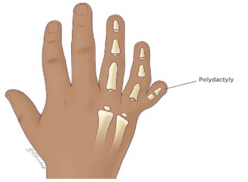
Cystic Fibrosis

- Inherited disease.
- Caused by a recessive allele.
- Results in the production of thick, sticky mucus in different organs.



Polydactyly

- Inherited disease.
- Caused by a dominant allele.
- Disease that causes a person to have extra finger or toes.



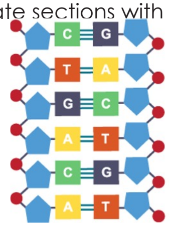
AQA Biology B6: Inheritance, genetics and variation (Triple only)

DNA and protein synthesis

DNA consists of two strands coiled into a **double helix**.

DNA is a polymer made from four different **nucleotides**. These are arranged in a repeating fashion. Each nucleotide consists of alternating sugar and phosphate sections with one of the four different bases attached to the sugar.
Each strand of **DNA** is made of chemicals called **bases**.
There are four different bases in DNA:

- thymine, T
- adenine, A
- guanine, G
- cytosine, C



There are chemical cross-links between the two strands in DNA, formed by pairs of bases. They always pair up in a particular way, called **complementary base pairing**:

- thymine pairs with adenine (T-A)
- guanine pairs with cytosine (G-C)

A sequence of three bases is the code for a particular amino acid, which is known as a triplet or the triplet code. The order of the bases controls the order in which amino acids are assembled to produce a particular protein.

The DNA code for the **protein** remains in the **nucleus**, but a copy, called mRNA, moves from the nucleus to the **ribosomes** where proteins are **synthesised** in the **cytoplasm**. The protein produced depends on the template used, and if this sequence changes a different protein will be made.

Carrier molecules bring specific amino acids to add to the growing protein in the correct order. There are only about 20 different naturally-occurring amino acids.

DNA structure determines the protein synthesised. If this changes a different protein will be made. A copy of the DNA is made, but is now mRNA.

The copy moves to the ribosome into to the cytoplasm. Amino acids are connected together in a specific order at the ribosome (see diagram) to create a specific protein molecule.
Each protein molecule has hundreds, or even thousands, of amino acids joined together in a unique sequence. It is then folded into the correct unique shape. This is very important, as it allows the protein to do their jobs

Not all parts of the DNA code for proteins, there is a coding and non-coding part of DNA, which can switch genes on and off, so variations in these areas may affect gene expression, and if the correct protein is synthesised or not

Mutations

Mutation is a change in a **gene** or **chromosome**. It is a rare, random change in the genetic material and it can be inherited.
Causes of mutations happen continuously and can be spontaneous. They are caused by ionising radiation or chemical mutations

Genetic testing

Genetic testing involves analysis of a person's **DNA** to see if they carry alleles that cause genetic disorders. It can be done at any stage in a person's life.
Antenatal testing is used to analyse an individual's DNA or chromosomes before they are born. This testing is offered to couples who may have an increased risk of producing a baby with an inherited disorder, but it can't detect all the risks of inherited disorders.
Neonatal testing known as the new born blood spot test involves analysing a sample of blood that is taken from pricking a baby's heel. It detects genetic disorders in order to treat them early.
Pre-implantation genetic diagnosis (PGD) is used on embryos before implantation. Fertility drugs stimulate the release of several eggs.The eggs are collected and fertilised in a Petri dish. This is known as in vitro fertilisation (IVF). Once the embryos have reached the eight-cell stage, one cell is removed.The cells are tested for the disorder causing alleles. Embryos that don't contain the disorder allele are implanted into the uterus

Human Genome Project

The **genome** of an organism is the entire genetic material of that organism. The whole human genome has been studied, and this has great importance for medicine.
In order to exploit its secrets, it is vital that the human genome is fully understood.
It enables us to:
-search for genes linked to different types of disease
-understand inherited disorders and their treatment
-trace human migration patterns from the past

Ionising radiation includes gamma rays, X-rays and ultraviolet rays. The greater the dose of radiation a cell gets, the greater the chance of a mutation.
Mutations could cause different genes to be switched on or off, and this could create a different or faulty protein to be synthesised. For example, if the protein is an important enzyme, the specific substrate might not fit into the substrate binding site. If it is a structural protein such as collagen, it might lose its strength.
However, most DNA mutations do not alter a protein, they only alter it slightly so its appearance or function is not changed.

Limitations of genetic testing

Genetic tests are not available for every possible inherited disorder, and are not completely reliable. They may produce false positive or false negative results, which can have serious consequences for the parents involved.

False positives
A false positive is a genetic test that wrongly detected a certain allele or faulty chromosome. The individual could believe that they have inherited a genetic condition, when they have not.

False negatives
A false negative is a genetic test that has failed to detect a certain or faulty chromosome. The parents may be given incorrect results. These results can have an impact on the lives of individuals, such as planning the level of care needed for children with inherited disorders.

Gene therapy
Gene therapy involves inserting copies of a normal allele into the chromosomes of an individual who carries a faulty allele. It is not always successful, and research is continuing to try and develop this possible treatment further.
Gene therapy involves these basic steps:
-identify the gene involved in the genetic disorder
-restriction enzymes cut out the normal allele
-many copies of the allele are made
-copies of the normal working allele are put into the cells of a person who has the genetic disorder due to a mutated or faulty copy of an allele.

Problems in the process
The problems involved in the process:
-the alleles may not go into every target cell, which are cells that need the new non-faulty cell
-the alleles may be inserted into the chromosomes in random places, rather than in the required position, so they do not work properly
-some treated cells may be replaced naturally by the patient's own untreated cells, as cells are frequently replaced through the process of mitosis during growth and repair

Different methods
Different methods are used to get the alleles into the patient's cells, including:
-using nose sprays, which allow a patient to introduce the working allele up their nose and it will be taken into their body and incorporated
-using cold viruses that are modified to carry the allele - the viruses go into the cells and infect them
-the direct injection of DNA
Gene therapy can have major ethical implications in society as people disagree with gene alteration in people, as they believe it is unnatural. Other people think that gene therapy is a good idea, as it prevents unnecessary suffering in affected individuals. Gene therapy only affects the individual involved in the process and not any future generations who would be likely to inherit similar diseases.

AQA Biology B6: Inheritance, genetics and variation

Natural selection is a process where organisms that are better adapted to an environment will survive and have more offspring. This means their genes are passed on to the future generations. This process is fundamental to the process of **evolution**.
Charles Darwin was a famous English naturalist, who during his life came up with a theory of evolution. He is associated with the term 'survival of the fittest' which describes how natural selection works, by selecting the best examples of an organism to survive. For example, individuals that are best adapted to their environments are more likely to survive and therefore reproduce.

Selective breeding or artificial selection is when humans breed plants and animals for particular genetic characteristics.

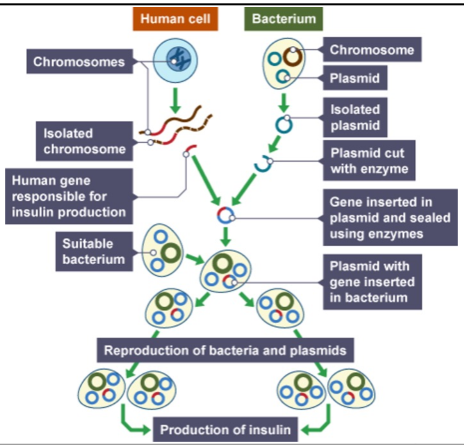
Selective breeding takes place over many generations. These are the main steps for both plants and animals involve:
1 Decide which characteristics are important enough to select.
2. Choose parents that show these characteristics from a mixed population.
3. They are bred together.
4. Choose the best offspring with the desired characteristics to produce the next generation.
5. Repeat the process continuously over many generations, until all offspring show the desired characteristics.

Desirable characteristics in plants	**Desirable characteristics in animals**
Disease resistance Increased yield Large/unusual flowers	Increased milk or meat Large eggs Gentle temperament
Benefits	**Risks**
New varieties may be economically important Produce more or better quality food	Reduced genetic variation Rare diseases can be unknowingly selected Physical problems

Genetic engineering is also called **genetic modification** or GM. It involves modifying the genome of an **organism** by introducing a **gene** from another organism to result in a desired characteristic.
Genetic engineering involves these steps:

1. selection of the desired characteristic
2. the gene responsible for the characteristic is 'cut out' of the **chromosome**
3. the gene is transferred and inserted into another organism
4. replication of the modified organism.

Uses include: making insulin, genetically modified crops, golden rice, treating medical diseases



Benefits of genetic engineering

Genetic modification is a faster and more efficient way of getting the same results as selective breeding.
Improve crop yields or crop quality, which is important in developing countries. This may help reduce hunger around the world.
Introduce herbicide resistance, which results in less herbicides being used, as weeds are quickly and selectively killed.
Insect and pest resistance can be developed and inserted into the plants. The plant produces toxins, which would discourage insects from eating the crop.
Sterile insects could be created such as a mosquito. They would breed, which would lead to infertile offspring. This may help with spread of diseases, such as malaria, dengue fever and the Zika virus.

Risks of genetic engineering

Transfer of the selected gene into other species. What benefits one plant may harm another.

Some people believe it is not ethical to interfere with nature in this way. Also, GM crop seeds are often more expensive and so people in developing countries cannot afford them.

GM crops could be harmful, for example toxins from the crops have been detected in some people's blood.
GM crops could cause allergic reactions in people.

Pollen produced by the plants could be toxic and harm insects that transfer it between plants.

Cloning

Clones are genetically identical individuals. The cloning of plants has many important commercial implications. It allows a variety of a plant with desirable characteristics to be produced cheaply, quickly and on a large scale. Cloning often follows **genetic modification**. It allows many copies of the GM organism to be produced. **Cloning** expensive food crops has been carried out for many years, and causes the public fewer ethical and moral concerns than animal cloning.

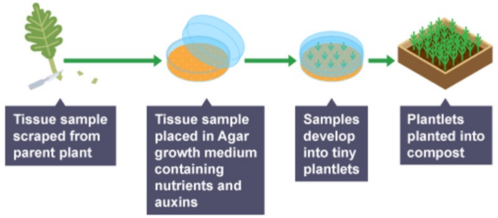
Cuttings

The simplest way to clone a plant involves taking a **cutting**. This is an old but simple technique, used by gardeners. A branch from the parent plant is cut off, its lower leaves are removed, and the stem is planted in damp compost. Plant hormones are often used to encourage new roots to develop. The cutting is usually covered in a clear plastic bag to keep it moist and warm. After a few weeks, new roots develop and a new plant grows.

Embryo transplants	**Adult cell cloning**
Sperm is taken from a animal Artificial insemination happens Zygotes develop and then are removed from the uterus Embryos develop Embryos are split into smaller cells before they specialise Identical embryos are transplanted into the host mothers Offsprings are clones of each other	The nucleus is removed from an unfertilised egg cell. The nucleus from an adult body cell, such as a skin cell, is inserted into the egg cell. An electric shock stimulates the egg cell to divide to form an embryo. These embryo cells contain the same genetic information as the adult skin cell. When the embryo has developed into a ball of cells, it is inserted into the womb of an adult female to continue its development

Tissue culture

Another way of cloning plants is by **tissue culture** also called **micropropagation**. It works with small pieces of plants, called **explants**. These are grown **in vitro** using sterile **agar jelly** that contains plant hormones and nutrients. This makes tissue culture more expensive and difficult to do than taking cuttings. This is an important way to preserve rare plant species or grow commercially in larger nurseries



AQA Biology B6: Inheritance, genetics and variation

Jean Baptiste Lamarck
Lamarck's theory involved two ideas:
- a characteristic which is used more and more by an organism becomes **bigger and stronger**, and one that is not used eventually **disappears**
- any feature of an organism that is improved through use is **passed to its offspring**

However, through modern science we now know that in the vast majority of cases this type of inheritance cannot occur.
Lamarck's theory cannot account for all the observations made about life on Earth.

Charles Darwin
Darwin proposed that:
- individual organisms within a particular species show a wide range of variation for a characteristic
- individuals with characteristics most suited to the environment are more likely to survive to breed successfully
- the characteristics that have enabled these individuals to survive are then passed on to the next generation

This theory is called natural selection.

Alfred Russel Wallace was a great admirer of Darwin and a fellow naturalist, who independently proposed the theory of evolution by natural selection. Wallace produced scientific journals with Darwin in 1858, which prompted Darwin to publish On the Origin of Species the following year. Wallace worked around the world gathering evidence to support his evolutionary theory.

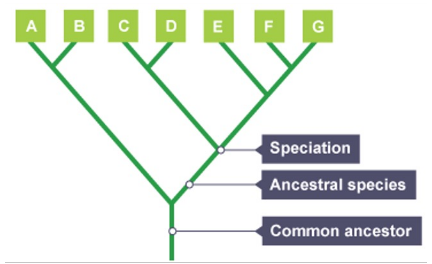
Alfred Russel Wallace
A **species** is a group of organisms able to interbreed and produce fertile offspring.

New species as a result of:	**Isolation can also cause new species to arise by:**
Genetic variation Natural Selection Speciation	Geographical isolation Preventing interbreeding Mutations Evolution

Fossils
A **fossil** is the preserved remains of a dead **organism** from millions of years ago. Fossils are found in rocks and can be formed from:
- hard body parts, such as **bones and shells**, which do not decay easily or are replaced by minerals as they decay
- parts of organisms that have not decayed because one or more of the conditions needed for decay are absent. For example, **dead animals and plants** can be preserved in **amber**, peat bogs, tar pits, or in ice
- preserved traces of organisms, such as **footprints**, **burrows** and rootlet traces - these become covered by layers of **sediment**, which eventually become rock

The fossil record is incomplete as we have not found all of the fossils as some early organisms were soft bodied.

Evolutionary trees
Evolutionary trees are used to represent the relationships between organisms. Branches show places where **speciation** has occurred, and a new species has evolved.



In this evolutionary tree, species A and B share a recent common ancestor. Species A is therefore most similar to species B.

Species F and G also share a recent, yet different, common ancestor, which itself shared a common ancestor with species E. All seven species share a common ancestor, probably from the distant past. The information is collected from a variety of sources such as fossil records to DNA sequences.

Antibiotic resistance
Bacteria can evolve quickly because they reproduce at a fast rate. Mutations of **bacteria** produce new strains. Some bacteria might become **resistant** to certain **antibiotics**, such as penicillin, and cannot be destroyed by the antibiotic. The evolution of the bacteria is an example of **natural selection**.

Development of resistance
The main steps in the development of resistance are:
- random mutations occur in the genes of individual bacterial cells
- some mutations protect the bacterial cell from the effects of the antibiotic
- bacteria without the mutation die or cannot reproduce when the antibiotic is present
- resistant bacteria can reproduce with less competition from normal bacterial strains

We can reduce the spread by not over prescribing, completing the course of antibiotics, and restricting agricultural antibiotic use

Extinction
Extinction occurs when there are no remaining individuals of a species alive.
- Several factors can cause a species to become extinct. They include:
- new diseases
- new **predators**
- new, more successful competitors
- changes to the environment over geological time, such as climate change
- a single catastrophic event, such as a massive volcanic eruption or a collision between an asteroid and the Earth
- A species may also become extinct through speciation.

Carl Linnaeus
Living organisms are classified into groups depending on their structure and characteristics. This system was developed in the eighteenth century by Carl Linnaeus. The classification of species allows the subdivision of living organisms into smaller and more specialised groups.

Domain
Kingdom
Phylum
Class
Order
Family
Genus
Species

The **binomial** system of naming species uses Latin words. Each name has two parts, the genus and the species. For example, human beings belong to the genus *Homo*, and our species is sapiens - so the scientific name is *Homo sapiens*. The binomial system is important because it allows scientists to accurately identify individual species.

Three-domain system
Classification systems have continued to be developed by other scientists, such as Carl Woese who developed the three-domain system. This is based on evidence now available from chemical analysis.
The updated system divides organisms into:
- Archaea (primitive bacteria usually living in extreme environments)
- Bacteria (true bacteria)
- Eukaryota (including protists, fungi, plants and animals)

AQA Biology B7: Ecology

Key words

Ecosystems- Interaction of living organisms (biotic) with non living (abiotic) parts of their environment
Abiotic- non living factors in an ecosystem
Biotic- living factors in an ecosystem
Interspecific competition- competition between individuals of different specific species
Intraspecific competition- competition between individuals of the same species
Biodiversity- variety of all the different species of organisms on earth or within an ecosystem
Trophic level- level of feeding in a food web or chain
Decomposers- breakdown of dead plant and animal matter by secreting enzymes or by detritus feeders
Adaptations- features that enable organisms to survive in conditions where they normally live
Extremophiles- organisms that live in extreme environments for example high/low temperatures, high/low salinity, high/low pH. high/low pressures
Quadrat- set, square area that is placed and organisms can be counted
Transect- a line that is measured which one counts and records how many different species are in a quadrat
Predator- An animal that hunts, kills and eats other animals for food
Prey- Organisms that predators kills for food
Consumer- an organism that eats
Sampling- The selection of subjects included in a study/experiment/investigation.
Peat bog- Muddy area of land that is a carbon sink
Carbon sink- an area/body that absorbs lots of carbon dioxide

Interdependence and competition

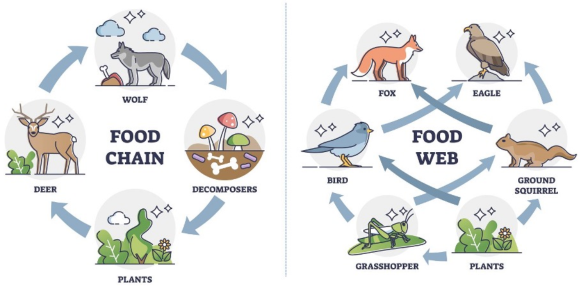
To survive and reproduce organisms need materials from their surroundings and other living organisms. Plants in a community or habitat often compete with each other for light and space, and for water and mineral ions from the soil. Animals often compete with each other for food, mates and territory.

Organisms have adaptations that enable them to survive in the conditions in which they normally live. These adaptations may be structural, behavioural or functional.

Some organisms live in the environments that are very extreme, such as high temperatures, pressures or salt concentration. These organisms are extremophile-bacteria living in deep sea vents or the mouth of the volcano are examples of them.

Levels of organisation

Feeding relationships within a community can be represented by food chains. All food chains begin with a producer which synthesises molecules. This is usually a green plant or algae which makes glucose by photosynthesis. Producers are eaten by primary consumers, which in turn may be eaten by secondary consumers and then tertiary consumers. At the top of a food chain or web there is an Apex predator.



Abiotic factors

Abiotic factors are non-living. They include light intensity, temperature and moisture levels. The abundance and distribution of living organisms in an **ecosystem** are affected by abiotic factors.

Examples of abiotic factors include:

- Temperature
- Water levels
- Soil pH
- Soil moisture
- Humidity
- Oxygen concentration (in aquatic environments)
- Concentration of carbon dioxide
- Salinity levels
- Wind

Biotic factors

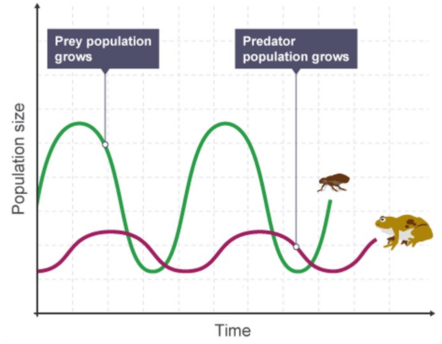
The abundance and distribution of organisms are affected by **biotic** factors, which are factors that are living.

Examples of biotic factors include:

- **New predators**- this can have a devastating effect. Predators need to catch enough prey to survive.
- New pathogens- Pathogens can be very quickly transmitted through population.
- **Out competition-** is when one species out-competes another and causes the population to decrease due to lack of food and resources.
- **Availability of food-** All animals need food to survive and if food is limited this will affect the population. Ecosystems with rich food supplies have more species than other areas.

Predator- prey relationships

In a healthy, balanced **ecosystem** the numbers of **predators** and **prey** remain fairly constant. They can go up and down during each year but generally over the years, these increases and decreases remain fairly constant.



Quadrats are square frames of wire usually 0.25 m^2. These are placed on the ground to look at the plants or slow-moving animals within them. When looking at plants in a quadrat the following sampling can be used:

- **Number of an individual species**: the total number of individuals of one species (eg daisies) is recorded.
- **Species richness:** the number of different plant or animal species is recorded but not the number of individuals within a species.
- **Percentage cover:** the percentage of the quadrat area that is covered by one species (eg grass). This is easier to estimate if a quadrat has wires making smaller sections. Percentage cover rather than number of individuals is used when estimating plant frequencies if it is difficult to identify individual plants, such as grasses or moss.

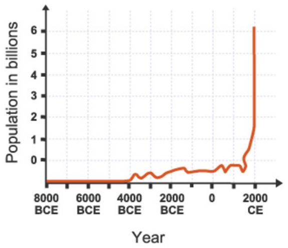
Sampling

Random sampling using a quadrat involves the placing of quadrats at random coordinates. Regardless of whether you are investigating the number of individual species, the species diversity or the percentage cover in different areas you would use random sampling.

Systematic sampling would be used along the transect to link changes in **species** to abiotic factors. This is when a quadrat is placed at regular intervals along a transect to monitor and measure distribution across a habitat. Examples where this could be used include under a tree to a field, from a walk/pathway or across different habitats.

Human population growth

The number of people alive now is at a record level and is increasing.



Graphs of this shape are called **exponential**. Interestingly, we see the same pattern of growth in many populations of living organisms with sufficient resources. There are many reasons why our population increases:

-better health care so people are living longer
-new medicines are being developed so people don't die of previously fatal diseases
-farmers are able to produce more food using new breeds and equipment
-some religions do not permit the use of **contraception**

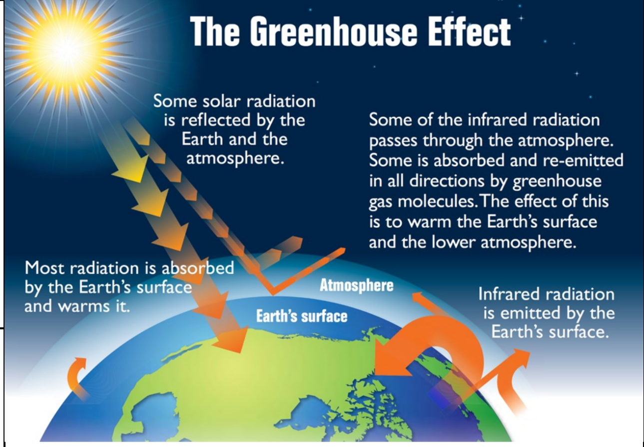
As the population grows, the pollution we produce also increases, which may cause significant issues.

Deforestation

Is the process of cutting down trees for resources or space as the land is needed for farming, building or industry. Deforestation destroys the **habitats** of the organisms that live there and through this kills individuals of many **species**.

Peat bogs

Peat bogs are large areas where decomposition is very slow and peat is formed. Peat is used by gardens. When peat is removed this reduces biodiversity. Peat bogs also store lots of carbon and are carbon sinks- if we remove them it contributes to the greenhouse effect.



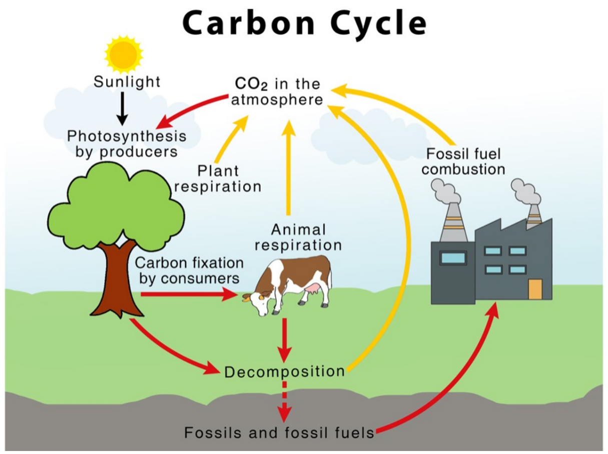
The consequences of global warming are the melting of the ice caps, sea levels rise, flooding, weather patterns changing, animal migration patterns change, tropical diseases increase and spread, species may become extinct

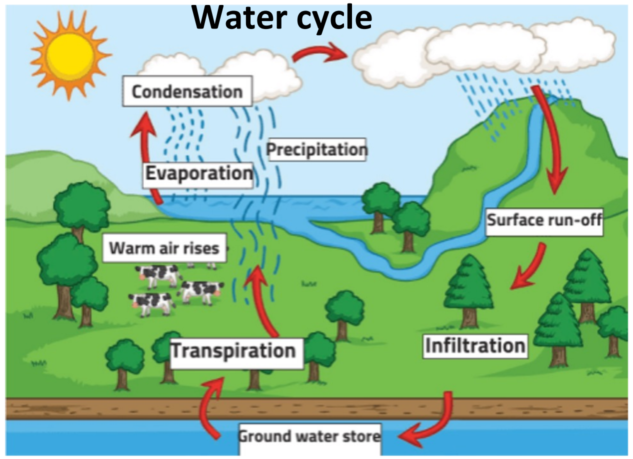
Maintaining biodiversity:

-Breeding programmes to preserve endangered species
-Protect and develop new endangered habitats (National parks)
-Replanting hedgerows because there is a higher biodiversity in them than in fields they surround
-Reducing deforestation and the release of greenhouse gases
-Recycling rather than landfills

Cycling materials

Atoms exist in different forms or compounds at different times in history and cycle between them. We can see this cycling in the **element** carbon and the **compound** water.





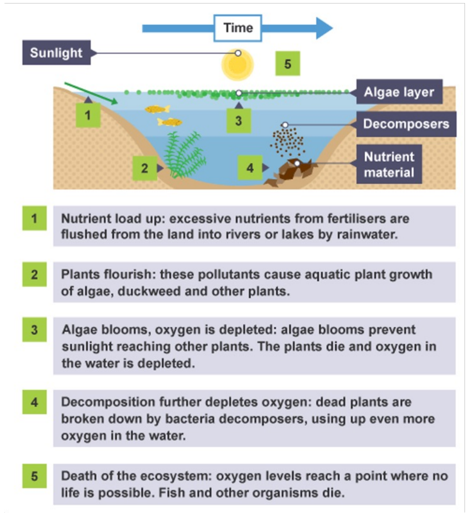
Other elements and compounds also exist in cycles. Many humans eat protein in the form of meat from other animals. Our bodies break this down into its constituent parts called amino acids and then use these to make proteins within our own bodies for growth and repair. When we eventually die these building blocks are returned to the environment to be used by other living organisms.

Decomposing bacteria and fungi help dead organisms break down and rot. They help recycle minerals and nutrients to the environment, which can then be used by other organisms. As they **decompose** dead matter, the decomposers also **respire** and so release carbon dioxide to the environment, contributing to the **carbon cycle**.

Pollution and waste management

As the human **population** increases, the volume of waste and **pollution** that is produced also increases. Polluting an **ecosystem** harms or kills the organisms that live within it.

Water pollution: Some farmers use too many fertilisers, which can run off fields during heavy rain. This can pollute nearby streams and rivers leading to **eutrophication**. Some water pollution even comes from **toxic** chemicals released illegally by factories.



Air pollution Combustion of fossil fuels and other fuels releases carbon dioxide. This contributes to the **greenhouse effect** and leads to **global warming**. It also releases sulfur dioxide and nitrogen oxides which can cause acid rain. Air pollution can also be caused by tiny particulates from smoke which can cause **smog**.

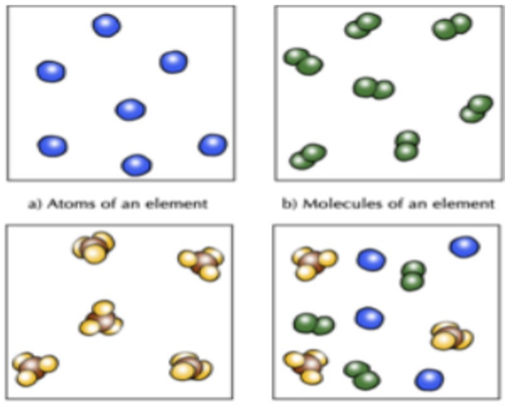
Land pollution: The rubbish we throw out that is not **recycled** goes into a landfill. These are huge holes in the ground into which our rubbish is dumped. Some things like batteries cannot be put into **landfill sites** because of the toxic chemicals they contain. They must be recycled. Other land pollution comes when some people dump rubbish in public or other private places, often to avoid paying for it to be disposed of. This is caused fly tipping and is illegal.

Land use: The larger the human population gets, the more land we require. More houses must be built, more resources found, more food must be grown and more waste is produced. This often means less space and fewer resources for other animals and plants.
Often **biodiversity** is significantly reduced when land is cleared for human uses, such as building, quarrying, farming and waste disposal. Think about the reduction in biodiversity, which occurs when an area of rainforest is cut down to grow crops.

AQA Chemistry C1: Atomic Structure and the Periodic Table

All the elements are listed in the **periodic table.**

Elements are chemically combined together to make **compounds.**
A **chemical reaction** is needed to make elements into compounds.
Elements are made up of atoms that are all the same.
Compounds are made of different elements.
If two or more atoms join together by sharing their electrons they are a **molecule.**
Mixtures are not chemically combined.



a) Atoms of an element
b) Molecules of an element
c) Molecules of a compound
d) Mixture of elements and a compound

You can see which elements are in a compound by looking at its **formula.**

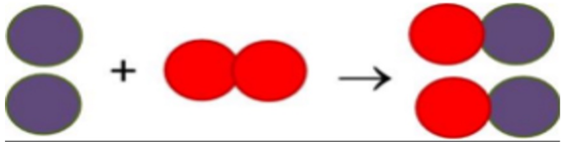
e.g. MgO contains Magnesium (Mg) and Oxygen (O)
The word equation would be:
Magnesium + Oxygen → Magnesium oxide

The symbol equation would be:

$Mg + O_2 \rightarrow MgO$

We need to make sure this is balanced:

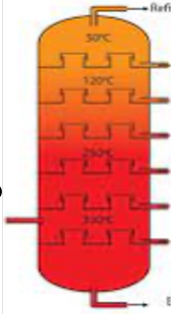
$2Mg + O_2 \rightarrow 2MgO$



Mixtures can be separated by **physical processes** – they do not require a chemical reaction.

Filtration, Crystallisation, Distillation, Chromatography

Fractional distillation is used to separate liquids that have different boiling points. The tower is cooler towards the top The gases will rise up until they reach their condensing temperature, where the liquids will run off.

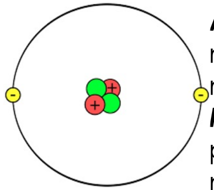


Atomic theory has developed over time:

- 400BC – **Democritus** described material as being made of small particles called 'atoms'
- 1803AD – **Dalton** said all matter is made of atoms and there different types
- 1897AD – **JJ Thomson** discovered the **electron.** Proposed the plum pudding model where negative electrons were embedded in a ball of positive charge
- 1911AD – **Rutherford** suggested the atom has a positively charged nucleus and consisted mostly of empty space
- 1913AD – **Niels Bohr** explained that electrons orbited the nucleus at specific distances
- 1932AD – **James Chadwick** discovered the **neutron**

The structure of the atom		
	Relative Charge	Relative Mass
Electron	-1	0.0005
Proton	+1	1
Neutron	0	1

Protons and Neutrons are in the NUCLEUS
Electrons ORBIT the NUCLEUS

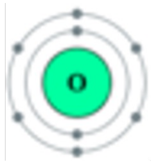


Atomic (proton) number is the number of protons in the nucleus of an atom
Mass number is the number of protons and neutrons in the nucleus

	Atomic number	Mass number	Number of protons	Number of electrons	Number of neutrons
Carbon	6	12	6	6	6
Fluorine	9	19	9	9	10
Sodium	11	23	11	11	12

Isotopes of an atom have the same numbers of protons and electrons, but a different number of neutrons.
The **Relative Atomic Mass (A_r)** is the average mass of all the different isotopes of an element

$$A_r = \frac{(\%\ of\ isotope\ a \times mass\ of\ isotope\ a) + (\%\ of\ isotope\ b \times mass\ of\ isotope\ b)}{100}$$



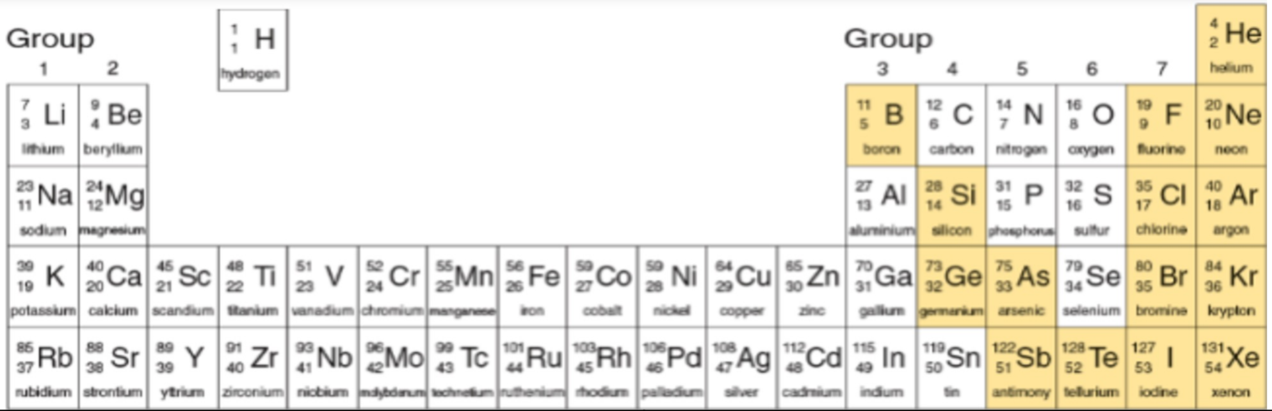
Electrons occupy shells:

- 1st shell = 2 electrons
- 2nd shell = 8 electrons
- 3rd shell = 8 electrons

The electronic structure can be numbered e.g. 2,8,2 = Mg
If an atom loses an electron it becomes charged. A charged particle is called an **ion**

Keywords: (you should be able to spell, say, and use these terms):

Atom – the smallest part of an element that can not be broken down
Element – a substance made from only one type of atom
Compound - a substance made from two or more elements, chemically combined
Molecule – a substance made from two or more atoms, chemically combined
Proton – found in the nucleus of an atom. Has a charge of +1
Neutron – found in the nucleus of an atom. Has a charge of 0
Electron – found orbiting the nucleus of an atom. Has a charge of -1
Atomic (Proton) number – the number of protons in the nucleus of an atom
Mass number – the number of protons and neutrons in the nucleus of an atom



The periodic table is arranged by the atomic (proton) number.

- The **groups go down** the periodic table. Elements in the same group have the same number of electrons in their outer shell, but a different number of shells.
- The **periods go across** the periodic table. Elements in the same period have the same number of shells, but a different number of electrons in their outer shell.

The periodic table has developed over time:

- Some elements have been known since ancient times.
- 1829 AD - **Dobereiner** arranged into 'triads' based on their properties. This only worked for very few elements (Li, Na, K, Cl, Br, and I).
- 1860 AD - new list of more accurate atomic weight published.
- 1865 AD - **John Newlands** noticed that when elements were ordered by atomic weight, there was often a pattern of similar properties every eight elements - 'law of octaves'
- 1869 AD - **Dimitri Mendeleev** also ordered by atomic weight BUT has left gaps for elements which hadn't been discovered yet.
- 1932 AD - Discovery of isotopes fully explained why atomic number is used.

Metals are found to the left of the periodic table. **Non-metals** are found to the right.

Physical properties:

Metals	Non-metals
lustrous	dull
hard (with the exception of mercury which is a liquid at room temperature)	soft, brittle, liquids or gas (for most non-metals at room temperature)
high density	low density
high tensile strength	low or no tensile strength or gas
high melting point and boiling point	low melting point and boiling point
good conductors of heat	poor or no **thermal conductivity**
good electrical conductivity	poor or non conductors of electricity (with the exception of carbon)

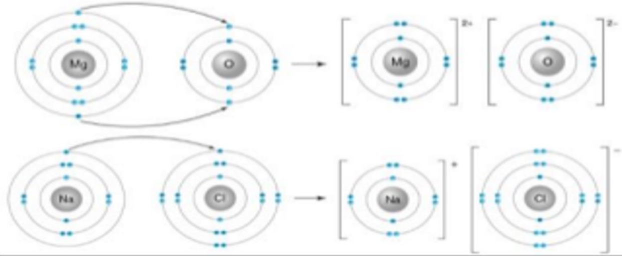
Chemical properties:

Metals	Non-metals
React with oxygen to make oxides	React with oxygen – e.g. carbon and oxygen make carbon dioxide
React with acid to make salt	

Sulfur and phosphorus both react with oxygen to make oxides. Both sulfur dioxide and phosphorus oxide turn universal indicator red. They are acidic oxides.	Calcium and potassium both react with oxygen to make oxides. Both calcium oxide and potassium oxide turn universal indicator blue. They are basic oxides.

Metals form basic oxides. Non-metals form acidic (or neutral) oxides.

Ions are charged particles. **Metals lose electrons** to form positive ions. **Non-metals gain electrons** to form negative ions.



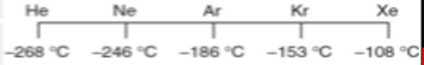
Patterns in reactivity

Group 0
Helium (He)
Neon (Ne)
Argon (Ar)
Krypton (Kr)
Xenon (Xe)

Group 0 elements (Noble Gases)

- They are all gases.
- They are all unreactive (because they all have a full outer shell)

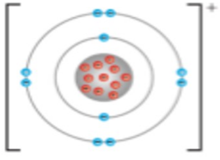
The boiling point increase down the group.



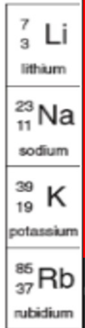
Group 1 elements (alkali metals)

- React vigorously with water to make hydrogen and metal hydroxide.
- Reactivity increases down group.

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

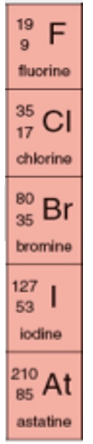


- Burn in oxygen to form oxides.
- Make ions with a **+1 charge.**



Group 7 elements (halogens)

- Non-metals
- Exist in pairs (F_2, Cl_2)
- React vigorously with metals
- Reactivity decreases down group



Potassium + Chlorine → Potassium Chloride
$2K + Cl_2 \rightarrow 2KCl$

- React with metals to make salts
- React with non-metals to make gases or liquids such as acids
- **More reactive halogens will displace less reactive halogens in metal halide solutions**
- Gas (F_2, Cl_2), Liquid (Br_2) and Solid (I_2) at room temperature.

The reactivity in Group 1 and 7 are in opposite directions.

- Reactivity increases down Group 1 because outer shell electrons get further away from the nucleus as you go down the group. There is less 'pull' on the electron, so it is lost more easily.
- Reactivity decreases down Group 7 because the outer electron gets further away from the nucleus as you go down the group, so it is harder for the nucleus to pull electrons in to make a full outer shell.

Transition metals are found between Groups 2 and 3.

- They have typical metal properties
- They are often used as catalysts (speed up reactions)
  - Iron is used in Haber Process to make ammonia
  - Nickel is used in the manufacture of margarine
- Compounds are often coloured

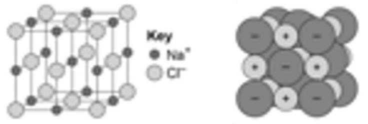
Compound	Copper	Iron(II)	Iron(III)	Nickel
Colour	Blue	Pale green	Orange/Brown	Green

AQA Chemistry C2: Bonding, structure and the properties of matter

Key Words

Ion - an atom or compound with a positive or negative charge.
Electrostatic Attraction - the attraction between positive and negative charges.
Cation - a positive ion.
Anion - a negative ion.
Lattice - a giant structure of alternating positive and negative ions.
Intermolecular force - forces that occur between molecules.

Ionic Lattice



Ionic Lattice: a giant structure of ions in regular arrangement. A positive ion followed by a negative ion.

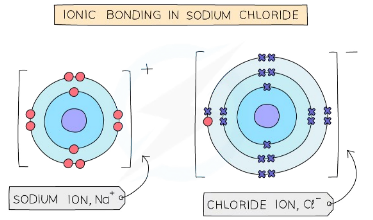
These forces act in all directions in the lattice

Ionic Bonding

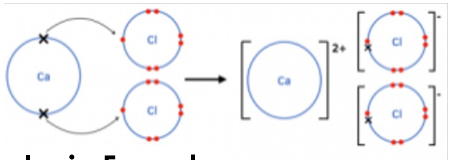
You should be able to explain how ionic bonding works and draw dot and cross diagrams for it.

Ionic bonding occurs in compounds formed from metals combined with non-metals.

Outer shell electrons are **transferred** from the metal to the non-metal. The metal forms a positive ion, the non-metal forms a negative ion.



As shown in the dot and cross diagram, Sodium outer shell electron (red circle) is transferred to Chlorine outer shell.



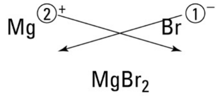
This is the dot and cross diagram for $CaCl_2$. Calcium has two outer shell electrons. Chlorine has space for one electron in its outer shell. Two chlorine atoms are needed.

Ionic Formula

When two ions form an ionic compound, their formula can be determined from the charges of the individual ions.

Ca^{+2}	Cl^{-1}	$CaCl_2$
Ba^{+2}	O^{-2}	BaO
K^{+1}	S^{-2}	K_2S
Fe^{+3}	Br^{-1}	$FeBr_3$
Cr^{+3}	O^{-2}	Cr_2O_3

Ionic Formula Trick



Properties of Ionic Compounds:

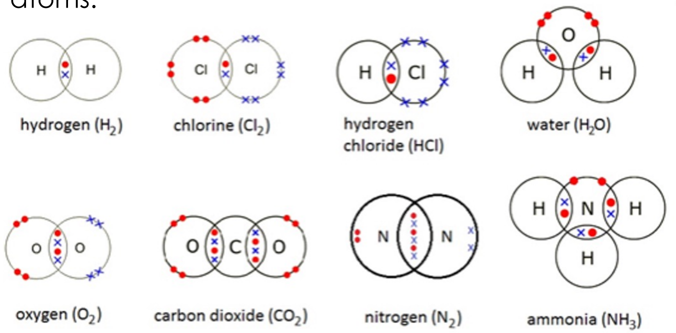
- High boiling and melting point because of strong electrostatic attraction between positive and negative ions.
- Conducts electricity when molten or dissolved in water (aqueous).

Covalent Bonding

You should be able to explain how covalent bonding works and draw dot and cross diagrams on this section.

Covalent bonding occurs in compounds formed from non-metals

Outer shell electrons are **shared** between different atoms.

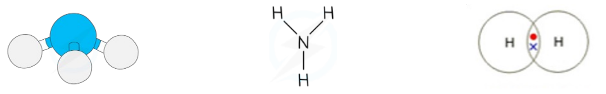


As shown in the dot and cross diagram, electrons are shared between two or more atoms. This is represented by interlocking circles.

Properties of Covalent Compounds:

- Low boiling and melting points.
- Cannot conduct electricity.

Models for Representing Compounds.



Ball and Stick **2D** **Dot and Cross**

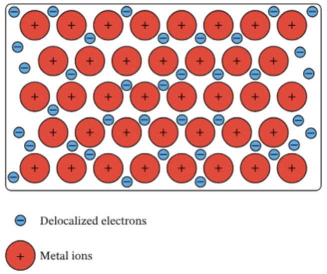
	Dot and Cross	2D	Ball and Stick
Pros	• Useful for illustrating the transfer of electrons • Indicates from which atom the bonding electrons come from.	• Simple and easy to understand • Adequately indicate what atoms are in a molecule and how they are connected	• Useful for illustrating the arrangement of atoms in 3D space • Especially useful for visualizing the shape of a molecule
Cons	• Fails to illustrate the 3D arrangements of the atoms and electron shells • Doesn't indicate the relative sizes of the atoms (all atoms look the same size).	• Fail to illustrate the relative sizes of the atoms and bonds • Cannot give you an idea of the shape of a molecule and what it looks like in 3D space	• Fails at indicating the movement of electrons • The atoms are placed far apart from each other, which in reality is not the case as the gaps between atoms are much smaller.

Metallic Bonding

You should be able to explain the structure of metallic bonding and the properties of metallic bonds.

Metallic bonding occurs in compounds formed from metals and alloys.

Outer shell electrons are in a **sea of delocalised electrons,** surrounding the positive metal ions.

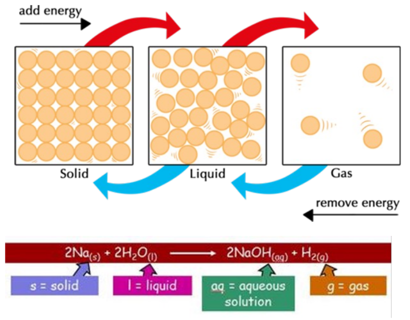


The electrons in the outer shell of metal atoms are **delocalised** and so are free to move through the whole structure. The sharing of delocalised electrons gives rise to strong metallic bonds.

Properties of Covalent Compounds:

- High boiling and melting points.
- Can conduct electricity because of the sea of delocalised electrons.

Change of State and State Symbols



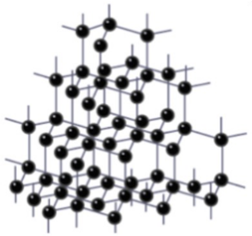
Limitations of model: no forces included, that all particles are represented as spheres and that the spheres are solid.

The amount of energy needed to change state depends on the strength of the forces between the particles of the substance. The stronger the forces between the particles the higher the melting point and boiling point of the substance.

AQA Chemistry C2: Bonding, structure and the properties of matter

Giant Covalent Structures

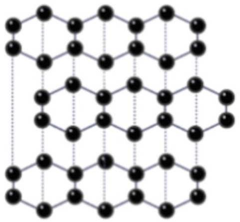
You should be able to identify each giant covalent structure and be able to describe their properties and bonding.



Diamond

Diamond

- Each carbon atom forms four covalent bonds with other carbon atoms.
- Very hard.
- High melting and boiling point because of strong covalent bonds.
- Does not conduct electricity because no delocalised electrons. Each outer shell electron is involved in a covalent bond.



Graphite

Graphite

- Each carbon atom forms three covalent bonds with three other carbon atoms.
- A single layer is called **graphene.**
- Layers of hexagonal rings which have no covalent bonds between the layers.
- High melting and boiling point because of strong covalent bonds.
- Can conduct electricity because of one delocalised electron.

Fullerene

Fullerene

- Each carbon atom forms four covalent bonds with other carbon atoms in a cyclical manner.
- High melting and boiling point because of strong covalent bonds.
- Does not conduct electricity because no delocalised electrons. Each outer shell electron is involved in a covalent bond.

Polymers

You should be able to explain what a polymer is and how to pull out repeating units from a long polymer chain.

The atoms in the polymer molecules are linked to other atoms by strong covalent bonds. This means they are usually solid at room temperature.

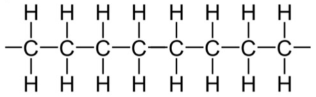
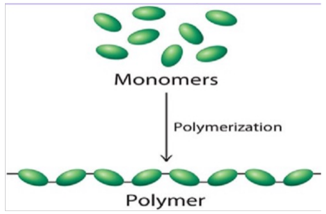


Figure 1. Short segment of poly(ethene). Poly(ethene) consists of many ethene (C_2H_4) molecules covalently bonded together (represented by the black lines). The covalent bonds at the end have been left empty to represent the long length of the chain.



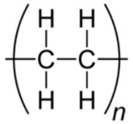
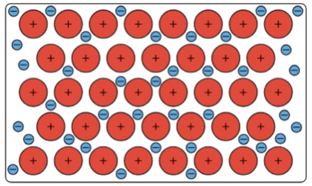


Figure 2. Repeating Unit. A more efficient way to represent polymers is through drawing the smallest repeating unit. The figure represents the smallest repeating unit ethene (C_2H_4) in brackets with bonds coming out of the bracket to represent the next repeating unit. The 'n' is a large number and illustrates just how big the polymer is!

Properties of Metals

You should be able to identify properties of metals and explain how the structure of metals contributed to these properties.



In pure metals, atoms are arranged in layers, which allows metals to be bent and shaped.

- High melting and boiling point because of strong bonds between positive and negative ions.
- Metals are good conductors of electricity because the delocalised electrons in the metal carry electrical charge through the metal.
- Metals are good conductors of thermal energy because energy is transferred by the delocalised electrons.

Nanoparticles

You should be able to describe what a nanoparticle is and calculate the order of magnitude.

Particle	Diameter
Atoms and small molecules	0.1 nm
Nanoparticles	1 to 100 nm
Fine particles (also called particulate matter - $PM_{2.5}$)	100 to 2,500 nm
Coarse particles (PM_{10}, or dust)	2500 to 10,000 nm
Thickness of paper	100,000 nm

Nanoscience is the study of structures that are between 1 and 100 nanometres (nm) in size.

Uses of Nanoparticles

- medicine
- electronics
- cosmetics
- sun creams
- deodorants
- catalysts

Advantages	Disadvantages
• Can be used in cosmetics as it is absorbed much deeper into the skin. • Can be used to deliver medicines as it is easily absorbed.	• Breathing in tiny particles could have negative effects on our lungs. • Could damage our cells if used to deliver medicine. • Nanoparticle could accumulate in the organism over time. We do not know the long-term effects of this.

A zinc oxide nanoparticle has a diameter of 32 nm. The diameter of a zinc atom is 0.28 nm. Estimate how many times larger the nanoparticle is compared to a zinc atom.

Worked example answer

Round each number to 1 significant figure:

30 nm and 0.3 nm

Number of times larger $\approx \frac{30}{0.3} = 100$

The nanoparticle is about 100 times larger than the zinc atom. This is an example of an **order of magnitude** calculation.

AQA Chemistry C3: Quantitative Chemistry (Blue - Triple only, Red - Higher only)

Keywords and Terms:

Accuracy: how closely a measured value of a quantity matches its 'true' value

Avogadro's number: the number of atoms, ions or molecules in one mole of any substance (6.02×10^{23})

Avogadro's Law: at a given temperature and pressure, equal volumes of different gases will contain an equal number of molecules

Atom economy: a measure of how many reactant atoms form a desired product

Closed system: a system where no substances can enter or leave during a reaction. This means a container will have the same mass at the start and end of a reaction

Concentration: the amount of substance dissolved in a given volume of water

Conservation of Mass: no atoms are lost or gained in a chemical reaction

Isotopes: forms of an element that have the same number of protons but a different number of neutrons

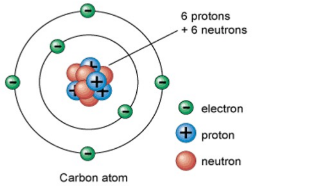
Limiting Reactant: the reacting substance that is completely used up in a chemical reaction, and determines how much of a product is made

Mole: one mole is the Avogadro's number of particles in a substance

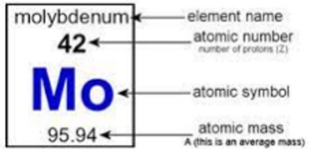
Non-enclosed: a system in which gases and other substances can enter and leave during a reaction, this means the total mass of a container will change

Relative Masses and the Mole

You must be able to calculate the relative formula mass of a compound, use this to calculate the number of moles for a given mass of a substance, (and use this to calculate the number of particles in the mass)



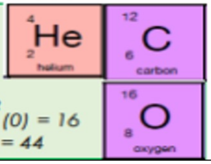
Atoms are made up of **protons**, **neutrons** and **electrons**.
Protons and neutrons have a mass of 1. Electrons are negligible.

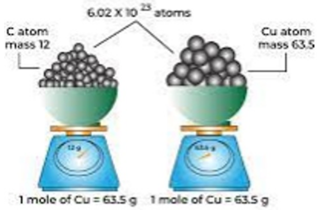


Ar is the Atomic mass of an element
Mr is the molecular or formula mass of a compound. It is the combination of all the elements

Worked examples
Helium (He) Ar = 4

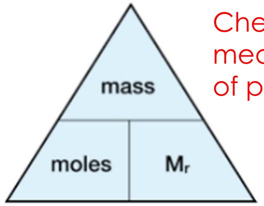
Carbon dioxide = CO_2
Carbon (C) = 12 Oxygen (O) = 16
Mr of CO_2 = 12 + (16 x 2) = 44



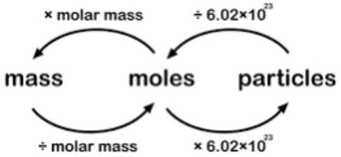


The masses of atoms are compared by measuring them relative to atoms of Carbon-12.
One mole of any substance is its relative formula mass, in grams.

Moles = Mass / Mr



Chemical amounts are measured in **moles**. The number of particles in 1 mole is 6.02×10^{23}



6.20×10^{23} atoms = 1 mole

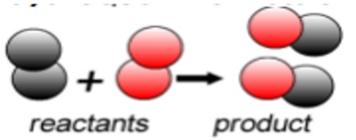
Calculating Relative Atomic Mass, Ar

The relative atomic mass of an element is the mean value for the isotopes of that element. It takes into account the percentage abundance of the isotopes. E.g. Cl has 2 isotopes:

$$A_r = \frac{(75x35)+(25x37)}{100} = 35.5$$

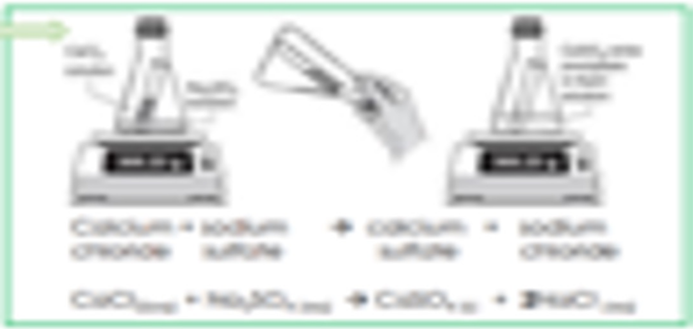
Conservation of Mass

Mass of reactants must **always** equal the mass of the products. We cannot create or destroy atoms.



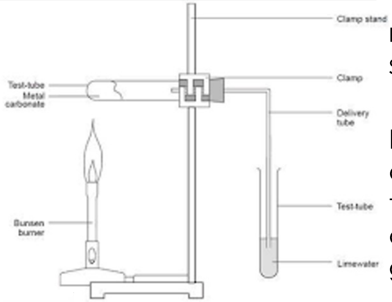
2g + 2g → 4g

Conservation of mass always occurs, but is easiest to prove in a **closed system**, such as the experiment below.

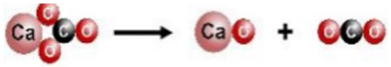


Some reactions appear to involve a change in mass, because a reactant or product is a **gas** and its mass has not been accounted for. This occurs in **non-enclosed** systems.

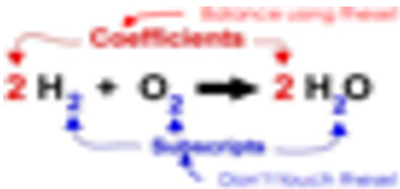
Non-enclosed: Thermal decomposition
The reaction seems to lose mass as CO_2 escapes



Lime water goes cloudy showing the presence of carbon dioxide gas



$CaCO_3$	→	CaO	+	CO_2
100g	→	56g	+	44g



Balancing Equations

There are the same numbers of each type of atom at the start and end of any reaction, this means that equations must be **balanced**.

$Mg + O_2 \rightarrow MgO$ **(unbalanced)**

$2Mg + O_2 \rightarrow 2MgO$ **(balanced)**

AQA Chemistry C3: Quantitative Chemistry (Blue - Triple only, Red - Higher only)

Keywords and Terms:

Percentage yield - the actual mass of a product collected in a reaction, divided by the maximum mass that could have been formed in theory, x100.

Range - the difference between the highest and lowest values in a set of data.

Relative atomic mass, Ar - the average mass of the atoms compared with Carbon -12. The average mass of all the isotopes of an element.

Reaction pathway - the sequence of reactions needed to produce a desired product from a particular set of raw materials.

Relative formula mass, Mr - the total mass of all the atoms in a chemical formula.

Resolution - the smallest measurement that a piece of equipment can make.

Solute - the solid that dissolves in a solvent.

Solvent - the liquid in which a solute dissolves.

Solution - mixture formed when a solute dissolves in a solvent.

Theoretical yield - the maximum amount of product that can me made in a chemical reaction.

Uncertainty - the interval between which the true value of a quantity can be expected to lie.

Concentration - the number of particles present in a given volume.

Limiting Reactants

A reaction finishes when one of the reactant is used up. The other reactant has nothing left to react with, so some of it is left over:

- The one that is used up is the **limiting reactant**
- The one that is left over is in **excess**

The mass of the product formed depends on the mass of the limiting reactant

Reacting Masses

The mass of a reactant or product can be determined from the balanced symbol equation. Once balanced, the equations tells you how many moles of each substance react with each other:

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

This equations states that **1 Mg** reacts with **2 HCl** to produce **1 $MgCl_2$** and **1 H_2**

Using the mole formula, calculate the Mr and the moles from the equation, and then you can work out the mass of a product or reactant you have.

Worked example: How much Carbon dioxide can be made from 12g of Carbon?

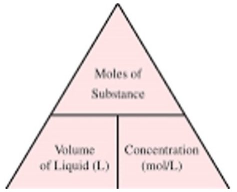
1	2	3	4
Work out the balanced equation $C + O_2 \rightarrow CO_2$	**Calculate the Ar/Mr of the substance they give you the mass for** C = 12	**Calculate the number of moles of this substance** Moles = 12/12 = 1mole	**Calculate the Ar/Mr of the substance you are finding the mass for** CO_2 = 44

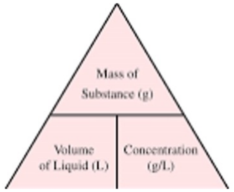
5	6
Find the mole ratio from the equation $C:CO_2$ = 1:1	**Use the equation to calculate the mass of the unknown substance (CO_2)** M = n x Mr; 1 x 44 = **44g**

Concentration calculations

Concentration is a measure of the amount of a substance in a given volume. The amount of substance can be in mass or moles. Volume can be in cm^3 or dm^3

To convert cm^3 to dm^3, divide by 1000





To convert g/dm^3 into mol/dm^3, divide by the Mr

Yield and Percentage yield

The amount of a product that can be formed in theory is known as the **theoretical yield**. The amount of product actually formed is the **actual yield**.

The **percentage yield** tells you how much product was made in comparison to the theoretical yield.

It can be calculated by:

$$\frac{\textbf{Actual yield}}{\textbf{Theoretical yield}} \times 100$$

Factors affecting the yield of a chemical reaction:

- Products left in equipment
- Reversible reactions don't go to completion
- Unexpected reactions
- Loss during separation and purification

Atom economy

The atom economy of a reaction is a measure of the starting materials that end up as useful products. The remaining starting materials are said to be 'wasted' in by products.

It can be calculated by:

$$\frac{\textbf{Mr of desired product}}{\textbf{Total Mr of reactants}} \times 100$$

Maximising atom economy in industry will conserve the world's resources, reduce pollution and waste, and eventually increase the potential profits.

Gas Volume

A certain volume of gas always contains the same number of gas molecules under the same conditions.

One mole of any gas at room temperature and pressure is $24dm^3$ (or $24,000cm^3$).

You can use the molar gas volume and balanced symbol equation to calculate volumes of gaseous reactants or products.

Worked example: What volume of hydrogen is produced from 12g of Magnesium with an excess of Hydrochloric acid?

1. Write the balanced equation: $Mg + 2HCl \rightarrow MgCl_2 + H_2$
2. Find the moles of what you have the mass of: Mg = 12/24 = 0.5mol
3. Find the ratio of Mg to H_2: 1:1 Moles of H_2 is 0.5
4. Calculate the volume of gas: 0.5mol x $24dm^3$ = **$12dm^3$**

AQA Chemistry C4: Chemical Changes (Blue - Triple only, Red - Higher only)

Keywords and Terms:

Acid - when dissolved, solution has a pH of less than 7. Acids have high concentrations of Hydrogen ions (H^+).

Alkali - when dissolved, the solution has a pH of more than 7. Alkalis contain Hydroxide ions (OH^-).

Anode - the positive electrode where electrons go during electrolysis.

Base - reacts with an acid to form a salt as one of its products. Soluble bases are called alkalis.

Cathode - the negative electrode where electrons come out during electrolysis.

Displacement reaction - a reaction in which a more reactive element takes the place of a less reactive element in a compound.

Electrolysis - the breakdown of an substance containing ions, using electricity

Electrolyte - the ionic substance being broken down during electrolysis.

Electrode - the positive or negative conductors (rods) in electrolysis. The anode or cathode.

Half equation - an equation that describes reduction or oxidation. Can be used to show the reactions that occur at electrodes.

Reaction of Metals

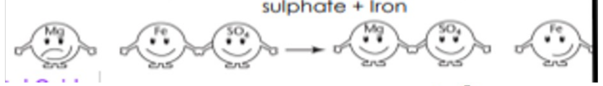
The reactivity series (you must be able to decide which reactions occur and state how one can determine the reactivity of metals)

- potassium — most reactive
- sodium
- calcium
- magnesium
- aluminium
- carbon
- zinc
- iron
- tin
- lead
- hydrogen
- copper
- silver
- gold
- platinum — least reactive

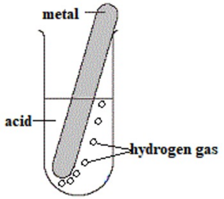
Some metals are so reactive that they react with water. Others are less reactive, but still react with acids. We can order metals by their reactivity.

Reactivity is the tendency of a metal atom to form ions.

A more reactive metal can take the place of a less reactive metal from a solution of its compound.
This is a **displacement** reaction.

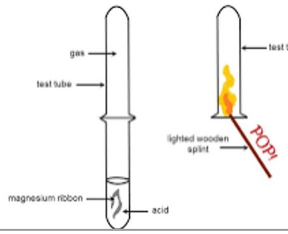


Metal + Oxygen → Metal oxide
Metal + Water → Metal hydroxide + Hydrogen
Metal + Acid → Metal salt + Hydrogen



OILRIG
Oxidation **i**s **L**oss of electrons
Reduction **i**s **G**ain of electrons

E.g. $2HCl + Mg \rightarrow MgCl_2 + H_2$
Magnesium is oxidised:
$Mg \rightarrow Mg^+ + 2e^-$
This is a half equation

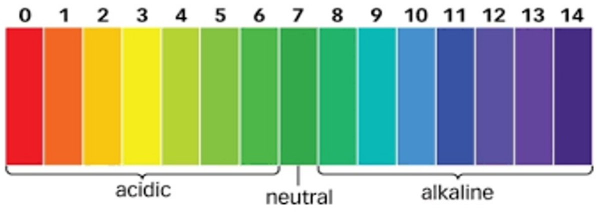


Extracting metals from ores

Silver,gold and platinum are unreactive metals and are found as elements.	Elements below Carbon and above silver can be displaced by carbon (smelting)	Elements above Carbon are extracted using electrolysis.

Reactions of Acids

Acids produce H^+
Alkalis produce



- **A base is a substance that neutralises an acid.**
- Metal oxides and metal hydroxides are bases.
- A few bases are soluble in water, these are called **alkalis.**

NEUTRALISATION happens when an acid and base react

Acid + Base → Salt + Water

An **ionic equation** shows only the atoms and ions that change during a reaction.
E.g.displacing copper with iron
$Fe(s) + Cu^{2+}(aq) \rightarrow Fe^{2+}(aq) + Cu(s)$

Acid + Metal → Salt + Hydrogen
Acid + Alkali → Salt + Water
Acid + Insoluble base → Salt + Water
Acid + Carbonate → Salt + Water + Carbon dioxide

Strong and weak acids

Strong acid	Weak Acid
Lower pH value	Higher pH value
High degree of ionisation	Low degree of ionisation
Has higher concentration of H+ ions	Has lower concentration of H+ ions
Example: hydrochloric acid, Nitric acid, Sulphuric acid	Example: Ethanoic acid, Carbonic acid, Sulphurous acid

It is possible to have an acid that is:
- Strong and concentrated
- Weak and concentrated
- Strong and dilute
- Weak and dilute

Naming Salts formed
Hydrochloric acid → Chloride
HCl
Nitric acid → Nitrate
HNO_3
Sulphuric acid → Sulphate
H_2SO_4

Metal **carbonates** with acids to make a salt and water, but carbon dioxide is also produced

Metal Carbonate + Acid → Salt + Carbon dioxide + Water

Keywords and Terms:

Indicator - a chemical that changes colour in solutions of different pH

Ionic equation - an equation that shows only those atoms or ions that change in a reaction

Metal ore - a rock that contains enough metal to make it worthwhile to extract the metal. Usually an oxide.

Oxidation/Oxidised - a reaction where oxygen is lost, or electrons are lost

pH - a number which shows how strongly acidic or alkaline a solution is

Reactivity series - a list of the elements in order of their reactivity. Usually decided from observing reactions with water or acid

Reduction/Reduced - a reaction in which oxygen is removed or electrons are gained

Salt - a compound comprised of ions. Often formed when some/all of the Hydrogen in an acid is replaced by a metal

Strong acids - these acids completely ionise in aqueous solution

Titration - an analysis technique that allows you to determine the concentration of acid or alkali solutions

Weak acids - acids that do no ionise completely in aqueous solution

Titrations

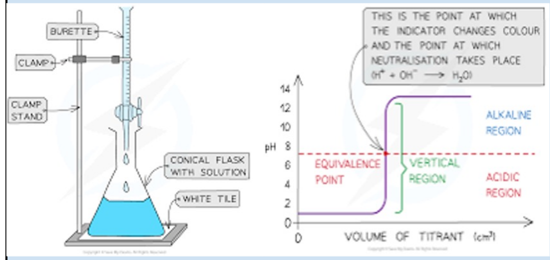
Titrations are a method of analysing the concentrations of solutions. They allow you to find out *exactly* what volume of acid is needed to neutralise a measured volume of alkali - or vice versa. You can then this data to calculate the concentration of the one you don't know

More pH scale

- The pH scale is related to the concentration of H^+ ions
- Strong acids have lower pH values than weak acids of similar concentrations
- As the pH decreases by one unit, the H^+ concentration increases by a factor of x10

E.g. a solution of pH 1 has 1000 more H^+ than a solution of pH 4.

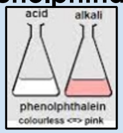
Titration setup: **Titration graph:**



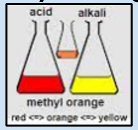
Indicators

Universal indicator is used to estimate the pH of a solution because it turns a variety of colours. If you are reacting an acid and alkali, you want to see a sudden end-point and need a different indicator.

Phenolphthalein



Methyl Orange



Related Calculations

In titrations we need to know the ratio of molecules that react and their concentrations. In order to do this, we will need to use two calculations

Titration Calculation Worked example

In a titration, 25.0 cm³ of 0.100 mol/dm³ sodium hydroxide solution is exactly <u>**neutralised**</u> by 20.00 cm³ of a dilute solution of hydrochloric acid. Calculate the concentration of the hydrochloric acid solution.

Step 1: Calculate the amount of sodium hydroxide in moles

Convert volume into dm³ by dividing by 1000

n = c x v: 0.100 x (25/1000) = 0.0025mol

Step 2: Find the amount of hydrochloric acid in moles

Write out the balanced symbol equation and work out ratio

$HCl + NaOH \longrightarrow NaCl + H_2O$

1:1 ratio, so moles of HCl is same as NaOH = 0.0025mol

Step 3: Calculate the concentration of hydrochloric acid in mol/dm³

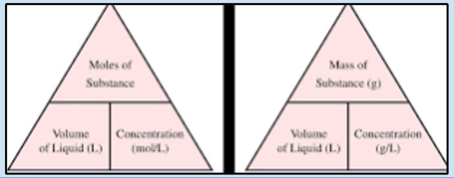
Convert volume into dm³ by dividing by 1000

c = n/v: 0.0025/ (20/1000) = 0.125mol/dm³

Step 4: Calculate the concentration of hydrochloric acid in

Multiple concentration by Mr:

0.125 x 36.5 = 4.56g/dm³



Electrolysis

Electrolysis is the process by which **ionic substances (salts)** are broken down into simpler substances when an electric current is passed through them. For electrolysis to work, the ions must be free to move. Ions are free to move when the ionic substance is **dissolved** in water or when **melted.**

Positive
Anode
Negative
Is
Electrode

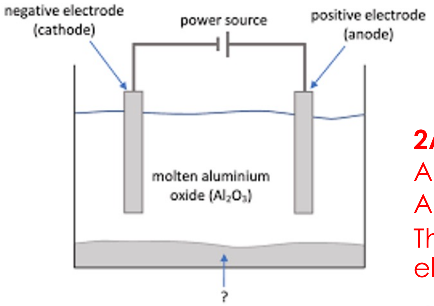
The anode and cathode are electrodes - these are conductors that are connected to the power supply.

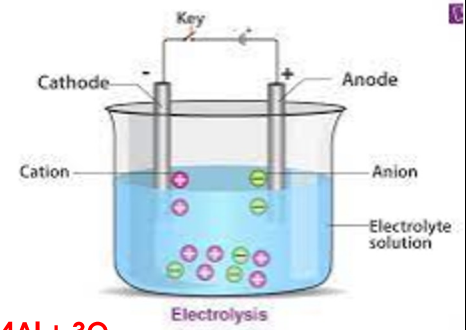
Positive ions in the electrolyte are called **cations** and are attracted to the **cathode** (negative electrode).

Negative ions are called **anions** and are attracted to the **anode** (negative electrode).

Electrolysis to extract metals

Metals towards the top of the reactivity series must be extracted using electrolysis. An example if Aluminium





$2Al_2O_3 \rightarrow 4Al + 3O_2$

At the **cathode:** $4Al^{3+} + 12e^- \rightarrow 3O_2$

At the **anode:** $6O^{2-} + 12e^- \rightarrow 3O_2$

The oxygen reacts with the carbon electrodes: $3C + 3O_2 \rightarrow 3CO_2$

Predicting the products of electrolysis

Molten Ionic Compounds

Cathode	Anode
Metal forms	Halide → Halogen

Aqueous Ionic Compounds

Cathode	Anode
Less reactive than H → Metal forms More reactive than H → H_2	Halide → Halogen All other anions → Oxygen

Half Equations

$2NaCl \rightarrow 2Na + Cl_2$

At the **cathode:** $2Na^+ + 2e^- \rightarrow 2Na$

At the **anode:** $2Cl^- \rightarrow Cl_2 + 2e^-$

AQA Chemistry C5: Energy changes (Blue - Triple only, Red - Higher only)

Keywords and Terms:

Activation energy - the minimum energy required for a reaction to take place between reacting particles

Battery - contains two or more metals in contact with an electrolyte (cell). The chemical reaction can push electrons around a circuit. Multiple cells are called a battery

Bond energy - amount of energy needed to break one mole of a particular bond

Catalyst - changes the rate of a reaction without being used up. They provide a reaction pathway with a lower activation energy

Endothermic - a reaction in which the reactants have LESS energy than the products. Energy is taken in from the surroundings - they feel COLD

Energy level diagram - shows the energy of the reactants and products. Can be used to determine if a reaction is exothermic or endothermic

Enthalpy of reaction - the difference between the energy of the reactants and the energy of the products in a reaction

Exothermic - a reaction in which the reactants have MORE energy than the products. Energy is released to the surroundings. They feel HOT

Fuel cell - a device that generates electricity by using a chemical reaction to convert fuel and oxygen into electricity, heat, and water

Hydrogen fuel cell - an electrochemical cell that combined Hydrogen and oxygen to produce water and energy

System - where a reaction takes place. If closed, it means no gases can enter or leave but if open, they can

Thermal energy - heat energy

Endothermic and Exothermic reactions

In a chemical reaction, energy is **conserved.** This means that the total energy of the system is the same before and after the reactions.

Exothermic reactions

- Products have less energy than the reactants
- Energy is given out as heat to the surroundings
- The temperature of the surroundings will increase

Examples include: combustion, oxidation, neutralisation
Uses: self heating cans, hand warmers

Endothermic reactions

- Products have more energy than the reactants
- Energy is absorbed from the surroundings
- The temperature of the surroundings will decrease

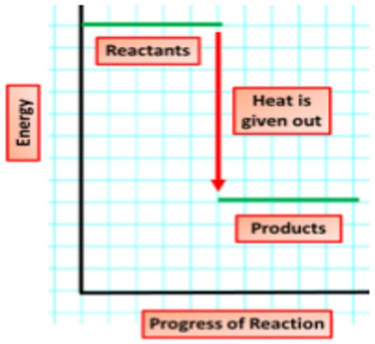
Examples include: thermal decomposition, reaction between citric acid and sodium hydrogen carbonate
Uses: sports injury packs

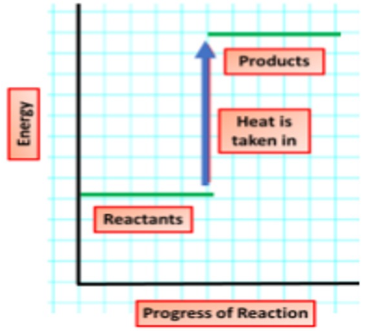
The reactants involved in a reaction must have their bonds broken in order to forms new substances - this requires energy (endothermic). When new products are made, new bonds are formed - this releases energy (exothermic)

If a reaction **gives out more energy when new bonds are formed**, than the energy needed to break the bonds - the reaction is **EXOTHERMIC** overall.

If a reaction **takes in more energy breaking bonds**, than is released when new bonds are formed - the reaction is **ENDOTHERMIC** overall.

Energy level diagrams





An **energy level diagram** shows whether a reaction is exothermic or endothermic.

It shows t**he amount of energy** the reactants and the products have, and **the difference in energy** between them.

In **exothermic reactions**, the **products are LOWER** than the reactants - **energy is released.**

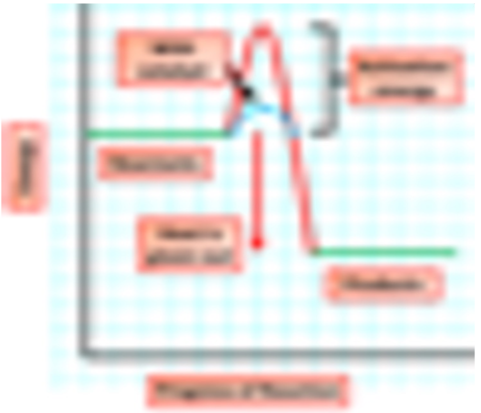
In **endothermic reaction**, the **products are HIGHER** than the reactants - **energy is taken in.**

Reaction profile

A reaction profile is similar to the diagrams above, in that it shows the amount of energy the reactants and products have.

They also show the reaction progression, and the **activation energy** for that reaction (minimum energy needed for the reaction to take place) .

The curved line shows the energy as the reaction proceeds



Bond energies

We can calculate the energy change in a reaction using bond energies (the amount of energy needed to break one mole of a particular bond).

Different bonds have different amounts of energy associated with them e.g. a H-H bond has a bond energy of 432kJ/mol. This means that 432kJ/mol is needed to break this bond OR is released when this bond is formed.

Worked example to calculate an energy change for a reaction:

$$2H_2 + O_2 \rightarrow 2H_2O$$

H-H + O=O → H-O-H
H-H H-O-H

1. **Determine the types of bonds that are being broken/ formed, and how many of each:**

Bonds broken	Bonds formed
H-H x 2	H-O x 4
O=O x 1	

1. **Add together the energy for the bonds being broken, and the bonds being formed:**

Bonds broken	Bonds formed
H-H x 2 = 436 x 2 - 872kJ/mol	H-O x 4 = 464 x 4 = 1856kJ/mol
O=O x 1 = 498kJ/mol	

872 + 498 = 1370kJ/mol

1856kJ/mol

Bond	Bond energy (kJ mol^{-1})
H-H	436
O=O	498
O-H	464

1. **Calculate the overall energy change by: BONDS BROKEN - BONDS FORMED**

Bonds broken - Bonds formed = Energy change

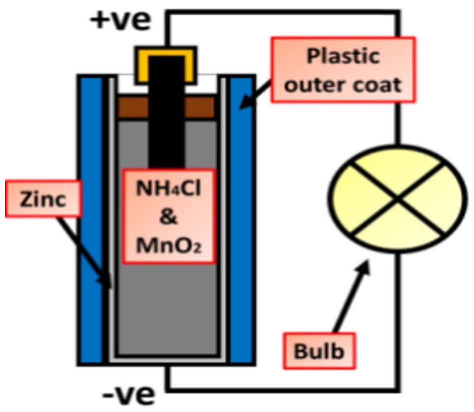
1370 - 1856

-486kJ/mol

If the energy change is negative, it is an exothermic reaction.

Cells and batteries

Cells contain chemicals which react to produce electricity.
The voltage produced by a cell is dependent upon a number of factors including the **type of electrode** and **electrolyte**.

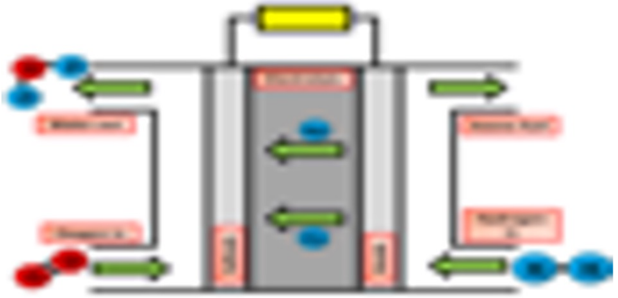


A simple cell can be made by connecting two different metals in contact with an electrolyte.
Batteries consist of two or more cells connected together in series to provide a greater voltage.

In non-rechargeable cells and batteries the chemical reactions stop when one of the reactants has been used up. E.g. Alkaline batteries

Rechargeable cells and batteries can be recharged because the chemical reactions are reversed when an external electrical current is supplied.

Hydrogen fuel cells



At cathode: $2H_2 + 4OH^- \rightarrow 4H_2O + 4e^-$
At anode: $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$

Fuel cells are supplied by an external source of fuel (eg hydrogen) and oxygen or air.

The fuel is oxidised electrochemically within the fuel cell to produce a potential difference.

The overall reaction in a hydrogen fuel cell involves the oxidation of hydrogen to produce water.

Hydrogen fuel cells offer a potential alternative to rechargeable cells and batteries.

Type of cell	Pros	Cons
Alkaline	Cheaper to manufacture	May end up in landfill, expensive to recycle
Rechargeable	Can be charged many times before being recycled	Costs more to manufacture
Hydrogen fuel	Easy to maintain, small, water is only product	Very expensive to manufacture, need constant supply of Hydrogen fuel (flammable gas)

AQA Chemistry C6: Rate and extent of chemical change (Red - Higher only)

Keywords and Terms:

Catalyst - a substance that increases the rate of a reaction without being used up
Collision theory - a model that explains the rate of chemical reactions
Equilibrium - where the concentrations of the reactants and products no longer changes in a closed system. The forward and reverse reactions have not stopped, but proceed at the same rate as each other
Gradient - change in y value divided by change in x, for a line on a graph
Precipitate - a solid appearing in a solution
Reaction rate - measure of how quickly a reactant is used up, or a product is formed
Reversible reaction - a reaction where reactants can become products and products can become reactants spontaneously. All reactions are reversible in theory, but many are not in practice
SA:V - surface area to volume ratio
Tangent - a straight line that touches, but doesn't intersect, a curve on a graph
Turbidity - cloudiness

Collision theory

For a chemical reaction to occur:

- Reactant particles must collide with each other
- The particles must have enough energy for them to react

A collision that produces a reaction is called a **successful collision.**
The minimum energy needed for a collision to be successful is called the **activation energy.**

Calculating the rate of reaction

The rate of a reaction is a measure of how quickly a **reactant is used up**, or a **product if formed.**

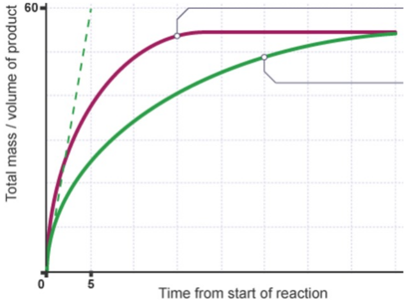
The units for rate of reaction can be:

- mol/s
- g/s
- cm³/s

E.g. if 4 moles of a **product** were made during 10 seconds, the average rate of reaction would be 4÷10 = **0.4mol/s**
Or, if 40g of a **reactant** was used up during 10 seconds, the average rate of reaction would be 40g ÷10 = **4g/s**
Or, if 50cm³ of **product** was made during 25 seconds, the average rate of reaction would be 50cm³ ÷25 = **2cm³/s**

Calculating the gradient for a line
Find the change in y and divide by the change in x (as shown on the graph opposite)

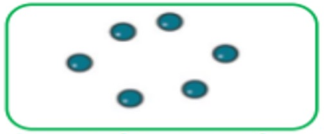
Calculating a reaction rate at a given time
You can find the reaction rate by drawing the tangent to the line and calculating the gradient for that line



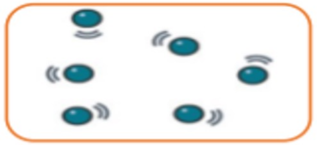
Factors affecting the rate of reactions

Slower Reaction

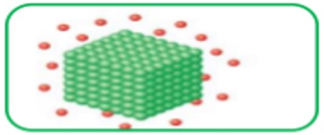
Faster Reaction



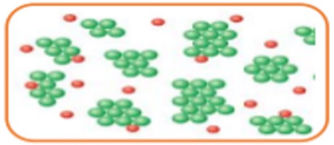
Lower temperature
Particles have LESS energy
Move around SLOWER
Particles less likely to collide



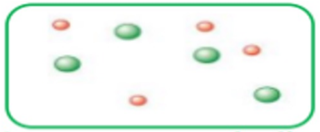
Higher Temperature
Particles have MORE energy
Move around FASTER
Particles less likely to collide



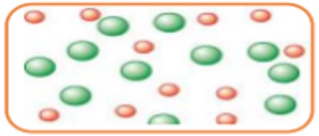
Lower SA:V
Fewer particles are EXPOSED
Frequency of collisions decreases



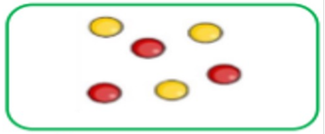
Higher SA:V
More particles are EXPOSED
Frequency of collisions increases



Lower concentration
Fewer particles = Less crowded
Frequency of collisions decreases



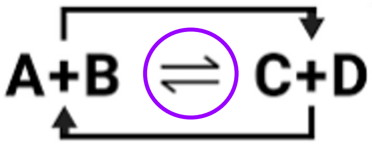
Higher concentration
More particles = More crowded
Frequency of collisions increases



Lower pressure
Particles are not as crowded
Frequency of collisions decreases

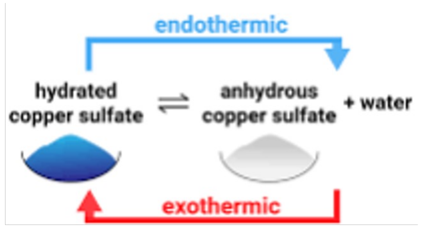
Higher pressure
Particles are more crowded
Frequency of collisions increases

Reversible reactions
In some reactions, the products react together to reform the reactants.
These are **reversible** reactions. They are represented by:



E.g. the reaction between **anhydrous** copper (II) sulphate and water is **<u>reversible</u>**

Anhydrous copper sulphate is a white power and when it reacts with water, it produced a blue solid. This is **EXOTHERMIC**.
When the blue copper sulphate is heated, it produces the white copper sulphate and water. This reaction is **ENDOTHERMIC**, as it needs heat.



Energy changes in reversible reactions
If the forward reaction is exothermic, the backward reaction will be endothermic.

If the forward reaction is endothermic, the backward reaction will be exothermic

The energy being transferred will be the same in both directions

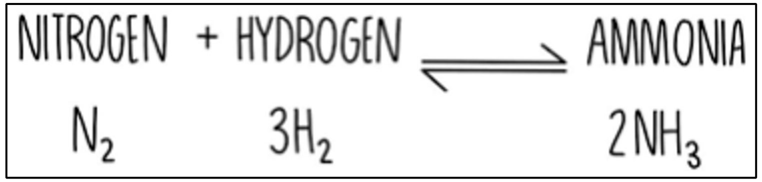
Equilibrium

Some reactions occur in a **closed system** - this means no reactants or products can enter or leave.

If a reversible reaction takes place in a closed system, the forwards and backwards reactions will reach a state of **equilibrium.**
This means they occur at exactly the same rate.

If the conditions of a reaction at equilibrium change, the system will respond to counteract the change - this is **Le Chatelier's principle**.
E.g. if you increase the temperature of a reaction, the system will respond by decreasing the temperature

The reaction to make ammonia is a good example of a reversible reaction to demonstrate changes that occur.

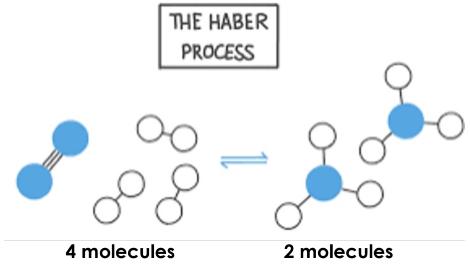


The Haber process (making ammonia) uses the following conditions:
- As low a temperature as possible
- As high a pressure as is safe
- Uses a catalyst - due to low temperature

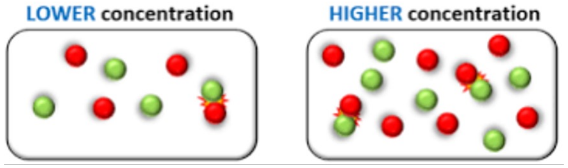
Le Chatelier's principle
The equilibrium position for a reaction can be changed by changing the following conditions:
- Pressure
- Concentration
- Temperature

The system responds to counteract these changes, which will result in a change in the amount of product made

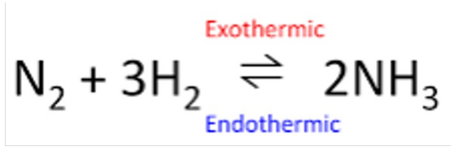
Industry can make use of this principle to produce the maximum amount of product (for the best profits!)



If the **pressure** of a reaction is **increased**, the equilibrium position moves to the side with fewer molecules.
In the case of the reaction above, equilibrium would move to the right, as there are fewer molecules



If the **concentration** of a reactant is **increased**, the equilibrium position moves to the side away from this reactant.
In the case of the reaction above, if the concentration of Nitrogen was increased, equilibrium would move to the right - away from this reactant, to make more of the product.



If the **temperature** of the reaction is **increased**, the equilibrium position moves in the direction of the endothermic reaction.
In the case of the reaction above, if the temperature was increased, equilibrium would move to the left - as the backward reaction is endothermic. This would decrease the temperature.

AQA Chemistry C7: Organic chemistry (Blue - Triple only, Red - Higher only)

Keywords and Terms:

Alkane - homologous group of hydrocarbons where there are only single bonds between carbon atoms
Alkene - homologous group of hydrocarbons where there is at least one double bond between carbon atoms
Complete Combustion - the process where hydrocarbons burn completely
Cracking - a reaction in which large hydrocarbons are broken down into smaller, more useful ones
Crude oil - a mixture of hydrocarbons which is formed from the remains of dead animal and plants matter which fossilised millions of years ago
Fossil fuels - non-renewable energy sources, such as coal, oil and natural gas
Fractionating column - a tall subdivided container used for fractional distillation. The top is cooler than the bottom
Hydrocarbons - compounds made from Hydrogen and Carbon atoms only
Incomplete combustion - the process where hydrocarbons do not burn completely in air due to insufficient oxygen
Saturated hydrocarbon - a compound consisting of only single carbon - carbon bonds
Unsaturated hydrocarbon - a compound consisting of at least one double carbon - carbon bond

Combustion

Complete combustion occurs in an unlimited supply of oxygen.
It produces CO_2 and water.

$$C_3H_6 + O_2 \rightarrow CO_2 + H_2O$$

Incomplete combustion occurs when there is a limited oxygen supply. The hydrocarbon does not burn completely.
It produces CO, CO_2 and water.

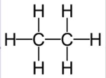
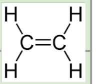
$$C_3H_6 + O_2 \rightarrow C + CO + CO_2 + H_2O$$

Crude oil

Crude oil is a **non-renewable** resource. It is made up of the remains of dead plant and animal matter from millions of years ago. As a result, it cannot be replaced as quickly as it used up, and eventually we will run out. Crude oil is mixture of **different sized hydrocarbons**. It is an important source of **fuel** and **feedstocks.**

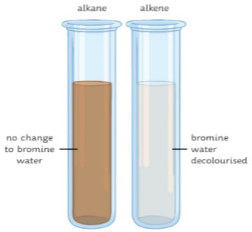
Alkanes and Alkenes

Hydrocarbons can be broken into **homologous groups**, such as alkanes and alkenes. These are groups that all share the same general formula, and have chemical properties that are similar.

Alkanes	Alkenes
Saturated (single bonds)	Unsaturated (at least one double bond)
General formula: C_nH_{2n+2}	General formula: C_nH_{2n}
Names end in 'an 	Names end in 'en 
Example: Ethane	Example: Ethene

Test for Alkenes

We can find out whether a hydrocarbon is an alkane or alkene by carrying out a chemical test using **Bromine water**



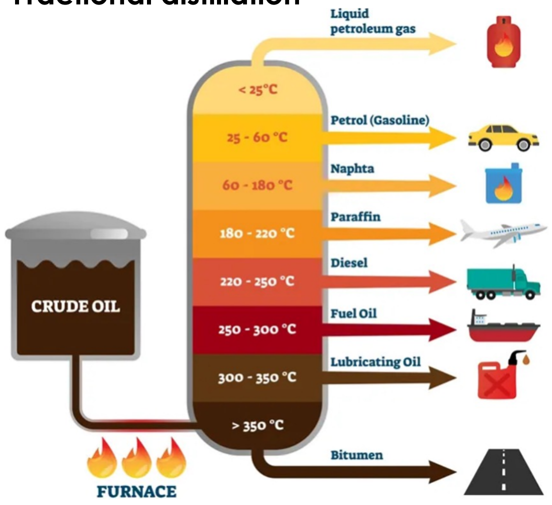
Naming Hydrocarbons

No. of Carbon atoms	Prefix
1	Meth-
2	Eth-
3	Prop-
4	But-
5	Pent-

Properties of Hydrocarbons

Properties	Short chain	Long chain
Boiling point	Low boiling point	High boiling point
Viscosity (thickness)	Low viscosity	High viscosity
Flammability	High flammability	Low flammability

Fractional distillation



Fractional distillation is the process used to separate crude oil into smaller **fractions** of hydrocarbons. Each fraction contains hydrocarbons of similar chain lengths
It works by using the **boiling points** of the different sized hydrocarbons.
The column is cooler at the top and hotter at the bottom.
Smaller hydrocarbons **condense** towards the top of the column, while larger hydrocarbons condense towards the bottom.

Stages of fractional distillation

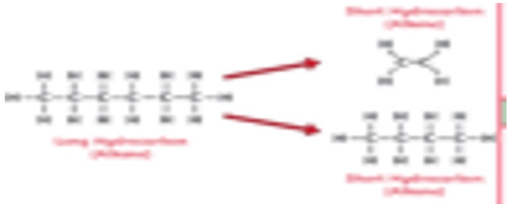
- Crude oil is heated to around 450° as it enters the column
- The vapours start to rise up the column
- vapours condense when they reach a part of the column that is below the temperature of their boiling point
- Each liquid is led away from the column

Cracking

A thermal decomposition reaction used to break down long chain hydrocarbons into shorter more useful hydrocarbons. There are various types:

Steam Cracking	Catalytic Cracking
Uses a high temperature of over 800° with no catalyst	Heat a hydrocarbon to a temperature of 550° and pass over a hot catalyst called zeolite, which contains aluminium oxide and silicon oxide

Cracking produces a **short chain alkane** and an **alkene.**
It is a useful process because it helps match the supply of fractions to the demand. The alkenes produced can be used as **feedstock** for the **petrochemical industry**.
Alkenes can also be used to make **polymers**, such as poly(ethene)



Alkenes are a group of hydrocarbons that are <u>unsaturated</u>, with the general formula **C_nH_{2n}**
Their C=C bond is their **functional group**, it determines their properties.

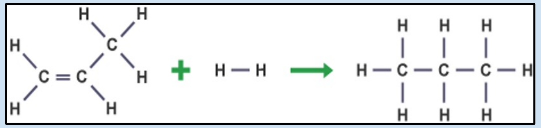
Reactions of alkenes:
Combustion:

- Alkenes undergo combustion (burning) - most likely to be incomplete
- Burn with a smoky flame (soot)
- Produce CO, CO_2, H_2O

Addition reactions
This where one molecule combines with another e.g. Bromine to form one large molecule

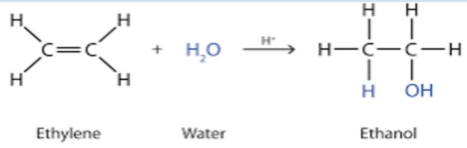
Hydrogenation:

- Alkenes react with Hydrogen
- In the presence of a catalyst
- Produces an alkane



Hydration:

- Alkenes react with water (steam)
- At around 300°C and with a catalyst
- Produces an alcohol



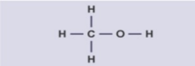
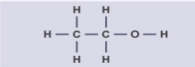
Reactions with Halogens:

- These are spontaneous reactions
- These produce haloalkanes

Alcohols
Alcohols have the functional group **-OH (hydroxyl).** This determines their reactions.

They are named similarly to alkanes and alkenes, in that the **first part of their name** is determined by the **number of Carbon atoms**. **Second part** of the name ends in **-ol.**

We can represent them using molecular or structural formulae.

Alcohol	Formula	Structure (showing all the covalent bonds)
Methanol	CH_3OH	
Ethanol	C_2H_5OH	

Reactions of alcohols:
Combustion:

- Undergoes complete combustion
- Produce CO_2, H_2O

Reactions with Sodium:

- Bubbles of Hydrogen gas are produced
- Sodium alkoxides are formed - where the alk is replaced by the first part of the alcohols name e.g.

<u>Sodium + Ethanol → Sodium ethoxide + Hydrogen</u>

Solubility in water:
Smaller chain alcohols can mix easily with water to produce a solution.
As the chains get longer, this gets harder.
Oxidation of alcohols:
Alcohols can be **oxidised** to produce Carboxylic acids

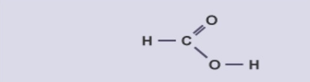
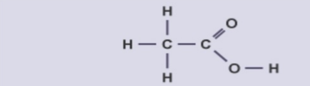
Making ethanol by fermentation
Fermentation is an anaerobic process
Glucose → Ethanol + Carbon dioxide
Yeast provides the enzymes needed for the process

Conditions needed:

- Sugar dissolved in water, mixed with yeast
- An air lock, to stop air getting out
- Warm temperature - 25-35°

Carboxylic acids
Have the functional group -, **Carboxyl**. Carboxylic acids are weak acids. Vinegar is the carboxylic acid, ethanoic acid.

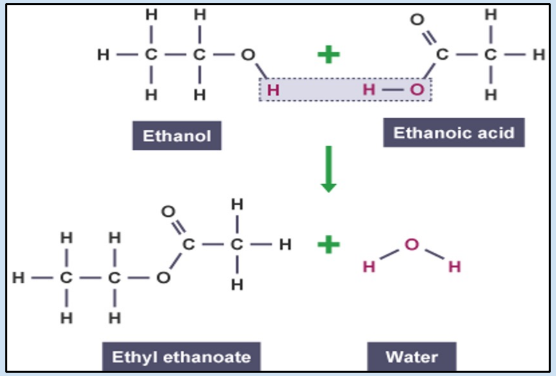
Similarly to the other organic substances, the first part of the name comes from the number of Carbon atoms.
The second part ends in **-anoic acid.**

Name	Formula	Structure (showing all the covalent bonds)
Methanoic acid	HCOOH	
Ethanoic acid	CH_3COOH	

Carboxylic acids have typical acidic properties:

- Dissolve in water to form acidic solutions with a pH of less than 7
- React with metals to form a salt and hydrogen
- React with bases to form a salt and water
- React with carbonates to form a salt, water and CO_2

Esters
Carboxylic acids react with alcohols to produce esters.
Esters are organic compounds with the functional group -COO.
ethanol + ethanoic acid → ethyl ethanoate + water



Addition polymerisation
A **<u>polymer</u>** is a substance of high **<u>relative formula mass</u>**, made up of small **<u>repeating units.</u>**
E.g. Poly(ethene) is a polymer made from a very large number of ethene **<u>molecules</u>** (monomer) combined together.
The reaction is called a **polymerisation reaction.**

Some polymers are naturally occurring:

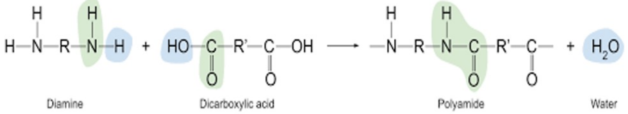
- **DNA - made of monomers called nucleotides**
- **Proteins - made up of chains of amino acids**
- **Starch and Cellulose - made from sugars**

Condensation polymerisation

- Reaction in which a polymer is formed and a water molecule is released
- Monomers must have a functional group

Man made polymers e.g. polyester, can be used in clothing. Polyester is made in a condensation polymerisation reaction.

Polyester can be made from a monomer that contains 2 hydroxyl groups, and another with 2 carboxyl groups



Amino acids

- Contain 2 functional groups: NH_2, COOH
- Made in cells to make proteins
- They react by condensation polymerisation to make proteins
- One water molecule is produced

AQA Chemistry C8: Chemical analysis (Blue - Triple only)

Keywords and Terms:

Chromatogram - a graph that shows the result of separating the components of a mixture by chromatography

Chromatography - a technique used to separate mixtures based on their solubilities. It can give information to help identify substances

Flame emission spectroscopy - an instrumental method used to analyse metal ions in solutions

Flame test - qualitative test used to identify metal ions. Carried out by inserting a nichrome wire loop with an unknown compound into a flame and observing the colour

Formulation - a mixture that has been designed as a useful product. Made by mixing the components in carefully measured quantities to ensure the product has the required properties

Impure substance - a substance made up of two or more elements or compounds that are not chemically bonded

Instrumental methods - instrumental methods can be used to detect and identify elements and compounds. They are accurate, sensitive and rapid

Mobile phase - where the molecules can move during chromatography, it is always the liquid (solvent) or gas

Pure substance - a single element or compound not mixed with any other substance. Nothing has been added to it

Rf value - the ratio of the distance moved by a compound to the distance moved by the solvent

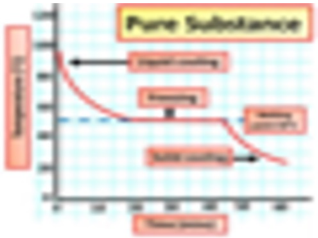
Stationary phase - where the molecules are stationary during chromatography. It is the solid or liquid supported on a solid (the paper).

Pure substances

Consists of only one element or one compound.
A mixture consists of two or more different substances, not chemically joined together

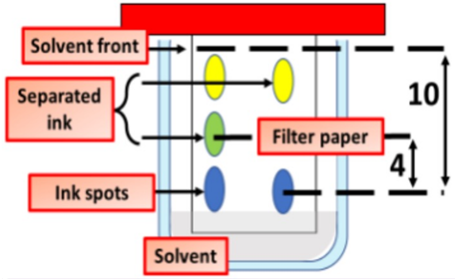
Pure substances have **sharp melting points**, but **mixtures** melt over a **range of temperatures**.
The difference is most easily seen when the temperature of a liquid is measured as it cools and freezes.

The graph shows a cooling curve for a compound called salol.
The horizontal part of the graph shows a sharp melting point - this means it is pure.
Impure salol would have a gradual fall in temperature as it freezes.



Chromatography

1. Draw a **pencil** line across the chromatography paper, 1-2cm from the bottom
2. Use a pipette or capillary tube to add small spots of each ink to the pencil line on the paper
3. Place the paper into a container with a **suitable solvent** in the bottom
4. Allow the solvent to move through the paper, but remove the chromatogram before it reaches the top
5. Allow the chromatogram to dry, then measure the distance travelled by each spot and by the solvent (solvent front)



The **height of the spots** can help you to identify substances present. E.g. in this chromatogram both substances contain TWO of the same substances (blue and yellow), and one other substance (green).

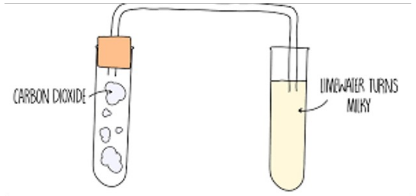
$$Rf = \frac{\text{distance moved by the compound}}{\text{distance moved by the solvent}}$$

Formulations

A formulation is a mixture designed as a useful product.
They are made by mixing the components in carefully measured quantities (mass of solid or volume of liquid) to ensure that the product has the required properties for its use.
Examples are:

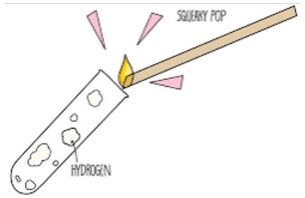
Tests for Gases

Carbon dioxide: Use **Limewater** (Calcium hydroxide solution)
If CO_2 is bubbled through limewater, it **turns cloudy**



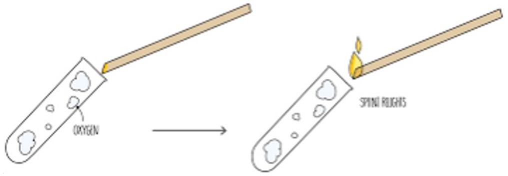
Hydrogen: Squeaky 'pop' test

Use a **burning splint** and place near the gas being tested.
A **popping sound** means Hydrogen is present



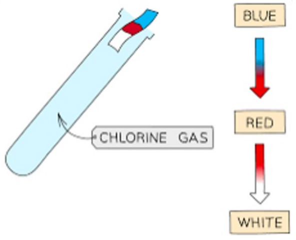
Oxygen: Use a glowing splint

Take a **glowing splint** and place it in a sample of the gas.
The **splint will relight** if oxygen is present



Chlorine: Litmus paper test

Use **damp blue litmus paper**, and place it in the sample of gas.
The litmus will turn red, and then will be **bleached white** if chlorine is present

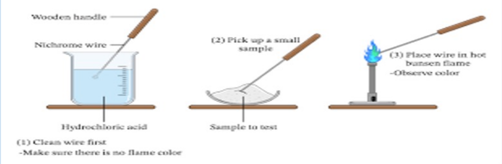


Flame tests

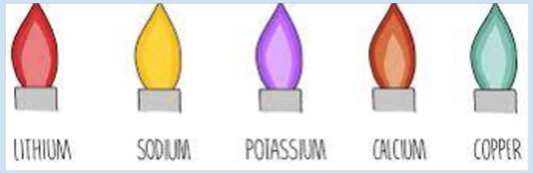
These are qualitative tests that enable us to identify some metal ions.
They produce distinctive colours when passed through a flame.

Method:

1. Take a nichrome wire loop and pass through a blue flame
2. Clean the nichrome wire loop using hydrochloric acid
3. Allow to cool quickly and then dip the wire into your metal ion sample
4. Pass the nichrome wire loop with the sample into the edge of a blue flame
5. Observe and record the colour



Ion present	Flame test colour
Lithium, Li^+	Crimson (red)
Sodium, Na^+	Yellow
Potassium, K^+	Lilac
Calcium, Ca^{2+}	Orange-red
Copper, Cu^{2+}	Green



Testing for metal ions

Dilute sodium hydroxide can be used to test for some metal ions.
The reaction produces **metal hydroxides** that are insoluble, and so appear as **precipitates**.
E.g. $CuSO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + Cu(OH)_2(s)$

The copper hydroxide produced is an precipitate (insoluble solid). You can tell because of the (s) state symbol in the equation.
You are expected to be able to write equations for these reactions

Metal ion	Precipitate colour
Aluminium, Al^{3+}	White
Calcium, Ca^{2+}	White
Magnesium, Mg^{2+}	White
Copper(II), Cu^{2+}	Blue
Iron(II), Fe^{2+}	Green
Iron(III), Fe^{3+}	Brown

It is possible to distinguish between Al and the other 2 cations that form white precipitates. **$Al(OH)_3$ will dissolve in EXCESS NaOH.**

You can then use a flame test to distinguish between Mg and Ca

Flame Emission Spectroscopy

A **spectrometer** is an instrument used to probe a properly of light, normally its **wavelength, frequency** or **energy**.

A **spectroscope** is a device that measures the spectrum of light. This is its **atomic line emission spectra.**

Electrons exist in distinct energy levels. The energy levels are unique for each element, therefore, the emitted wavelength of light can be used as an identifying fingerprint for that element. E.g. the atomic line emission spectrum below is unique for Mercury

Instrumental analysis

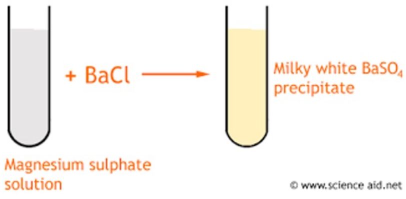
Elements and compounds can be detected and identified using instrumental methods. Instrumental methods are **accurate, sensitive** and **rapid**.
These include:

- chromatography
- electrophoresis
- Field flow fractionation

Then qualitative and quantitative Analysis can be performed

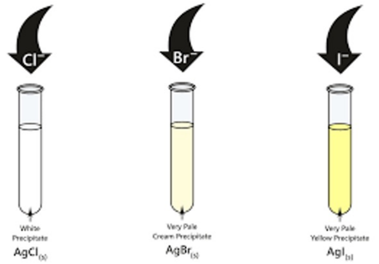
Testing for sulphates

1. **Acidify your sample** first by adding a small amount of **HCl.**
2. Add a few drops of **Barium chloride** solution to the solution
3. If a w**hite precipitate forms**, then sulfate ions are present



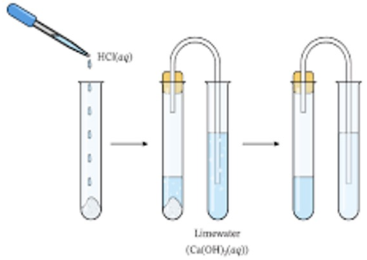
Testing for halides

1. Add a few drops of **nitric acid** to your sample
2. Add a few drops of dilute silver nitrate solution
3. Observe the colour of the precipitate that forms, as this can be used to determine the halogen present



Testing for carbonates

1. Add dilute hydrochloric acid to your sample
2. Bubbles will be given off if a carbonate is present due to the production of CO_2
3. Use limewater to test the gas. If it turns cloudy/milky, then the gas is CO_2

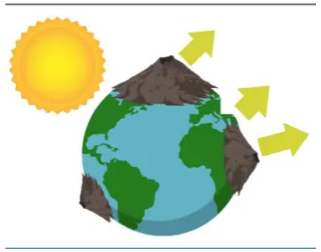


AQA Chemistry C9: Chemistry of the atmosphere

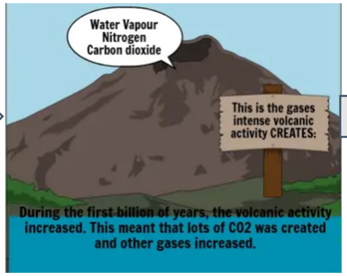
Keywords and Terms:

Aerobic respiration - the biological breakdown of glucose using oxygen to create carbon dioxide and water, releasing energy
Atmosphere - layer of gases that surrounds the Earth
Atmospheric pollutant - something not found in clean air or which causes problems close to the ground
Carbon footprint - total amount of carbon dioxide emitted over the full life cycle of a product, service or event
Climate change - long term changes in weather patterns, such as flooding, droughts, high temperatures
Enhanced greenhouse effect - human activities have increased the amount of greenhouse gases in the atmosphere, meaning more radiation is trapped and the average global temperature rises
Fossil fuels - formed from the remains of organisms millions of years ago, and release energy in combustion e.g. coal, oil and natural gas
Global warming - the gradual increase in the average surface temperature of the Earth
Greenhouse effect - traps some of the energy from the sun, which keeps Earth at a temperature which allows life
Greenhouse gas - a gas that absorbs infrared radiation and prevents it from escaping into space
Peer - reviewed science - scientific findings that are critically checked by other scientists for consistency
Photosynthesis - the process of making carbohydrates from raw materials, using light energy, in plants
Precipitate - a solid that is deposited from a solution or an insoluble solid
Secondary atmospheric pollutant - something formed in the atmosphere as a result of pollutants reacting with other molecules in the atmosphere
Sedimentary rock - formed from sediments that have settled at the bottom of a lake, sea or ocean, and have been compressed over millions of years.

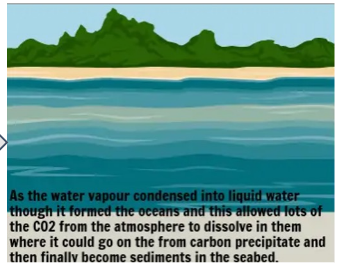
Development of the atmosphere - these processes formed the Earth's atmosphere



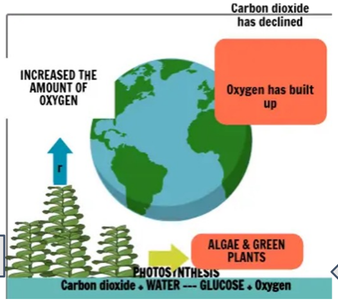
Early Earth was covered in active volcanoes



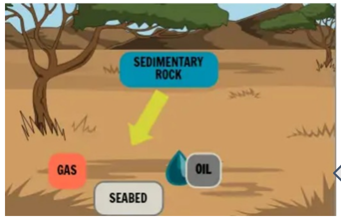
Over the next billion years, the volcanic activity got more intense releasing large amounts of CO_2, water vapour, methane and ammonia



Gradually the Earth started to cool, and the water vapour condensed forming the first oceans. Some CO_2 dissolved in the oceans forming soluble carbonate compounds (sedimentary rocks)



Life evolved from single celled organisms , to algae and plants that carried out photosynthesis. Decreasing CO_2 and increasing Oxygen. Eventually oxygen levels increased enough for animals to evolve

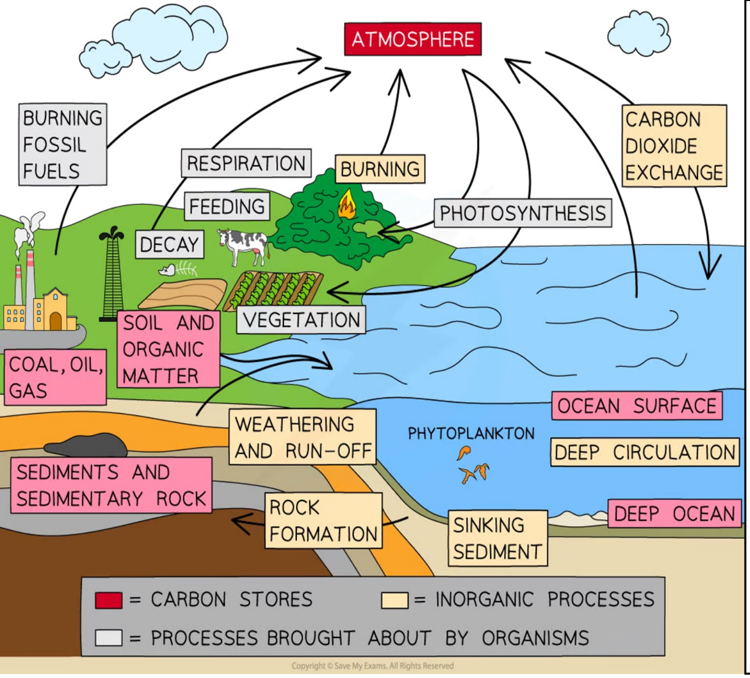


CO_2 decreased further as the remains of dead plants and animals became fossil fuels over millions of years

Main carbon dioxide deposits
Most of the CO_2 in the early atmosphere was removed - dissolving in the seas, forming rocks, forming the organic matter that makes up life, and forming fossil fuels.
Some CO_2 is necessary in the atmosphere to Earth warm enough for lide

Reduction of CO_2 by formation of deposits

Coal	Plants absorbed CO_2. They died and decayed. This layer of decaying plants was compressed to form coal
Oil & Natural gas	Plankton absorbed CO_2, Plankton died and were deposited in muds on the seafloor. They were covered and compressed over millions of years
Limestone	Shelled animals absorbed CO_2 to make calcium carbonate shells. The remains of these animals were compressed to form limestone



Fossil fuels, global warming and climate change

Most of the carbon in our atmosphere is CO_2.

When the carbon cycle is in balance, Carbon moves through plants become glucose, then other organic matter, before eventually being respired or decomposed and returning to the air.

The carbon cycle has been in balance for millions of years.

In the last 200 million years, we have been burning fossil fuels at a hugely accelerated rate. We have been releasing locked up carbon and releasing it and other pollutants into the atmosphere.

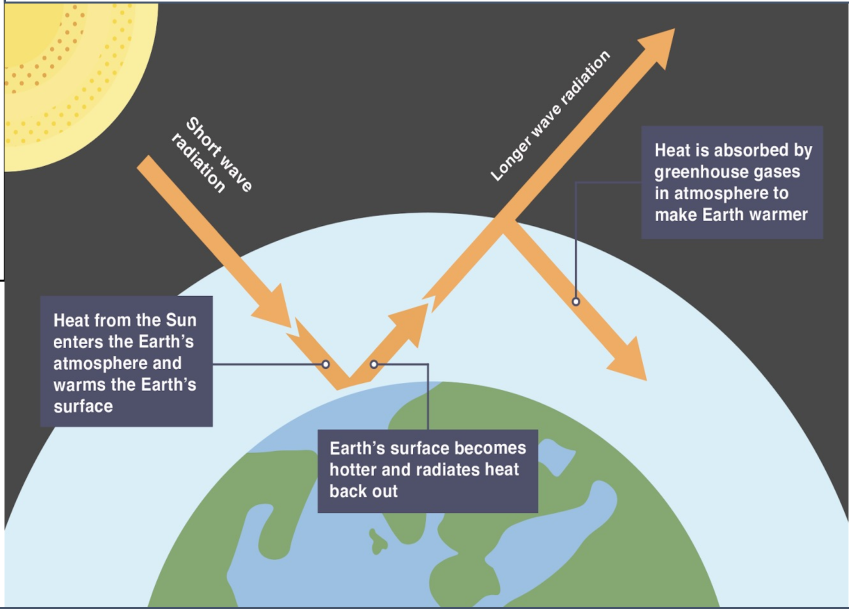
The increase in greenhouse gases has led to:

- **An enhanced greenhouse effect** (less infrared radiation is able to leave the atmosphere
- Leading to a gradual increase in Earth's mean surface temperature - **Global warming**
- Resulting in weather patterns around the world changing e.g. droughts, floods, extreme weather, destruction of habitats **(Climate change)**

Do human activities cause global warming?

Based on **peer-reviewed evidence**, many scientists believe that human activities will cause the temperature of the Earth's atmosphere to increase at the surface, and that this will result in global climate change.

However, it is difficult to model such complex systems as global climate change. This leads to simplified models, speculation and opinions presented in the media that may be based on only parts of the evidence and which may be **biased.**



Other atmospheric pollutants created by the combustion of fossil fuels are causing problems.

Atmospheric pollutant	Source	Impact on the environment	How it can be reduced
Carbon dioxide	Combustion of fossil fuels	Enhanced greenhouse effect	Use renewable energy, burn less fossils fuels
Particulate carbon (soot)	Incomplete combustion	Global dimming, health problems	More efficient combustion
Carbon monoxide		Toxic gas (colourless, odorless, not easily detected)	**Catalytic converters** fitted to car exhausts
Nitrous oxides"	Combustion engines (N_2 and O_2 from the air)	**Acid rain*** and respiratory problems	
Sulphur dioxide"	Burning coat (contains sulphur)		Removing sulphur dioxide from the waste gases

Carbon footprint

The carbon footprint is the total amount of carbon dioxide and other greenhouse gases emitted over the full life cycle of a product, service or event.

The carbon footprint can be reduced by reducing emissions of carbon dioxide and methane:

- Use alternative forms of energy
- Reduce consumption of fossil fuels, recycle more
- Improve energy efficiency
- Investigate carbon capture
- Plant more trees
- Reduce the amount of meat in our diets

AQA Chemistry C10: Using resources (Blue - Triple only, Red - Higher only)

Keywords and Terms:

Bioleaching - process where bacteria are used to extract metals from low grade ores.
Desalination - the removal of salt from sea water
Distillation - process used to separate liquids based on their boiling points
Finite - resources are those that are being used up at a faster rate than they can be replaced
Haber process - the reaction between Nitrogen and Hydrogen under specific conditions to make Ammonia
Leachate - acidic solutions produced by bacteria that contain metal ions from low grade ores
Life cycle assessment - a method used to evaluate the environmental impact of a product or process over its entire life cycle
Natural resources - materials or substances that are produced by the environment
Ore - a rock that contains enough of a metal compound to make it economically worthwhile extracting
Phytoextraction - process that uses plants to absorb metal ions from low grade ores, the plants are then harvested and burnt
Potable - safe to drink
Renewable - a resource that is being (or can be) replenished as it is used
Reverse osmosis - process where seawater is forced through a membrane at high pressure
Sustainability- meeting the needs of current generations without compromising the ability of future generations to meet their own needs.

Earth's resources

Humans use the earth's natural resources for:

- Energy and fuel
- Building materials for shelter
- Food
- Fuels for transport
- Materials for clothing

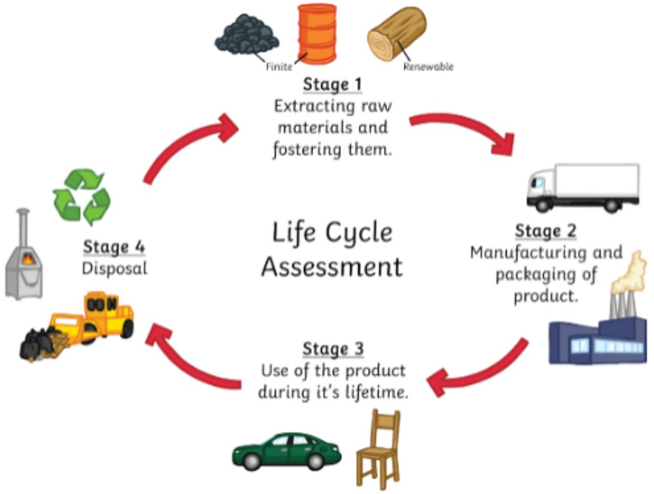
Natural resources, supplemented by agriculture and synthetic materials, provide food, timber, clothing and fuels. For example **Wood, Cotton and Leather**.

The human population is growing at an increasing rate. We are using **finite** resources faster than they are being replenished - this is **unsustainable.**

Obtaining raw materials from the Earth by quarrying and mining has an environmental impact.
Some products can be **reused** e.g. glass bottles.
Metals can be recycled by melting and recasting or reforming into different products.

Life Cycle Assessment

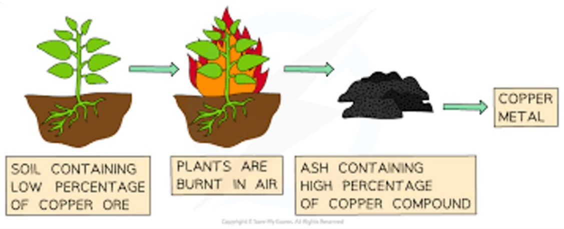
Life cycle assessments (LCAs) are carried out to **assess the environmental impact of products** in each of these stages:



Alternative methods of extracting metals

Earth's resources of metal ores is limited. E.g. supply for copper does not match demand. We must find alternative methods of extracting these metals from **low grade ores** (contain small amounts of metal).

Phytomining (Phytoextraction)



Bioleaching

Some bacteria break down **ores** to produce an acidic solution containing metal ions. The solution is called a **leachate**. It can produce **toxic substances**, e.g. sulphuric acid, which can damage the environment.

Comparative Life Cycle Assessments

Comparative LCAs are used to evaluate the environmental impact of products, to find which is lower:

Stage of Life Cycle	Plastic Bag	Paper Bag
Stage 1 – raw material	Uses a finite resource (crude oil). The processes of fractional distillation, cracking and polymerisation all require energy to make crude oil useful.	Made from trees/recycled paper. Making paper from trees requires more energy than recycled paper because trees have to be chopped down. Still uses less energy than making plastics from crude oil.
Stage 2 – manufacture	Cheap to make.	More expensive to make.
Stage 3 – use	Plastic bags have a low environmental impact as they can be used a number of times. In comparison to paper bags, they are much stronger.	Paper bags can only be reused a limited number of times and so have a short lifetime.
Stage 4 – disposal	The downside to plastic bags is that they do not biodegrade easily in landfill. Recycling options are available. If they are not disposed of correctly, plastic bags can have a detrimental impact on the environment and animal habitats.	Paper bags biodegrade easily in landfill sites.

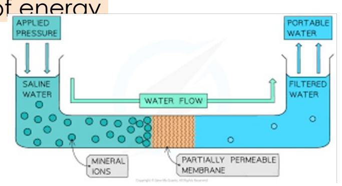
Water

Potable water is water that is safe to drink. It is different to pure water because it still contains **dissolved substances**.

In the UK rain provides low levels of fresh water that collects in; the **ground, lakes and rivers**.
It is then passed through **filter beds** to remove larger contaminants it is then **sterilized** by using either **chlorine, ozone or ultraviolet light** to kill bacteria.

It is not always possible to access fresh water.
Desalination of seawater can be done by **distillation**

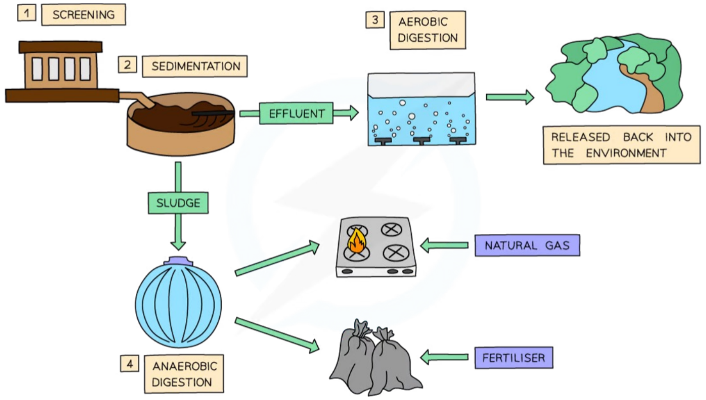
Or by processes that use membranes, such as **reverse osmosis**. These processes require large amounts of energy.



Waste water treatment

Urban lifestyles and industrial processes produce large amounts of waste water.
This water must be treated before it can be released into the environment.

Sewage and agricultural waste water will likely contain **harmful microbes** and **organic matter**.
Industrial waste water may contain **toxic chemicals** and **organic matter**.
Sewage treatment includes:



Ceramics, Composites and Glass

Glass

Most of the glass we use is soda-lime glass, made by heating a mixture of sand, sodium carbonate and limestone.
Borosilicate glass, made from sand and boron trioxide, melts at higher temperatures than soda lime glass.

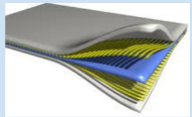
These materials are produced from limited materials

Ceramics

Pottery and brick ceramics are made by shaping wet clay and then heating in a furnace

Composites

A fibre, filament or reinforcement surrounded by a matrix



Uses

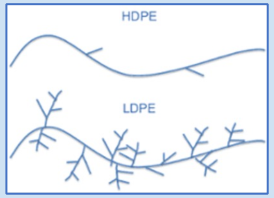
Fiberglass
Dental Fillings
MDF

Polymers

Polymers made are dependent on the monomers they are made from, and the conditions under which they are made.

Ethene can be polymerized in slightly different ways to produce LDPE and HDPE.

HDPE has a crystalline structure Therefore has a higher melting point due to the force of attractions



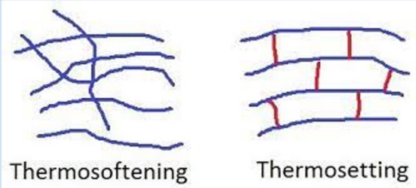
LDPE has side branches that stop the polymer molecules lining up properly, it is not crystalline, therefore it has weaker bonds and has a lower melting point.

Thermosoftening

Individual tangles polymers that melt when heated

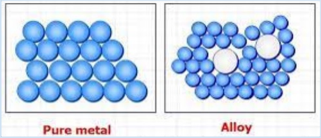
Thermosetting

Polymer chains with cross links between them, they do not melt when heated



Alloys

Most metals used everyday are alloys e.g. steel
Alloys are mixtures of at least one metal with another element, this makes them harder than the pure metals



Bronze is an alloy of copper and tin.
Brass is an alloy of copper and zinc.
Gold used in jewellery is usually an alloy with silver, copper and zinc. The proportion of gold in the alloy is measured in carats. 24 carat being 100% (pure gold), and 18 carat being 75% gold.

Steels are alloys of iron that contain specific amounts of carbon and other metals. High carbon steel is strong but brittle. Low carbon steel is softer and more easily shaped. Steels containing chromium and nickel (stainless steels) are hard and resistant to corrosion.

Aluminium alloys are low density.

Corrosion and its prevention

Corrosion is the destruction of materials by chemical reactions with substances in the environment. E.g. **Rusting of iron**

Both **air** and **water** are necessary for iron to rust.

Corrosion can be prevented by:
1) **Putting a barrier** between the metal and the air and moisture e.g. grease, paint, plastic, unreactive metal

2) **Sacrificial protection** - E.g. iron is covered or connected to a more reactive metal (such as Zinc) so it will 'corrode' ahead of the iron.

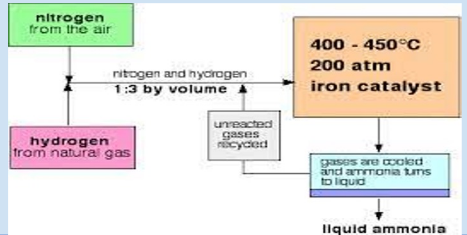
Aluminium has an oxide coating that protects the metal from further corrosion.

The Haber Process and Fertilisers

The Haber process is used to manufacture ammonia.

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

The Nitrogen in this process is from the fractional distillation of air and the hydrogen is obtained from the natural gas (CH_4) or electrolysis of water.
The reaction is reversible.
To separate the ammonia the, it is cooled and removed, the remaining nitrogen is recycled



NPK Fertilisers

Compounds such as Nitrogen, phosphorus and potassium (NPK) are used as fertilisers in agriculture.

Ammonia can be used to manufacture ammonium salts and nitric acid.

Potassium chloride, potassium sulphate and phosphate rock are obtained from mining.

Phosphate rock is treated with nitric acid or sulfuric acid to produce soluble salts that can be used as fertilisers.

AQA Physics P1: Energy

Key Words

Dissipation - energy becoming spread out.
Lubrication - a method for reducing wasted energy by adding a lubricant which reduces friction.
Insulation - a method for reducing wasted energy by adding an insulator.
Conversation of Energy - the law that states that energy cannot be created or destroyed.
Useful Energy - energy transferred to the store that is wanted.
Wasted Energy - energy that is not usefully transferred.
Closed System - an isolated system in which no energy changes take place out of or into the system.
Renewable Energy - Resources that can be replenished and will never run out.
Non-Renewable Energy - Resources that are finite and will run out.
Power - the rate of transfer of energy.
Work - energy transferred when a force moves an object over a distance.

Types of Energy Stores

Chemical energy	(e.g.fuel+oxygen)–Can be changed by bonds being made/broken
Kinetic energy	All moving objects have it
Gravitational potential energy	Energy stored in objects raised up against the force of gravity.
Elastic potential energy	The energy an elastic object stores if it is stretched.
Thermal Energy	A form of kinetic energy caused due to the motion of particles (hotter particles are more active and therefore have more KE).
Nuclear	Energy stored in the nuclei of atoms.
Magnetic	Two separated magnets that are attracted or repelling

Ways to reduce wasted energy: insulation, streamline design, lubrication of moving parts, and insulation.

Unit Conversions

1 kJ = 1,000 J	1 m= 1,000 mm	1 kg = 1,000 g
1 kW = 1,000 W	1 m = 100 cm	1 kg = 1,000,000 mg
1 kN = 1,000 N	1 min = 60 s	
	1 hour = 60 min	

Specific Heat Capacity

You should be able to define it and recall how to calculate it.

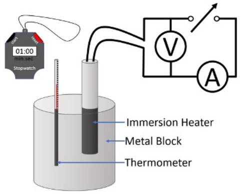
$$q = m\,C\,\Delta T$$

q (heat energy); m (mass of object releasing or absorbing the q); ΔT (change in Temp) $T_{final} - T_{initial}$

The energy needed to raise the temperature of a 1kg object by 1 degree celsius.

Each object has its own value for specific heat capacity.

Objects with a high specific heat capacity take a long time to heat up and cool down.



Word Equation	Symbol Equation	Units
GPE = mass X gravitational field X change in height,	GPE = mgΔh	GPE: Joules (J), Mass: kilograms (Kg), Height: Metres (m)
work done = force applied X distance moved	W = fs	Work done: Joules (J), Force applied: Newtons (N), Distance moved: Metres (m)
KE = ½ X mass X speed^2	KE = ½mv^2	KE: Joules (J), Mass: Kilograms (Kg), Speed: metres/second^2 (m/s^2)
elastic potential energy = ½ X spring constant X extension^2	E_e = ½ke^2	Elastic potential energy: Joules (J), Spring constant: Newtons per metre (N/m), Extension: metres (m)
efficiency = useful output energy / total input energy (X 100%)		Energy: Joules (J)
efficiency = useful output power / total input power (X 100%)		Power: Watts (W)
Power = energy transferred / time	E = P/T	Power: Watts (W), Energy transferred: Joules (J), Time: Seconds (s)

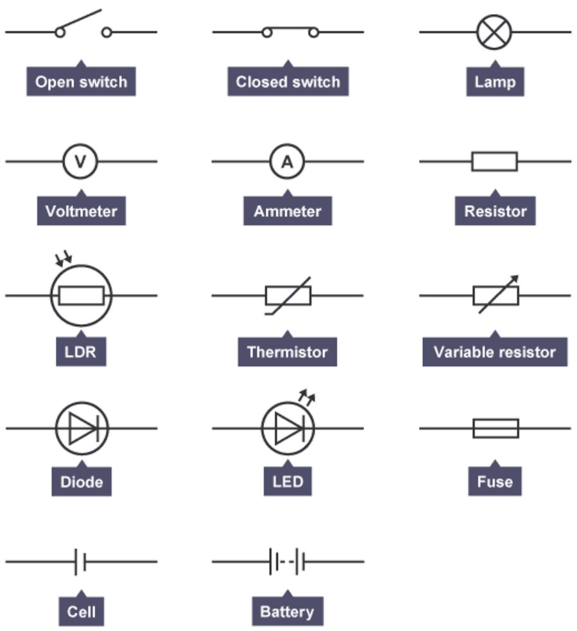
16/09/2020

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.

AQA Physics P2: Electricity

Key words

AC- Alternating current is when current flows in different directions
DC- Direct current is when current flows in one direction
Diode- A component that only flows in a forward direction
Current- The flow of electrons
Parallel- Components connected in parallel have the same potential difference, and current is equal to the sum of the components
Series- Components connected in series have the same current but share potential difference
National Grid- Network of power stations, transformers and cables that connect consumers to power stations.
Step up transformer- Device that increases the potential difference along cables
Step Down Transformer- Device that lowers the potential difference before it reaches the consumer to make it safe
Potential difference- energy carried by the electrons in a circuit
Resistance- A measure of the opposition to flow in an electrical circuit and measured in Ohms.



Electrons are negatively charged particles and they transfer energy through wires as electricity.

Charge is a property of a body which experiences a force in an electric field. Charge is measured in coulombs (C).

When current flows, electrical **work** is done and energy transferred. The amount of charge passing a point in the circuit can be calculated using the equation:

charge = current × time

$$Q = I \times t$$

Energy, voltage and charge

When a charge moves through a potential difference, electrical **work** is done and energy transferred. The potential difference can be calculated using the equation:

$$potential\ difference = \frac{energy}{charge}$$

$$V = \frac{E}{Q}$$

Resistance

When a charge moves through a potential difference, electrical work is done and energy transferred. The potential difference can be calculated using the equation:

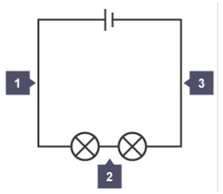
potential difference = current × resistance

$$V = I \times R$$

Resistance is measured in Ohms.

Series Circuits

A **series** circuit is one loop; all electrons in that loop form one current.
An **ammeter** will measure the same current wherever it is placed in the circuit.



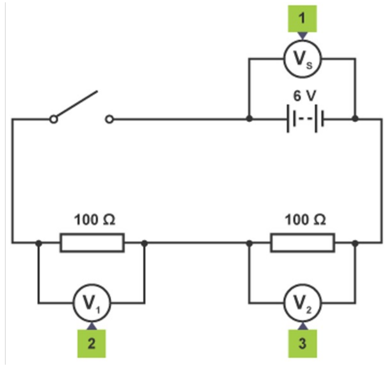
The current will transfer **energy** from the power supply to the components in the circuit. Since energy has to be conserved, all of the source energy is shared between the components. Since **potential difference** is used to measure changes in energy, the potential difference supplied is equal to the total of the potential differences across all other components

In series circuits:

Current is the same through each component

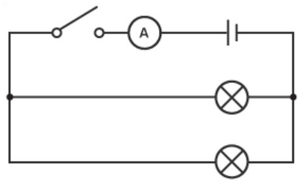
The total potential difference of the power supply is shared between the components

The total resistance of the circuit is the sum of individual resistors

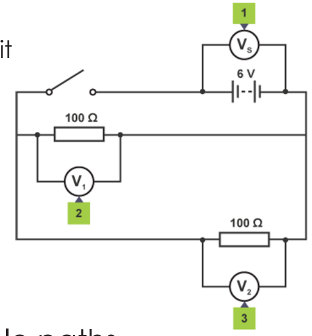


Parallel Circuits-

Since there are different loops, the current will split as it leaves the cell and pass through one or other of the loops. An **ammeter** placed in different parts of the circuit current splits



Since **energy** has to be conserved, the energy transferred around the circuit by the electrons is the same whichever path the electrons follow. Since **potential difference** is used to measure changes in energy, the potential difference supplied is equal to the potential differences across each of the parallel components.



The total resistance of the circuit is reduced as the current can follow multiple paths

Power

As **electrons** flow through wires, they collide with the **ions** in the wire which causes the ions to **vibrate** more. This increased vibration of the ions increases the temperature of the wire. Energy has been transferred from the chemical energy store of the battery into the internal energy store of the wire.

The amount of energy transferred each second (**power**) between the **energy stores** can be calculated using the equation:

power = current × potential difference

$$P = I \times V$$

Power can also be written as:

power = current^2 × resistance

$$P = I^2 \times R$$

The equation shows that a high current will have a much higher heating effect on the transmission wires than a low current. For this reason, transmitting energy at a high voltage with a low current will keep the wires cooler and waste less energy.

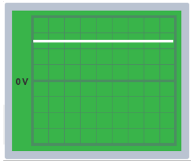
The amount of energy transferred depends on the **power** (the energy transferred each second) and the amount of time the appliance is switched on for. The energy transferred by an appliance can be calculated using the equation:

energy = power × time

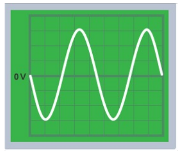
$$E = P \times t$$

AD/DC

On a voltage-time graph this would appear as a straight horizontal line at a constant voltage.
Car batteries, dry cells and solar cells all provide a direct current (dc) that only flows in one direction.



On a voltage-time graph, this would appear as a curve alternating between positive and negative voltages. The positive and negative values indicate the direction of current flow.

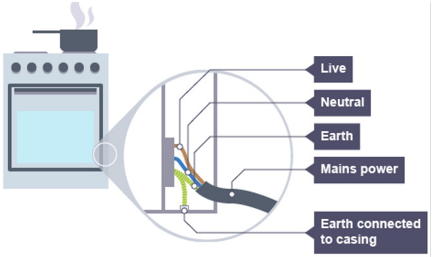


Power stations sometimes produce electricity using magnets. This provides an alternating current (ac). In the UK, the **mains electrical supply** is generated at a **frequency** of 50 Hertz (Hz) and is delivered to houses at 230 Volts (V).

Earthing

Earthing - Without the earth wire, if a fault occurs and the live wire becomes loose, there is a danger that it will touch the case. The next person who uses the appliance could get **electrocuted**.

The earth wire is therefore connected to the case and is attached to a metal plate or water pipe underground. As the wire is made of copper, the earth wire provides a low **resistance** path to the ground. In the event of a fault, the live current passing through the case will follow this path to the ground instead of passing through a person.



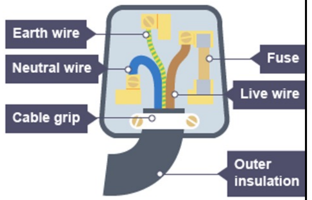
Fuses

Fuses- A fuse provides a built-in fail-safe to the electrical circuit for a device. The fuse contains a thin wire that will melt if the current gets too high. If there is a fault that causes the casing of the device to become live, a large current will flow through the low-resistance earth wire. This high current will cause the fuse to melt.

Once the fuse has melted, the circuit is broken and no more current flows through the device. This means the case of the device is no longer live and there is no more risk of electrocution.

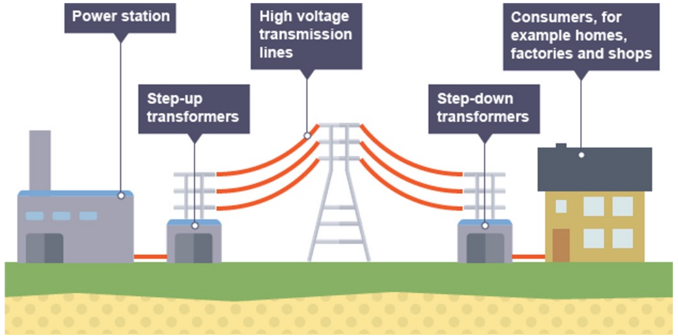
A plug connects a device to the mains electricity supply.
The cable between the device and the three-pin plug contains three copper wires that are coated with plastic.

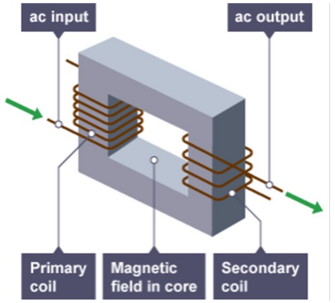
- copper wires are good **conductors**
- plastic is a good **insulator**



Features of a plug	Function
Outer insulation	All three wires in the cable are bundled together and there is extra plastic insulation wrapped round them all for safety
Cable grip	This holds the cable tightly in place so that wires do not become loose
Live wire	Copper wire coated with brown plastic along which the current enters the device
Fuse	A glass or ceramic canister containing a thin wire that melts if the current gets too high
Neutral wire	Copper wire coated with blue plastic that also connects to the cable in the wall and completes the circuit
Earth wire	Copper wire coated in striped plastic that provides a path for current to flow from the case of the device to the ground if there is a fault

The **National Grid** distributes electricity across the country. The National Grid connects power stations to homes, workplaces and public buildings all around the country. The electricity may be produced by a conventional power station turning a **generator** or by another **method**.





Transformers are used to change voltages and **currents** in **transmission lines**. A transformer is formed from two coils of wire around a magnetic core. The number of coils determines whether the transformers will step-up or step-down the voltage.

As the power transferred must stay the same:
increasing voltage decreases current   decreasing voltage increases current

AQA Physics P3: Particle model of matter (Blue - Triple only, Red - Higher only)

Keywords and Terms:

Density - the mass of an object divided by its volume

Internal energy - the energy stored inside a system by the particles (atoms and molecules) that make up the system. the total kinetic energy and potential energy of all the particles (atoms and molecules) that make up a system

Pressure - the amount of force exerted per area.

Specific heat capacity - the amount of energy required to raise the temperature of one kilogram of the substance by one degree Celsius

Specific latent heat - the amount of energy required to change the state of one kilogram of the substance with no change in temperature

Sublimation - the transition of a substance directly from a solid to a gas

Work - the transfer of energy by a force

Density

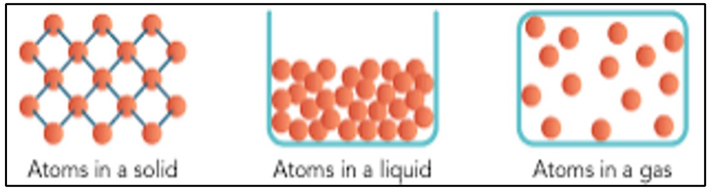
The density of a material can be defined by the equation:

$$\text{DENSITY } (kg/m^3) = \frac{\text{MASS } (kg)}{\text{VOLUME } (m^3)}$$

The particle model can be used to explain:

- The different states of matter
- Differences in density

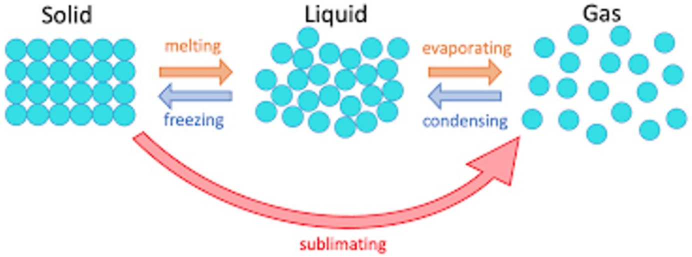
The Particle Model



Solids = more dense
Liquids = medium density
Gases = low density

Changing state

Changes of state are **physical changes** which differ from chemical changes because the material recovers its original properties if the change is reversed.



Internal energy

Energy is stored inside a system by the particles. This is called internal energy.

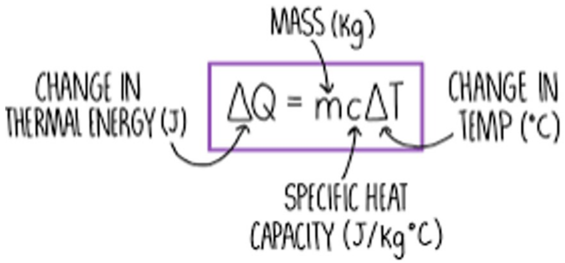
Internal energy is the total kinetic energy and potential energy of all the particles (atoms and molecules) that make up a system.

Heating changes the energy stored within the system by increasing the energy of the particles. This either raises the temperature of the system or produces a change of state.

Specific heat capacity

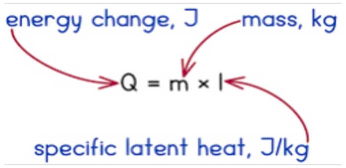
If the temperature of the system increases, the increase in temperature depends on the mass of the substance heated, the type of material and the energy input to the system.

The following equation applies:



Specific latent heat

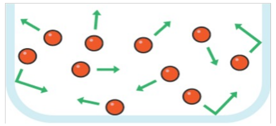
If a change of state happens:
The energy needed for a substance to change state is called latent heat.
When a change of state occurs, the energy supplied changes the energy stored (internal energy) but not the temperature.



Latent heat of fusion = change from solid to liquid
Latent heat of vaporisation = change from liquid to vapour

Particle motion in gases

The molecules of a gas are in constant random motion.
The temperature of the gas is related to the average kinetic energy of the molecules.
Changing the temperature of a gas, held at constant volume, changes the pressure exerted by the gas.



As the temperature increases, the pressure increases showing that pressure is directly **proportional** to temperature.

$$Pressure = \frac{Force}{Area}$$

Pressure in gases

A gas can be compressed or expanded by pressure changes.
The pressure produces a net force at right angles to the wall of the gas container (or any surface).
increasing the volume in which a gas is contained, at constant temperature, can lead to a decrease in pressure. For a fixed mass of gas held at a constant temperature:

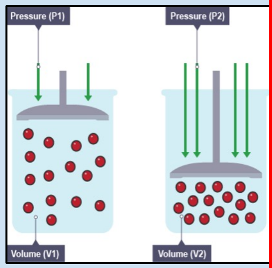
Pressure × volume = constant

Increasing the pressure of a gas

Work is the transfer of energy by a force.
Pressure can be increased by:

- **Decreasing the volume**
- **Increasing the temperature**

Forces applied to the particles in a gas result in a transfer of **energy**.
When a person presses a piston down on a column of gas, they apply a **force** that moves the piston a certain distance. They have done **work** on the gas by compressing it.



AQA Physics P4: Atomic structure (Blue - Triple only, Red - Higher only)

Keywords and Terms:

Alpha radiation - Highly ionising, not very penetrating, helium nuclei, positively charged, stopped in air

Atom - the smallest part of an element, with a radius of about 1×10^{-10}

Atomic mass - the number of protons and neutrons in an atom's nucleus

Atomic number - the number of protons in an atom. (Also the number of electrons)

Beta radiation - Quite ionising and penetrating, high speed electron, negatively charged, stopped by thin sheet of aluminium

Contamination - when an object has radiation introduced to it, and becomes radioactive for as long as the source

Electron - negative particle of an atom

Gamma radiation - most penetrating radiation, least ionising, not a particle, part of the EM spectrum

Half life - the time it takes for half of the unstable nuclei in a sample to decay or for the activity of the sample to halve or for the count rate to halve

Ionisation - the process by which an atom or a molecule acquires a negative or positive charge by gaining or losing electrons

Irradiation - exposing an object to radiation

Isotope - atoms of an element with the same number of protons but a different number of neutrons

Neutron - a neutral particle in the nucleus of an atom

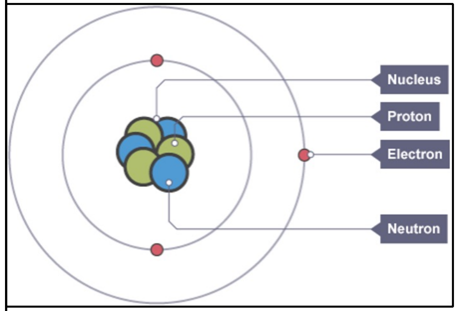
Nucleus - the centre of an atom

Radioactive decay - the process by which an unstable atomic nucleus loses energy by radiation

Atomic structure

Atoms are very small, having a **radius** of about **1×10^{-10} metres.**

Atoms make up ALL things.



The basic structure of an atom is a positively charged nucleus containing both protons and neutrons surrounded by negatively charged electrons.

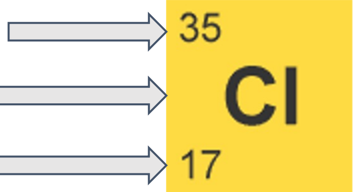
The radius of a nucleus is less than 1/10 000 of the radius of an atom.

The electrons are arranged on different energy levels - **EM radiation** can affect the positions of electrons.

Atomic mass - number of protons and neutrons

Chemical symbol

Atomic number - number of protons

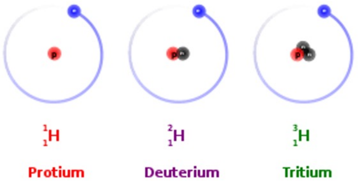


Atoms have the same number of protons and electrons. This is so that their charges balance out, and the atom is **neutral** overall.

Some atoms of elements have a **different number of neutrons**, BUT they will have the **same number of protons.**

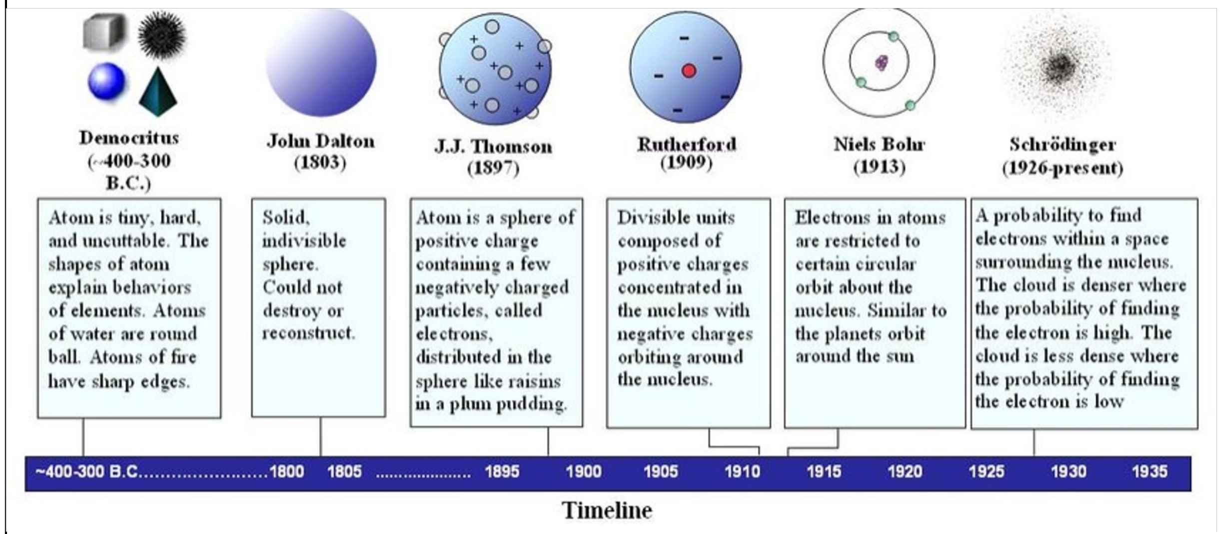
This changes their **mass number** but keeps the atomic number the same.

These are called **isotopes.**



Atoms can lose electrons to form **positive ions.**

Development of the atomic model



Nuclear radiation

Some atomic nuclei are **unstable**.

The nucleus gives out radiation as it changes to become more stable. This is a random process called **radioactive decay.**

The rate at which a source of unstable nuclei decays is called **activity.** Activity is measured in **becquerel (Bq)**.

Count rate is the number of decays recorded each second by a detector e.g. Geiger muller tube

The radiation emitted can be: an **alpha particle**, a **beta particle**, a **gamma ray** or a **neutron.**

Particle	What is it	Charge	Range in air	Penetration	Ionisation
Alpha (α)	2 protons + 2 neutrons	+2	Few cm	Stopped by paper	High
Beta (β^-)	Electron	-1	Few 10s of cm	Stopped by few mm Aluminium	Medium
Gamma (γ)	Electromagnetic wave	0	Infinite	Reduced by few mm Lead	Low

Nuclear equations

A nucleus changes into a new element by emitting **alpha particles** or **beta particles**.
These changes are described using nuclear equations.

Alpha particles can be represented as: ${}^{4}_{2}\alpha$ or ${}^{4}_{2}He$

Alpha decay changes the **mass number** of the element by -4 and the **atomic number** by -2

$${}^{219}_{86}\text{radon} \longrightarrow {}^{215}_{84}\text{polonium} + {}^{4}_{2}He$$

Beta particles can be represented as: ${}^{0}_{-1}\beta$ or ${}^{0}_{-1}e^{-}$

Beta decay changes the **atomic number by +1** but the **mass number stays the same..**
A neutron changes into a proton and a high speed electron.

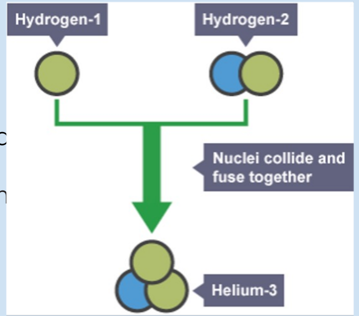
$${}^{14}_{6}\text{carbon} \longrightarrow {}^{14}_{7}\text{nitrogen} + {}^{0}_{-1}e$$

Gamma radiation does not cause the structure of the nucleus to change in any way. It is pure energy.

Nuclear fusion

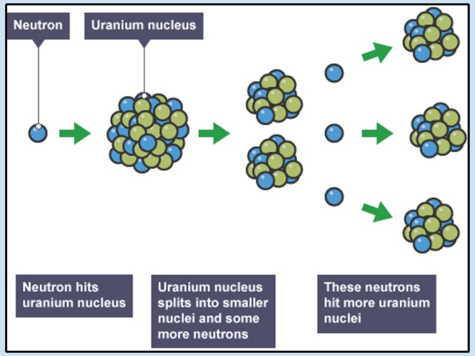
Nuclear fusion is the joining of two light nuclei to form a heavier nucleus.

In this process some of the mass may be converted into the energy of radiation.
Fusion reactions occur in stars where two hydrogen nuclei fuse together under high temperatures and pressure to form a nucleus of a helium isotope



Nuclear fission

The process of splitting a large, unstable atomic nucleus into smaller nuclei. Spontaneous fission is rare. Normally the unstable nucleus absorbs a neutron.



The nucleus undergoing fission splits into two smaller nuclei, and emits two or three neutrons plus gamma rays.
Energy is released by the fission reaction.
The neutrons may go on to start a chain reaction. The chain reaction is controlled in a nuclear reactor to control the energy released.

The explosion caused by a nuclear weapon is caused by an uncontrolled chain reaction.

Radioactive contamination

Radioactive contamination is the unwanted presence of materials containing radioactive atoms on other materials.

The hazard from contamination is due to the decay of the contaminating atoms.
The type of radiation emitted affects the level of hazard - due to different half lifes, as well as the different properties

Advantages	Disadvantages
Medical tracers - e.g. to check for blockages in blood vessels Checking for leaks in water supplies Can limit exposure - isotopes with shorter half lives	Isotopes may not go where needed Hard to ensure all contamination is removed Can potentially damage living cells

Background radiation

Background radiation is around us all of the time.
It comes from:

- Natural sources such as rocks and cosmic rays from space
- Man-made sources such as the fallout from nuclear weapons testing and nuclear accidents.

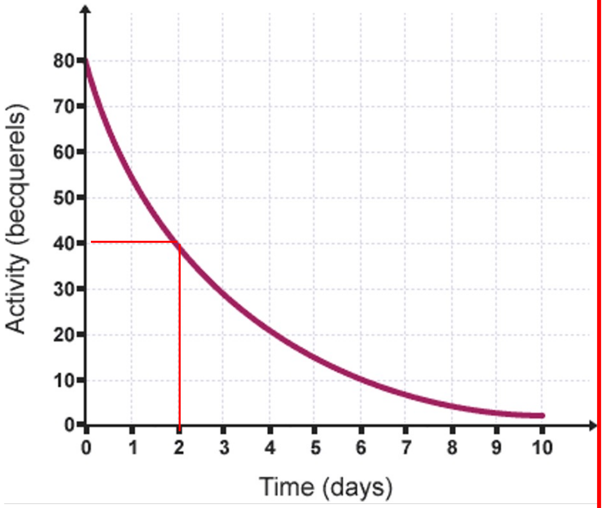
The level of background radiation and radiation dose may be affected by occupation and/or location.

Radiation dose is measured in **sieverts (Sv)**
1000 millisieverts (mSv) = 1 sievert (Sv)

Half life

The half-life of a radioactive isotope is the time it takes for the number of nuclei of the isotope in a sample to halve,

Radioactive decay is a random process. It is not possible to predict when a nucleus will decay, or which nuclei will decay next.



To calculate half life from a graph. Draw a line from half the original activity to the curve. Draw a line down to the time.

Calculating radioactive decay

Method 1: Halving Method

- Determine the number of half-lives elapsed
- Divide the number 1 by half for each half-life elapsed
- For example, if 4 half-lives have elapsed:
  $1 \div ½ \div ½ \div ½ \div ½ = 1 / 16$

Method 2: Raising to a Power

- Determine the number of half-lives elapsed
- Use your calculator to raise ½ to the number of half-lives
- For example, if 4 half-lives have elapsed:
  $(½)^4 = 1/16$

Both methods result in the same as a ratio of 1 remaining : 16 original nuclei, or 1:16

Irradiation

Irradiation is the process of exposing an object to nuclear radiation.
The irradiated object does not become radioactive.
Precautions must be taken to protect against hazards that a source presents.
Uses of irradiation include:

- Sterilisation - e.g. medical equipment, fruit
- Gamma knife - used to kill cancerous tumours in the body

Advantages	Disadvantages
Sterilisation can be done without high temperatures Used to kill bacteria on things that would melt	May not kill all bacteria on object Can be harmful, may expose people nearby to cell damage

AQA Physics P5: Forces (Blue - Triple only, Red - Higher only)

Keywords and Terms:

Acceleration - the change in an object's speed in a certain amount of time

Braking distance - the distance a vehicle travels after pressing the brakes

Circular motion - an object moving in a circle has constant speed but changing velocity

Conservation of Momentum - in a closed system, the total momentum before an event is equal to the momentum after the event

Displacement - the distance an object moves from its original position, and the direction it moves in

Elastic deformation - occurs when a spring is stretched and can then return to its original length

Inertia - the tendency of objects to continue in their state of rest or of uniform motion

Limit of proportionality - the length a spring can be stretched before it no longer is able to return to its original length. Beyond this point, a force extension graph is curved

Moment - the turning effect of a force

Momentum - moving objects with mass have momentum (mass in motion)

Reaction time - the time it takes to react to a stimulus

Resultant force - a single force that has the same effect as all the forces acting on an object

Scalar - a value with magnitude (size) e.g. speed or distance

Stopping distance - the sum of the thinking distance and braking distance

Terminal velocity - the maximum speed of a moving object, when the force moving an object balances the frictional forces

Thinking distance - the distance a vehicle travels while a driver is reacting

Vector - a value with magnitude and direction e.g. velocity and displacement

Velocity - the speed of an object in a particular direction

Work done - the energy transferred when a force makes an object move

Scalar and vector

We can put quantities into two groups: **scalar** and **vector**

Scalar is a quantity that has magnitude ONLY.

Vector is a quantity that has magnitude and direction.

These can be represented using arrows - the length of the arrow should be proportional to the size of the force.

Types of Forces

A force is a **push** or **pull** that acts on an object due to the interaction with another object.

All forces can be either:

- **Contact** – the objects are physically touching e.g. push, pull, air resistance, friction
- **Non-contact** - the objects are physically separated e.g. magnetic, gravity, electrostatic

Force is a **vector** quantity.

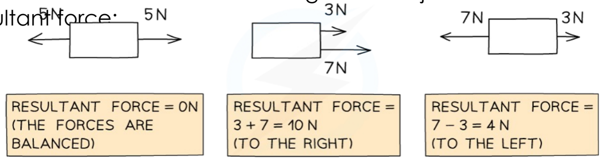
Resultant force

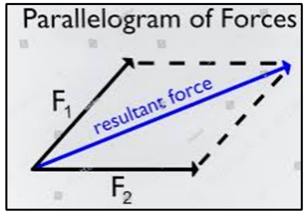
This is a single force that describes all of the forces operating on a body.

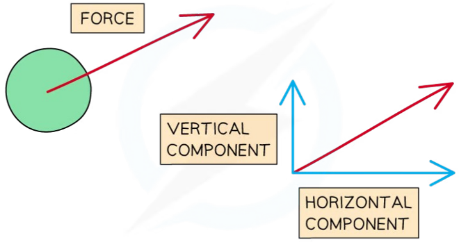
We can calculate the resultant force by:

- Subtracting the forces that are working in the opposite direction from each other
- Adding the forces that are working in the same direction to each other

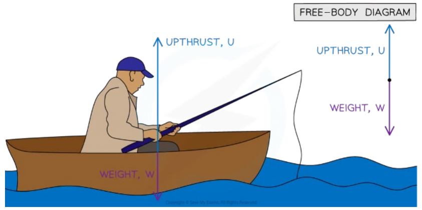
Force diagrams allow us to see the forces acting on an object and calculate the resultant force:







We can use free body diagrams to model the forces acting on an object:



Gravity

Weight is the force acting on an object due to gravity. It is measured in Newtons.

The force of gravity close to the Earth is due to the gravitational field around the Earth.

The weight of an object depends on the gravitational field strength at the point where the object is.

The weight of an object may be considered to act at a single point referred to as the object's '**centre of mass**'.

weight (N) = mass (kg) × gravitational field strength (N/kg)

W = m x g

The weight of an object and the mass of an object are directly proportional.

Weight is measured using a calibrated spring-balance (a newton meter).

Forces and elasticity

The extension of an elastic object, such as a spring, is directly proportional to the force applied, provided that the **limit of proportionality** is not exceeded.

force (N) = spring constant (N/m)× extension (m)

F = k x e

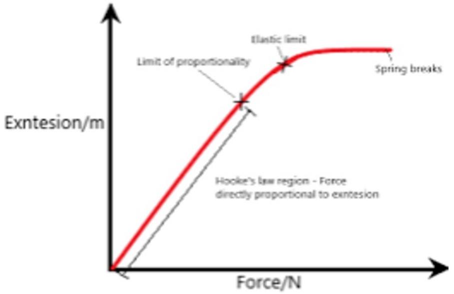
This relationship also applies to the compression of an elastic object, where 'e' would be the compression of the object.

A force that stretches/ compresses a spring does work and elastic potential energy is stored in the spring. Provided the spring is not inelastically deformed, the work done on the spring and the elastic potential energy stored are equal.

We can calculate the work done stretching or compressing a spring using the following:

elastic potential energy = 0.5 × spring constant × (extension)²

E_p = ½ x k x e^2



Work done and energy transfer

When a force causes an object to move through a distance, **work is done** on the object.

work done (J) = force (N) × distance (m)

W = F x s

One joule of work is done when a force of one newton causes a displacement of one metre.

1 joule = 1 newton-metre

Work done against the frictional forces acting on an object causes a **rise in the temperature** of the object.

Pressure

A **fluid** can be either a liquid or a gas.

The pressure in fluids causes a force normal (at right angles) to any surface.

The pressure at the surface of a fluid can be calculated using the equation:

pressure (Pa) = force normal to a surface (N) / area of that surface (m²)

The pressure due to a column of liquid can be calculated using the equation:

pressure (Pa) = height of the column (m) × density of the liquid (kg/m³) × gravitational field strength (N/kg)

The more water above an object, then the greater the force applied and the greater the pressure exerted.

A partially (or totally) submerged object experiences a greater pressure on the bottom surface than on the top. This creates a **resultant force upwards**. This force is called the **upthrust**.

Atmospheric pressure

The atmosphere is a thin layer (relative to the size of the Earth) of air round the Earth.

The atmosphere gets less dense with increasing altitude (height).

Air molecules colliding with a surface create atmospheric pressure.

As height above the surface increases, there is always less air particle.

So atmospheric pressure decreases with an increase in height.

Moments and levers

Some forces can cause objects to rotate.
This turning effect of a force is called the **moment of a force.** It can be calculated as follows:

moment of a force (Nm) = force (N) × distance (m)

M = F x d

If an object is **balanced**, the total clockwise moment about a pivot equals the total anticlockwise moment about that pivot.

Levers make use of moments to act as a **force multiplier**. They allow a larger force to act upon the load than is supplied by the effort, so it is easier to move large or heavy objects.

A lever consists of a pivot, an effort and a load.

Gears are wheels with toothed edges that rotate on an **axle** or shaft. The teeth of one gear fit into the teeth of another gear. This lets one gear turn the other, meaning one axle or shaft can be used to turn another shaft.

Newton's Laws

Newton's FIRST Law states that:
If the resultant force acting on an object is ZERO;

- A stationary object will remain stationary
- A moving object will continue to move at the same speed in the same direction

The tendency of objects to continue in their state of rest or of uniform motion is called **inertia**.

Newton's SECOND Law states that:
The acceleration of an object is proportional to the resultant force acting on it, and inversely proportional to the mass of the object. E.g. acceleration increases as mass decreases

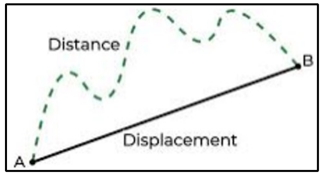
resultant force (N) = mass (kg) × acceleration (m/s²)

Inertial mass is a measure of how difficult it is to change the velocity of an object

Newton's THIRD Law states that:
Whenever two objects interact, the forces they exert on each other are equal and opposite.

Newton's Third Law can be applied to examples of equilibrium situation.

Distance vs Displacement



Distance is how far an object moves. It does not involve direction and therefore is a **scalar** quantity.

Displacement includes both the distance an object moves, measured in a straight line from the start point to the finish point and the direction of that straight line. Therefore, it is a **vector** quantity.

Speed

Speed is a **scalar** quantity.
The speed of a moving object is rarely constant.

The speed at which a person can walk, run or cycle depends on many factors, e.g. age, terrain, fitness and distance travelled.

Typical values for speed:

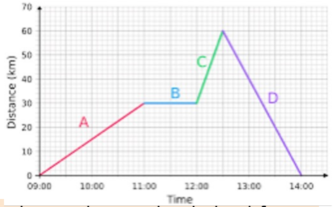
- walking~1.5 m/s
- running~3 m/s
- cycling~6 m/s.

The speed of sound and the speed of the wind also vary. A typical value for the speed of sound in air is 330 m/s.

Speed (m/s) = Distance (m) ÷ time (s)

The **velocity** of an object is its speed in a given direction. Velocity is a **vector** quantity.
Motion in a circle involves constant speed but changing velocity.

We can show an object's movement on a distance-time graph:



The speed of an object can be calculated from the gradient of its distance–time graph.

If an object is accelerating, its speed at any particular time can be determined by drawing a tangent and measuring the gradient of the distance–time graph at that time.

Acceleration

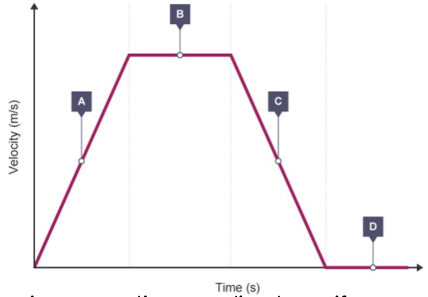
The average acceleration of an object can be calculated using the equation:

acceleration (m/s²)= change in velocity (m/s) / time taken (s)

An object that is slowing down is **decelerating**

The acceleration of an object can be calculated from the gradient of a velocity–time graph.

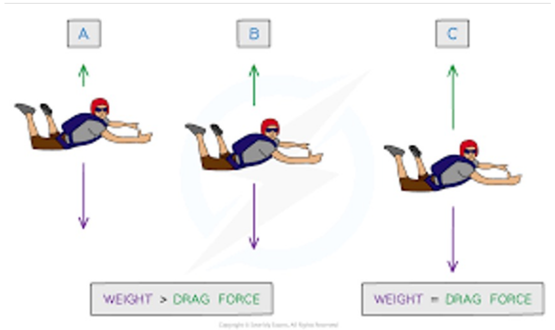
The distance travelled by an object (or displacement of an object) can be calculated from the area under a velocity–time graph.



The following equation applies to uniform acceleration:
(final velocity)² −(initial velocity)² = 2 × acceleration × distance

Near the Earth's surface any object falling freely under gravity has an acceleration of about 9.8 m/s²

An object falling through a fluid initially accelerates due to the force of gravity.
Eventually the resultant force will be zero and the object will move at its **terminal velocity.**



Braking

The stopping distance of a vehicle is the sum of the thinking distance and the braking distance.
For a given braking force the greater the speed of the vehicle, the greater the stopping distance.

Thinking distance - distance travelled while the driver reactions. Can be affected by: drugs, alcohol, tiredness, distractions

Braking distance - distance travelled from when the brakes are pressed to the car stopping. Can be affected by: adverse road conditions, poor condition of the car.

When a force is applied to the brakes of a vehicle, **work done** by the friction force between the brakes and the wheel reduces the kinetic energy of the vehicle and the temperature of the brakes increases.

The greater the braking force the greater the deceleration of the vehicle. Large decelerations may lead to brakes overheating and/or loss of control.

Momentum

Momentum is defined by the equation:
Momentum (kgm/s) = mass (kg) × velocity (m/s)

In a closed system, the total momentum before an event is equal to the total momentum after the event. This is called conservation of momentum.

When a force acts on an object that is moving, or able to move, a change in momentum occurs.

The equations F = m × a and a = v − u/ t combine to give the equation:

F = mΔv ÷ Δt

Force equals the rate of change of momentum

Car safety features

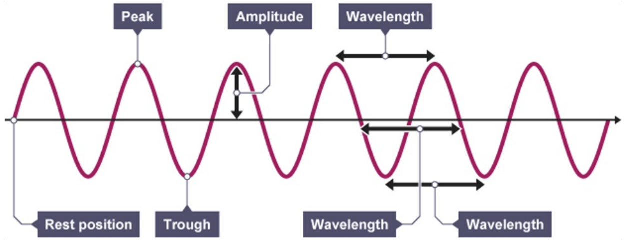
Crumple zones refer to the areas of a car that are designed to deform or crumple on impact.
These different safety features decrease the rate of change of momentum, which decreases the force of the collision on any people within the car.

AQA Physics P6: Waves (Blue - Triple only, Red - Higher only)

Key words

Longitudinal wave- A wave which moves in the same direction as the direction in which the particles are vibrating
Matter- Subatomic particles and anything made from tem- such as atoms and molecules. (Not energy!)
Medium- A material through which a wave can be transmitted
Oscillations- The repeated and regular fluctuation above and below the same position
Transverse wave- A wave that moves in a direction at right angles to the way in which the particles are vibrating
Vibration-Repeated movements back and forth about a fixed point
Frequency- The number of wave produced each second, the unit is Hertz (Hz)
Compression- An area of increased pressure in longitudinal waves (particles are closer together)
Rarefaction- An area of reduced pressure in longitudinal waves (particles are further apart)
Reflection- Light ray leaving the surface or boundary
Refraction- When a wave speed changes which changes the angle of the wave.
Normal- An imaginary line at right angles to the boundary between air and glass. All angles are measured to this line.
Vacuum- A volume that contains no matter
Wavelength- The length of a single wave measured from one peak to the next.
Amplitude- The height of a wave from its resting point, the bigger the amplitude the louder the sound.
Ray diagram- Diagram that represents the direction and angle of light.
Seismic wave- Shock waves travelling through the Earth, usually caused by an earthquake.
Concave- Curving inwards, rather than bulging outwards
Convex- An object or shape that curves or bulges outwards
Focal length- The distance between the centre of the lens and focal point
Principal focus- Known as the focal point where light rays appear to converge or diverge from.
Real image- An image formed when light rays are focused
Virtual image- An image from which rays of light appear to come but do not do so in reality.
Conduction- The transfer of heat through material by transmitting kinetic energy from one particle to another
Convection- The transfer of heat energy through a moving liquid or gas

Wave structure



Waves are one of the ways in which energy may be transferred between stores. Waves can be described as **oscillations**, or **vibrations** about a rest position.
In **longitudinal waves**, the vibrations are parallel to the direction of wave travel. In **transverse waves**, the vibrations are at right angles to the direction of wave travel.
Mechanical waves cause oscillations of particles in a solid, liquid or gas and must have a **medium** to travel through.
Electromagnetic waves cause oscillations in electrical and magnetic fields.

rest position - the undisturbed position of particles or fields when they are not vibrating
displacement - the distance that a certain point in the medium has moved from its rest position
peak - the highest point above the rest position
trough - the lowest point below the rest position
amplitude - the maximum displacement of a point of a wave from its rest position
wavelength - distance covered by a full cycle of the wave, usually measured from peak to peak, or trough to trough
time period - the time taken for a full cycle of the wave, usually measured from peak to peak, or trough to trough
frequency - the number of waves passing a point each second

Wave period and wave speed

The time period of a wave can be calculated using the equation:

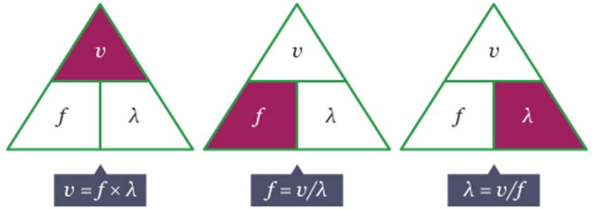
$$Time\ period = \frac{1}{frequency}$$

Example:

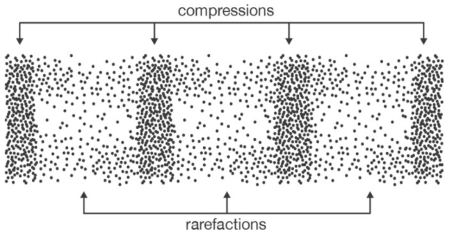
$$T = \frac{1}{f}$$
$$T = 1 \div 50$$
$$T = 0.02\ s$$

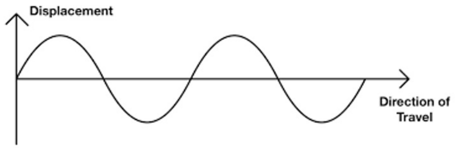
The speed of a wave can be calculated using the equation:

wave speed = frequency × wavelength



Longitudinal waves	Transverse waves
• Vibrations travel parallel to the direction of wave travel • Examples are sound waves, ultrasound waves and seismic waves • They have areas of compression and rarefaction	• Vibrations are at right angles to the direction of wave travel • Examples include vibrations on a guitar spring, light waves, electromagnetic waves





Light travels much faster than sound through air.
The speed of sound can be calculated using the equation:

$$speed = \frac{distance}{time}$$

An observer 400 m away records a 1.2 s time difference between seeing the hand signal and hearing the bang of the starting pistol.

$$v = \frac{d}{t}$$
$$v = 400 \div 1.2$$
$$v = 333\ m/s (3sf)$$

Electromagnetic waves are transverse waves. Their vibrations or **oscillations** are changes in electrical and magnetic fields at right angles to the direction of wave travel.
All electromagnetic waves:

- transfer energy as **radiation** from the source of the waves to an absorber
- can travel through a **vacuum** such as in space
- travel at the same speed through a vacuum or the air

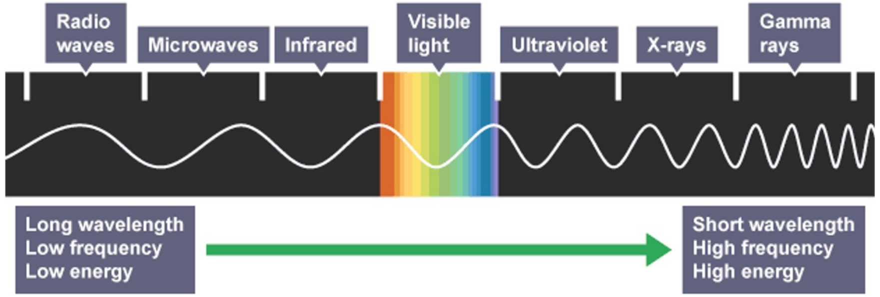
Electromagnetic waves travel at 300 million metres per second (m/s) through a vacuum.

Electromagnetic spectrum

Electromagnetic waves form a continuous **spectrum** of waves. This includes:

- waves with a very short **wavelength**, high **frequency** and high energy
- waves with a very long wavelength, low frequency and low energy

Electromagnetic waves can be separated into seven distinct groups in the spectrum.



Each group contains a range of frequencies. For example, visible light contains all the frequencies that can be detected by the human eye:

- red light has the lowest frequencies of visible light
- violet light has the highest frequencies of visible light

AQA Physics P6: Waves (Blue - Triple only, Red - Higher only)

Background radiation

All bodies (objects) emit and absorb **infrared radiation**. They do this whatever their **temperature**. The hotter the body:

- the more infrared radiation it gives out in a given time
- the greater the proportion of emitted radiation is visible light

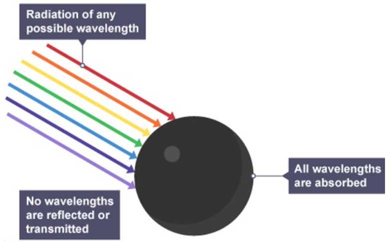
Black bodies

There are no known objects that are perfect at absorbing or emitting all the radiation, of every possible frequency, that may be directed at it. Some objects do, however, come close to this and these are referred to as "black bodies".

A perfect black body is a **theoretical** object. It would have these properties:

- it would absorb all the radiation that falls on it
- it would not **reflect** or **transmit** any radiation

An object that is good at absorbing radiation is also a good **emitter**, so a perfect black body would be the best possible emitter of radiation.



Stars are considered to be black bodies because they are very good emitters of most wavelengths in the **electromagnetic spectrum**. This suggests that stars also absorb most wavelengths. Whilst there are a few wavelengths that stars do not absorb or emit, this figure is very low, so they can be treated as black bodies. Planets and black holes are also treated as nearly perfect black bodies.

Poor absorbers and emitters

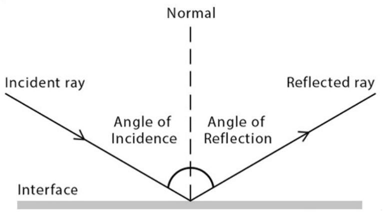
White and shiny silvery surfaces are the worst absorbers, as they reflect all visible light wavelengths. Poor absorbers are also poor emitters, and do not emit radiation as quickly as darker colours. Radiators in homes are usually painted white so that the infrared radiation is emitted gradually.

Reflection

Waves - including sound and light - can be reflected at the boundary between two different materials. The reflection of sound causes echoes. The law of reflection states that:

angle of incidence = angle of reflection

The **angles of incidence** and **reflection** are measured between the light ray and the **normal** - an imaginary line at 90° to the surface. The diagrams show a water wave being reflected at a barrier, and a light ray being reflected at a **plane** mirror.



Specular	Diffuse
Reflection on a smooth surface- this type of reflection happens on a flat mirror	Reflection that happens on a rough surface so light is scattered in all different directions

Sound waves are **longitudinal waves**. They cause particles to vibrate parallel to the direction of wave travel. The **vibrations** can travel through solids, liquids or gases. The speed of sound depends on the **medium** through which it is travelling. When travelling through air, the speed of sound is about 330 metres per second (m/s). Sound cannot travel through a **vacuum** because there are no particles to carry the vibrations.

Longitudinal waves

Ultrasound waves have a frequency higher than the upper limit for human hearing - above 20,000 Hertz (Hz). Different species of animal have different hearing ranges. This explains why a dog can hear the ultrasound produced by a dog whistle but humans cannot.

Seismic waves are produced by earthquakes in the Earth's crust. They can cause damage to structures on the Earth's surface, as well as **tsunamis**.

	P-waves	S-waves
Type of wave	longitudinal	transverse
Relative speed	faster	slower
Can travel through	solids and liquids	solids only

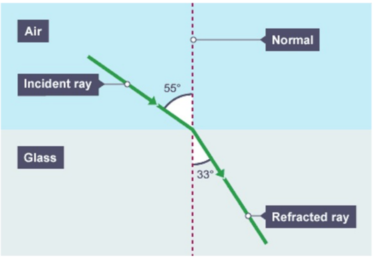
Colour

Within the visible light range of the **electromagnetic spectrum** there is a **spectrum** of colour. This is a **continuous** range of colours. In order of increasing **frequency** and decreasing wavelength these are given as: red, orange, yellow, green, blue, indigo, violet. Each colour within the visible light spectrum has its own narrow band of wavelength and frequency.

Waves can be **absorbed** at the boundary between two different materials. When waves are absorbed by a surface, the energy of the wave is transferred to the particles in the surface. This will usually increase the **internal energy** of the particles.

Refraction

Different materials have different densities. Light waves may change direction at the boundary between two transparent materials. **Refraction** is the change in direction of a wave at such a boundary.



The **density** of a material affects the speed that a wave will be **transmitted** through it. In general, the denser the transparent material, the more slowly light travels through it.

Glass is denser than air, so a light ray passing from air into glass slows down. If the ray meets the boundary at an angle to the **normal**, it bends towards the normal.

The reverse is also true. A light ray speeds up as it passes from glass into air, and bends away from the normal by the same angle.

For a given **frequency** of light, the **wavelength** is **proportional** to the wave speed:

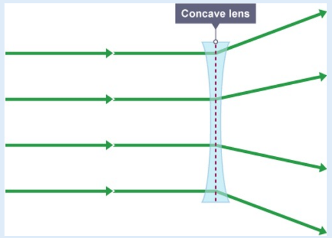
wave speed = frequency × wavelength

Lenses

A lens is a shaped piece of transparent glass or plastic that **refracts** light. When light is refracted it changes direction due to the change in density as it moves from air into glass or plastic. Lenses are used in cameras, telescopes, binoculars, microscopes and corrective glasses. A lens can be **convex** or **concave**.

Concave

A concave lens is thinner in the middle than it is at the edges. This causes parallel rays to **diverge**. They separate but appear to come from a principle focus on the other side of the lens.

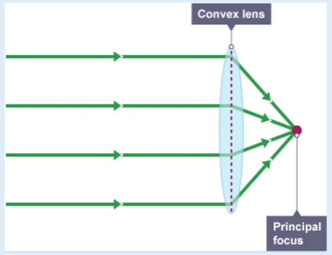


In a ray diagram, a concave lens is drawn as a vertical line with inward facing arrows to indicate the shape of the lens.

Concave lenses always produce images that are upright, diminished and virtual

Convex

A convex lens is thicker in the middle than it is at the edges. Parallel light rays that enter the lens **converge**. They come together at a point called the **principal focus**.



The distance from the lens to the principal focus is called the **focal length**.

The type of image formed by a **convex** lens depends on the lens used and the distance from the object to the lens.

Magnification

Magnification is a measure of the size of an image compared to the size of the object. Lenses and curved mirrors can produce magnified images

AQA Physics P7: Magnetism and electromagnetism (Blue - Triple only, Red - Higher only)

Keywords and Terms:

Attract - the force between oppositely charged objects

Compass - a device that is used to find direction by means of a needle that always points north

Conductor - a material that allows electricity to pass through

Electromagnetic - a soft metal core made into a magnet by the passage of electric current through a coil surrounding it.

Electrostatic attraction - force between unlike charges

Induced magnet - a material that becomes a magnet when it is placed in a magnetic field

Magnetic field - a region around a magnetic material or a moving electric charge within which the force of magnetism acts

Motor effect - the effect of the interaction between two magnetic fields, usually a force on a wire resulting in movement

Permanent magnet - produces its own magnetic field

Poles - ends of a magnet, where the magnetic field is the strongest

Repel - the force between like charges

Solenoid - a cylindrical coil of wire acting as a magnet when carrying electric current

Transformers - an apparatus for reducing or increasing the voltage of an alternating current

Permanent and induced magnets

Permanent magnets always have a **magnetic field** around them.

North pole and north pole – repel

South pole and south pole – repel

North pole and south pole - attract

Induced magnets are materials (iron, steel, nickel and cobalt), which become magnetic when they are placed in a magnetic field.

They lose their magnetism when they are removed from the field. **Induced magnets always attract!**

Magnetic fields

A magnetic field is the area around a magnet where you can feel the force of magnetism.

They can be represented using **magnetic field lines.**

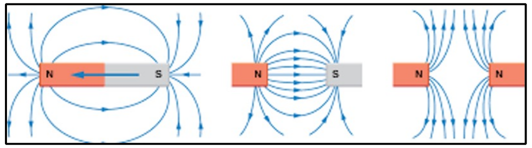
Magnetic field lines must:

- point north to south
- Never cross
- Be strongest at the poles

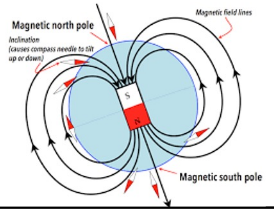
We can plot the field lines by using:

a) iron filings

b) Plotting compasses



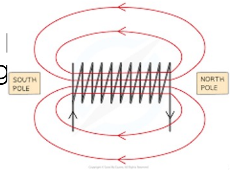
The Earth's liquid iron core produces a magnetic field. So the needle of a compass points north.



Electromagnets

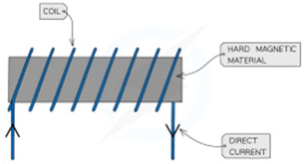
When a current flows through a conducting wire a circular magnetic field is produced around the wire. The strength of the magnetic field depends on the current through the wire and the distance from the wire.

Coiling the wire to form a **solenoid**
magnetic field similar to a bar mag



The strength of the magnetic field can be increased by increasing the current or adding an iron core

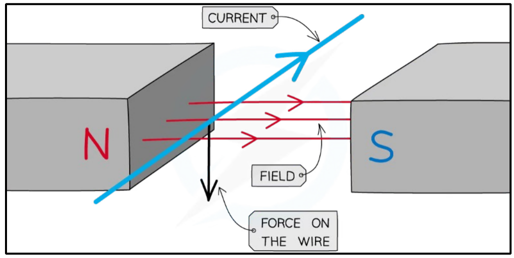
An **electromagnet** is a solenoid with an iron core.



The Motor effect and Fleming's left hand rule

When a wire carrying a current is exposed to the magnetic field of another magnet, then a force is produced on the wire at a right angle to the direction of the magnetic field produced.

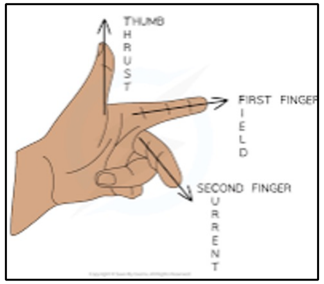
This is called **the motor effect.**



The larger the current, the stronger the magnetic field

It can be calculated by: **Force (N) = magnetic flux density (T) x current (A) x length (m)**

The direction of a motor effect force can be found using Fleming's left hand rule.



Worked example

A 5.0 cm wire carries a current of 0.75 A. Calculate the force acting on the wire when it is placed at right angles in a 0.60 T magnetic field.

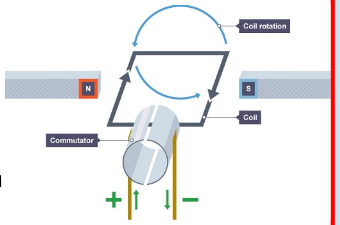
5cm/100 = 0.05m

F = B x I x l =

0.60T x 0.75A x 0.05m = **0.0225N**

Electric motors

A coil of wire carrying a current in a **magnetic field** experiences a force that tends to make it rotate. This effect can be used to make an electric motor.



Current in the left hand part of the coil causes a downward force, and current in the right hand part of the coil causes an upward force

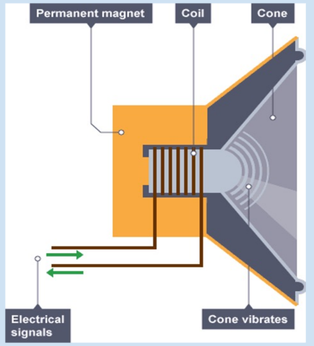
The coil rotates anticlockwise because of the forces described above

Loudspeakers

Loudspeakers and headphones use the motor effect to convert variations in current in electrical circuits to the pressure variations in sound waves.

This causes a cone to move, which creates pressure variations in the air and forms sound waves.

To make a loudspeaker cone vibrate correctly, the electric current must vary in the same way as the desired sound.



AQA Physics P7: Magnetism and electromagnetism (Blue - Triple only, Red - Higher only)

Induced potential and the generator effect

A **potential difference** or **voltage** is needed to make an electric current flow in a circuit. The following actions can induce a potential difference:

- a coil of wire is moved in a magnetic field
- a magnet is moved into a coil of wire

This is called **electromagnetic induction** and is often referred to as the **generator effect**.

The induced voltage produces an induced current if the conductor is connected in a complete circuit.
The induced current creates a magnetic field around itself - this magnetic field opposes the original change.

This effect occurs whether a magnet is moved into a coil, or a coil is moved around a magnet.

Factors affecting the induced potential

The direction of the induced current depends on the direction of movement of the magnet relative to the coil. The current is reversed when:

- the magnet is moved out of the coil
- the other pole of the magnet is moved into the coil

An induced potential difference or induced current will increase if:

- the speed of movement is increased
- the magnetic field strength is increased
- the number of turns on the coil is increased

Transformers

A **transformer** is a device that can change the **potential difference** or **voltage** of an alternating current:

- a step-up transformer increases the voltage
- a step-down transformer reduces the voltage

A basic transformer consists of a primary coil and a secondary coil wound on an iron core. Iron is used as it is easily magnetised.
Transformers only work with alternating current.

The ratio of potential differences on the **transformer** coils matches the ratio of the numbers of turns on the coils.

$$\frac{\text{primary voltage}}{\text{secondary voltage}} = \frac{\text{number of turns on primary coil}}{\text{number of turns on secondary coil}}$$

$$\frac{V_p}{V_s} = \frac{n_p}{n_s}$$

This is when:

- V_p is the potential difference in the primary (input) coil in volts (V)
- V_s is the potential difference in the secondary (output) coil in volts (V)
- n_p is the number of turns on the primary coil
- n_s is the number of turn on the secondary coil

In a step-up transformer, Vs > Vp. In a step-down transformer, Vs < Vp.

If transformers were 100% efficient, the electrical power output would match the power input.

To calculate power we use: P= I x V

The following equation can be used to calculate the power output from the transformer:

potential difference across primary coil × current in primary coil = potential difference across secondary coil × current in secondary coil

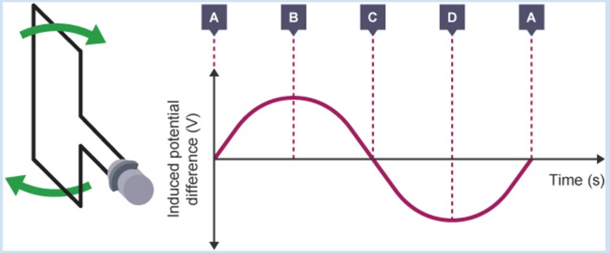
$$V_s \times I_s = V_p \times I_p$$

Uses of the generator effect

The generator effect is used in an alternator to generate ac and in a dynamo to generate dc.

An alternating current (ac) **generator** is a device that produces a **potential difference**.

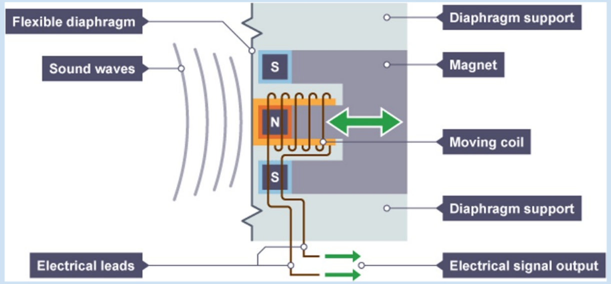
A simple **ac** generator consists of a coil of wire rotating in a magnetic field.
Cars use a type of ac generator, called an **alternator** to keep the battery charged and to run the electrical system while the engine is working.



The diagram shows four different positions of the coil in an alternator, and the corresponding potential difference produced.

Microphones

The microphone is a device that converts sound waves into electrical signals. Microphones use the **generator effect** to induce a changing current from the pressure variations of sound waves.

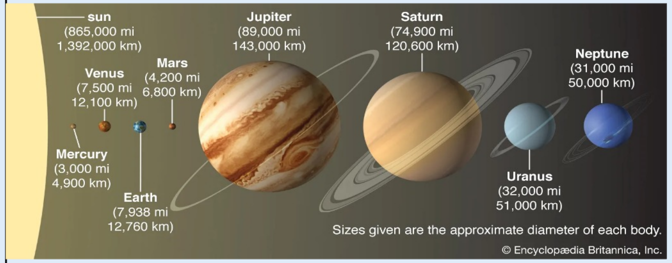


AQA Physics P8: Space (Triple only)

Key words

Acceleration- The rate of change in speed or velocity
Asteroid- A rock in space which orbits the sun but some may cross the Earth's orbit, producing a small risk of collision
Centripetal force- Force needed for circular motion, which acts towards the centre of a circle
Comet- A ball of icy rock that follows an elliptical orbit around the Sun.
Dwarf planet- An object orbiting a star that is massive enough to be rounded by its own gravity but has not cleared the neighbourhood of other objects and is not a satellite
Galaxy- A cluster of billions of stars, held together by gravity
Geostationary- A satellite orbiting a planet at the same rate as the planet.
GPE- The energy stored by an object lifted up against the force of gravity.
Nebula- A cloud of gas and dust in outer space. If massive enough, these can collapse under gravity to form a protostar
Nuclear fusion- Joining together of 2 smaller atomic nuclei to produce a larger nucleus. Radiation is released when this happens
Protostar- The early stage in the formation of a star, before nuclear fusion occurs
Satellite- Body that orbits a planet

Solar system



Moons are natural **satellites** that orbit a planet.
The Solar System contains smaller objects called **asteroids** - these orbit the Sun in highly **elliptical** orbits, which are oval or egg-shaped and may take millions of years to complete.
Asteroids are made of metals and rocky material.

The Milky Way is a **galaxy** containing billions of stars. The Sun is one of these stars.

The Sun
The Sun is the largest object in the Solar System. The Sun's huge gravitational field keeps many other objects - planets, dwarf planets, asteroids and comets - in orbit around it.

Planets
The Earth is one of eight planets in the Solar System. The planets orbit the Sun at different distances.

The Sun

The Solar System was formed around 4.6 billion years ago from a large cloud of dust and gas, called a **nebula**. This collapsed under its own gravity, transferring **gravitational potential energy** to **kinetic energy** in its particles. As the nebula collapsed it became denser, and rotated more rapidly. Collisions between particles caused kinetic energy to be transferred as **internal energy** and **thermal energy**. The core of the nebula began to form a hot, dense **protostar**.

When the Sun's core became hot enough and dense enough, **nuclear fusion** reactions began. In these reactions:

- hydrogen **nuclei** join together to form helium nuclei
- energy is transferred by radiation

A star like the Sun is at equilibrium - gravity tends to pull it inwards, and radiation pressure from the nuclear reactions tends to expand it outwards. In other words, the gravitational collapse is balanced by the expansion due to fusion energy.

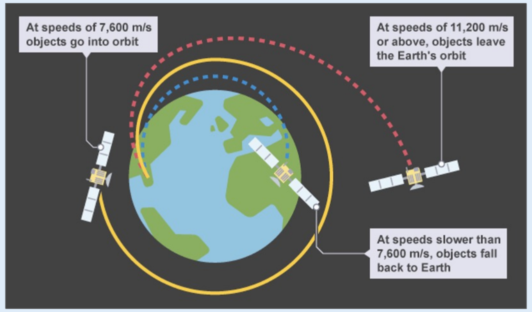
Orbital motion

Gravity provides the force needed to maintain stable orbit of both planets around a star and also of moons and artificial satellites around a planet.

Explaining orbits
For an object to remain in a steady, circular orbit it must be travelling at the right speed. The diagram shows a satellite orbiting the Earth.

There are three possible outcomes:

- If the satellite is moving too quickly then the gravitational attraction between the Earth and the satellite is too weak to keep it in orbit. If this is the case, the satellite will move off into space. This occurs at speeds around or above 11,200 metres per second (m/s).
- If the satellite is moving too slowly then the gravitational attraction will be too strong, and the satellite will fall towards the Earth. This occurs at speeds below 7600 m/s.
- A stable orbit is one in which the satellite's speed is just right - it will not move off into space or spiral into the Earth, but will travel around a fixed path.



Orbits and speed

Constant Speed
When an object moves in a circle at a constant **speed**, its direction constantly changes. A change in direction causes a **change in velocity**. This is because **velocity** is a **vector** quantity - it has an associated direction as well as a magnitude. A change in velocity results in **acceleration**, so an object moving in a circle is accelerating even though its speed may be constant.
An object will only accelerate if a **resultant force** acts on it. For an object moving in a circle, this resultant force is the **centripetal force** that acts towards the middle of the circle. Gravitational attraction provides the centripetal force needed to keep planets and all types of satellite in orbit.

Changing speed
The gravitational attraction between two objects decreases with distance. This means that the closer the two objects are to each other, the stronger the force of gravity between them. If the force between them is greater, a greater acceleration will occur. The greater the acceleration, the greater the change in velocity - this causes the object to move faster. This means that objects in small orbits travel faster than objects in large orbits.

Artificial satellites travel in one of two different orbits:

- polar orbits
- **geostationary** orbits

Polar orbits take the satellites over the Earth's poles. The satellites travel very close to the Earth (as low as 200 km above sea level), so they must travel at very high speeds (nearly 8,000 m/s).
Geostationary satellites take 24 hours to orbit the Earth, so the satellite appears to remain in the same part of the sky when viewed from the ground. These orbits are much higher than polar orbits (typically 36,000 km) so the satellites travel more slowly (around 3 km/s).