Knowledge Organiser – 4.1.1 Cell Biology

4.1.1 Cell Structure

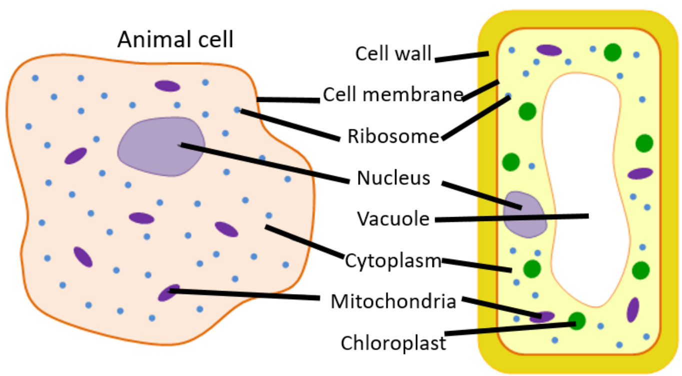
4.1.1.1. Eukaryotes & Prokaryotes:

Eukaryotic (plant, animal & fungal cells).
- Cell membrane
- Cytoplasm
- Genetic material enclosed in membrane

Prokaryotic (bacteria and archaea)
- smaller with no true nucleus.
- No mitochondria or chloroplasts.
- DNA loops called plasmids
- Bacteria are prokaryotes.

4.1.1.2	Definitions
eukaryotic	A type of cell that has a nucleus.
prokaryotic cell	A simple cell that does not have a nucleus – the DNA is free in the cytoplasm.
mitochondria	Structures in the cytoplasm of all cells where aerobic respiration takes place
ribosome	The site of protein synthesis.
sub-cellular	Structures smaller than a cell that are found within it.
tissue	A group of similar cells that carry out the same function, eg muscle tissue.
Nucleus	Contains the cell's genetic materials
Cell membrane	Controls the movement of substances in and out of the cell
Cytoplasm	where many chemical reactions take place
Chloroplasts	where photosynthesis occurs
Vacuole	Filled with cell sap to help support the plant
Cell wall	made of cellulose to strengthen the cell.

4.1.1.2 Animal & plant cells

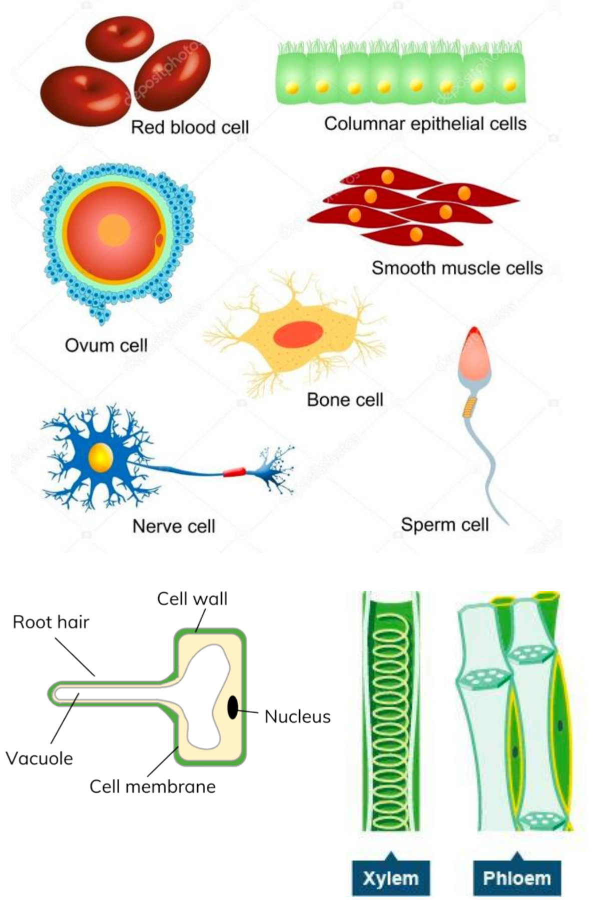


You must be able to label the animal and plant cells

Sub-cellular structures:
Most animal cells have the following
- **nucleus**
- **cytoplasm**
- **a cell membrane**
- **mitochondria**
- **ribosomes.**

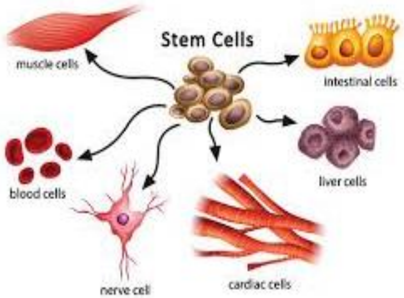
In addition to the parts found in animal cells, plant cells often have:
- **chloroplasts**
- a permanent **vacuole** filled with cell sap.
- Plant and algal cells also have a **cell wall made of cellulose**, which strengthens the cell

4.1.1.3. Cell specialisation:



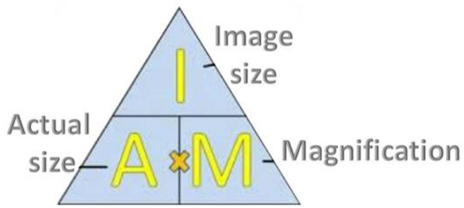
4.1.1.4 Cell differentiation

As an organism develops, cells differentiate to form different types of cells.
- Most types of animal cell differentiate at an early stage.
- Many types of plant cells retain the ability to differentiate throughout life.



4.1.1.5 Microscopy

Electron microscope
- has much **higher magnification** and **resolving power** than a light microscope.
- Can be used to **study cells in much finer detail.**
- Enabled biologists to see and **understand many more sub-cellular structures.**



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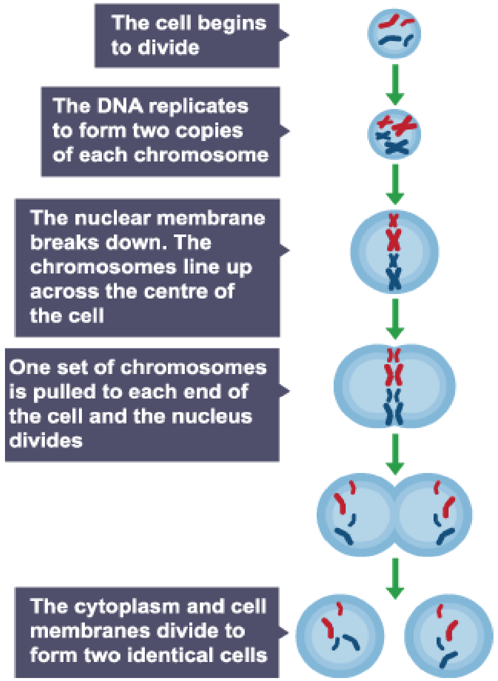
Knowledge Organiser – 4.1.2 Cell Biology

4.1.2 Cell Division : MITOSIS

- The nucleus of a cell contains **chromosomes** made of **DNA** molecules.
- Each chromosome carries a large number of **genes**.
- In body cells the chromosomes are **normally found in pairs**.
- **Mitosis** is **cell division for growth & repair**.
- 2 genetically identical daughter cells are formed.

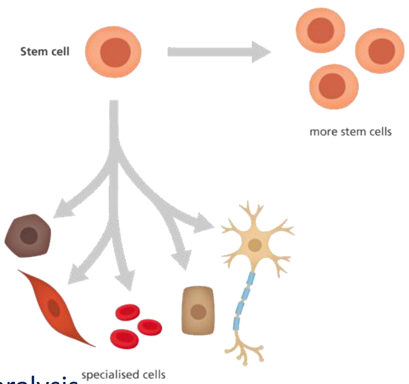


4.1.2.3 Stem cells - Plants

- **Meristem tissue** in plants can **differentiate into any type of plant cell**, throughout the life of the plant.
- can be used to **produce clones** of plants quickly and economically and to prevent extinction.
- **Crop plants** with special features such as disease resistance can be cloned to produce large numbers of identical plants for farmers.

4.1.2.3 Stem cells - animals

- A **stem cell is an undifferentiated cell of an organism** which is capable of giving rise to cells of any type.
- **Stem cells from human embryos can be cloned** and made to **differentiate into most** types of human cells.
- **Stem cells from adult bone marrow** can form many types of cells including **blood cells.**

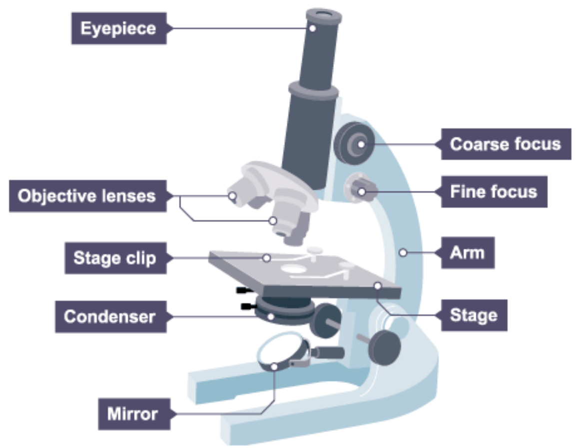


Treatment with stem cells

- may be able to help conditions such as diabetes and paralysis.
- In **therapeutic cloning** an embryo is produced with the same genes as the patient. Stem cells from the embryo are not rejected by the patient's body so they may be used for medical treatment.
- The use of stem cells has potential risks such as transfer of viral infection, and some people have ethical or religious objections.

RPA: Microscopy	Definitions
calibrate	To set an instrument or scale against a standard.
field of view	The area seen when looking through a microscope.
graticule	The graticule has a scale ruled on it and is used to estimate the size of a specimen when viewed with a microscope.
magnification	The amount that an image of something is scaled up when viewed through a microscope.
order of magnitude	For each order of magnitude, a number is ten times the previous one.
resolution	The fineness of detail that can be seen in an image - the higher the resolution of an image, the more detail it holds.
significant figure	Giving a number to a specified number of significant figures is a method of rounding. E.g., in the number 7483, the most significant, or important, figure is 7, as its value is 7000. To give 7483 correct to one significant figure (1 sf), would be 7000. To 2 sf, it would be 7500.
stage micrometer	A glass slide with a scale etched on it. It is used to calibrate the eyepiece graticule of a microscope.
standard form	A system in which numbers are written as a number greater than 1 and less than 10 multiplied by a power of 10 (either positive or negative.)

Required practical activity: use a light microscope to observe, draw and label a selection of plant and animal cells.
A magnification scale must be included



Knowledge Organiser – 4.1.3 Transport in Cells

4.1.3.1 Diffusion

Substances may move into and out of cells across the cell membranes via diffusion.

- Diffusion is the spreading out of the particles of any substance in solution, or particles of a gas, resulting in **a net movement from an area of higher concentration to an area of lower concentration**.

Some of the substances transported in and out of cells by diffusion are:

- **oxygen** and **carbon dioxide** in gas exchange,
- waste product **urea** from cells into the blood plasma for excretion in the kidney.

Factors which affect the rate of diffusion are:

- the difference in concentrations (**concentration gradient)**
- the **temperature**
- the **surface area** of the membrane.

The effectiveness of an exchange surface is increased by:

- having a **large surface area**
- a membrane that is **thin** to provide a short diffusion path
- (in animals) having an **efficient blood supply**
- (in animals, for gaseous exchange) being **ventilated**.

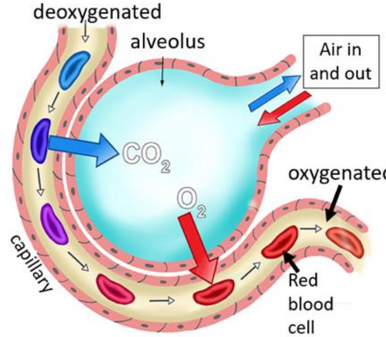
4.1.3.1 Diffusion - examples

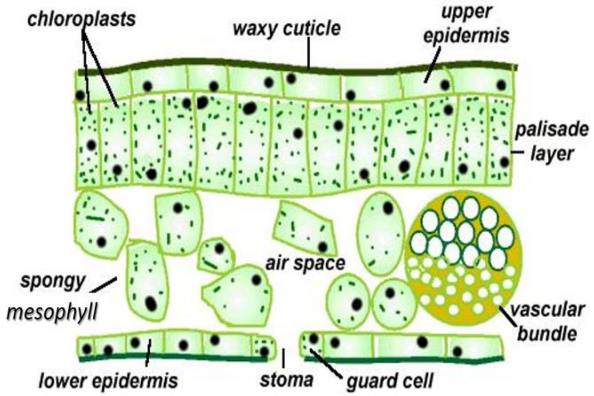
Single-celled organisms have a **large surface area to volume ratio**, allowing sufficient transport of molecules in and out of the cell.

Multicellular organisms have a **relatively small surface area to volume ratio** so they **need specialised exchange surfaces** and a transport system:

- Large surface area
- Thin membranes for a short diffusion path
- Efficient blood supply (animals)
- Being ventilated (animals)

Gas exchange in the alveoli

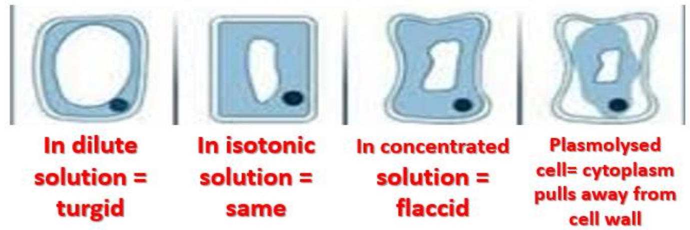




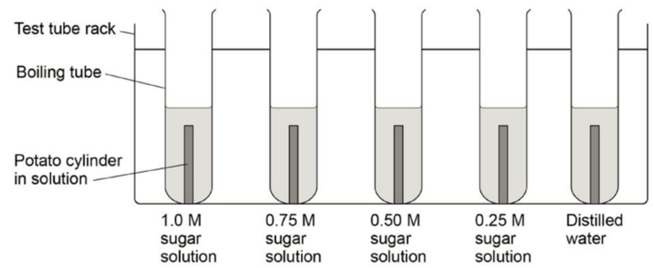
CO_2 diffuses from high concentration in the air space to a low concentration inside the mesophyll cells

4.1.3.2 Osmosis

Osmosis is the **diffusion of water from a dilute solution** to a **concentrated solution** through a partially permeable membrane.



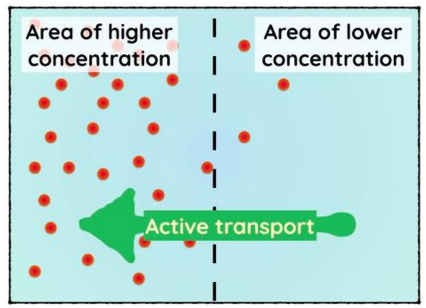
RPA: investigate the effect of a range of concentrations of salt or sugar solutions on the mass of plant tissue



4.1.3.3 Active Transport

Is the movement of substances from a more dilute to a more concentrated solution (<u>against</u> the concentration gradient).
It needs ENERGY from respiration.
for respiration.

Eg 1- **Mineral ions** absorbed **into root hair cells** from very dilute solutions in the soil.
Eg 2- **Sugar molecules** absorbed **from the gut** (lower concentration) into the blood for respiration.



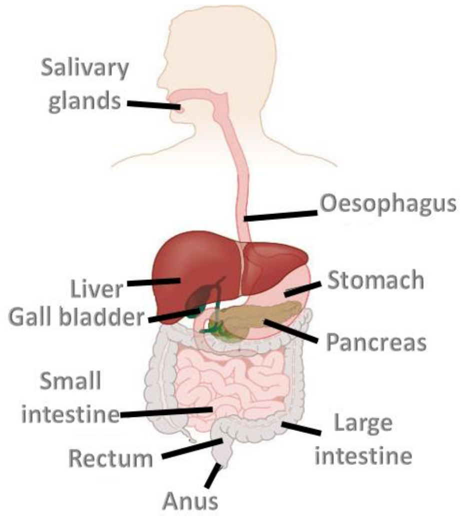
Knowledge Organiser – 4.2 Organisation

4.2.1 Principles of organisation

4.2.1	Definitions
Cells	The basic building blocks of all living organisms. Eg. Muscle, skin, nerve, root hair and palisade leaf cells
Tissue	A group of cells with a similar structure and function (job). Eg. Muscle, heart, xylem and epidermal tissue
Organs	A group of tissues performing a specific function. Eg. Heart, liver, brain, roots, stem, leaf & flower
Organ systems	Groups of organs working together to form an organism. Eg. circulatory, nervous & transpiration systems
Digestive system	Organ system in which several organs work together to digest & absorb food.

4.2.2 Animal tissues, organs and organ systems

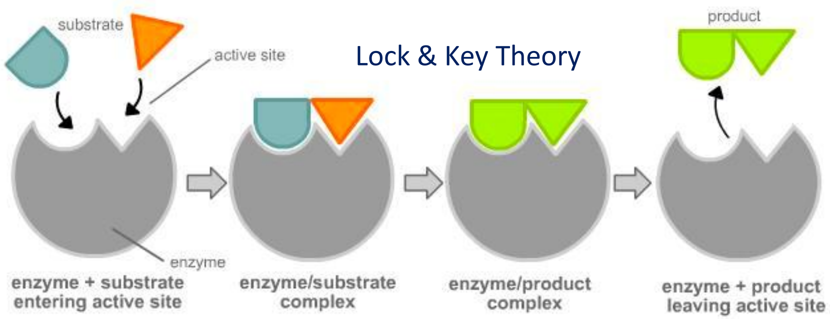
4.2.2.1 The human digestive system



Enzyme	Produced	Nutrients acted upon	Products (smaller molecules)	Optimum pH & temperature
Carbohydrase Eg. Amylase	Salivary glands	Carbohydrate Eg. starch	Simple sugars Eg. glucose	pH7 37°C
Protease	Stomach, pancreas	Protein	Amino acids	pH2 37°C
Lipase	Pancreas, small intestine	Lipid (fats & oils)	Glycerol & fatty acids	pH8 37°C

Enzymes are **biological catalysts** that breakdown food into small, soluble molecules that can be absorbed into the bloodstream from the digestive system.

Lock & Key Theory



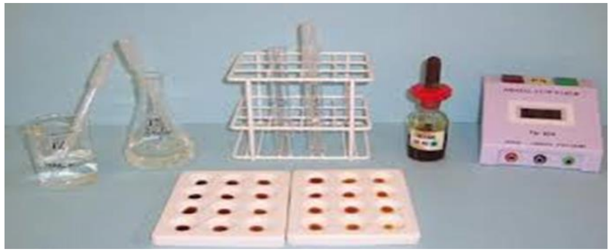
Denature. If the optimum conditions are not correct for an enzyme, it loses it’s shape and cannot attach to the substrate (nutrient molecule). It is “denatured”.

bile	Made in the liver, stored in gall bladder. Emulsifies fats to for digestion and neutralises stomach acid.
carbohydrate	Food consisting of sugars, starch and cellulose. Carbohydrates are vital for energy in humans and are stored as fat if eaten in excess.
digestion	The breakdown of large insoluble food molecules to smaller soluble ones.
digestive system	Organ system involved in breaking food down so that it can be absorbed into the bloodstream.
egestion	The process of passing out the remains of food that has not been digested, as faeces, through the anus.
emulsify	To mix water with lipids to produce a cloudy mixture called an emulsion.
fats	Naturally occurring compounds of carbon, hydrogen and oxygen. They are esters made from fatty acids and glycerol.
fatty acids	Carboxylic acids with a long chain of carbon atoms. Fatty acids react with glycerol to produce lipids (fats and oils).
gall bladder	Stores bile before releasing it into the duodenum.
glucose	A simple sugar used by cells for respiration.
glycogen	Animals store glucose as glycogen in their liver and muscle tissues.
gut	The digestive system.
lipid	Fat or oils, composed of fatty acids and glycerol.
liver	The large organ, beside the stomach, which has many functions, including processing substances absorbed by the digestive system and a role in the storage of the body's carbohydrate.
metabolism	All the chemical reactions in the cells of an organism, including respiration.
microvilli	Projections from the surface of an epithelial cell of the small intestine wall.
pancreas	Large gland located in the abdomen near the stomach which produces digestive enzymes and the hormone insulin.
protein	Organic compound made up of amino acid molecules. Proteins are needed by the body for cell growth and repair.
starch	A type of carbohydrate. Plants can turn the glucose produced in photosynthesis into starch for storage
sugar	A simple carbohydrate that is sweet to the taste.
villi	Finger-like projections in the small intestine that provide a large surface area for the absorption of food.

Knowledge Organiser – 4.2 Organisation

RPA: investigate the effect of pH on the rate of reaction of amylase on starch

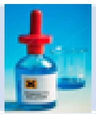
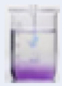
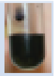
Amylase breaks down starch. Starch turns blue/black when iodine (an orange solution) is added.



- Starch solution (CV)
- Amylase solution (CV)
- Buffer solutions of
- different pH (**IV**)
- Spotting tiles
- Test tubes
- Water bath (temp CV)
- Iodine solution
- Stop clock

DV is the time at which the starch/ amylase solution no longer turns blue/black.

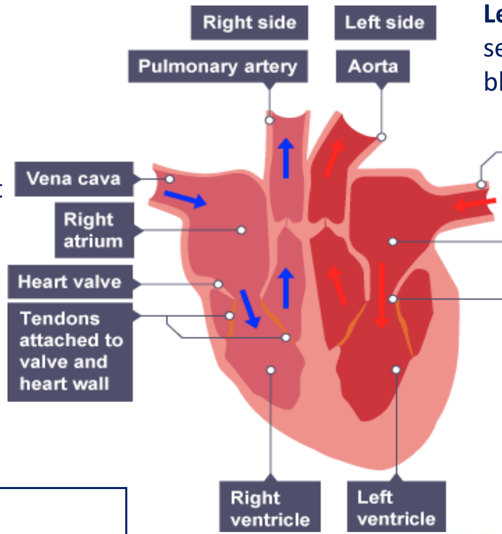
RPA: use qualitative reagents to test for carbohydrates (starch and glucose), proteins and lipids

Food group	Reagent	Positive result
Glucose	Benedict's solution (heated) 	Bright blue to orange/ brick red 
Protein	Biuret's solution 	Bright blue to lilac 
Starch	Iodine solution 	Orange to blue/ black 
Lipid (Fat/oil)	Ethanol & water 	Clear to Milky/ cloudy 

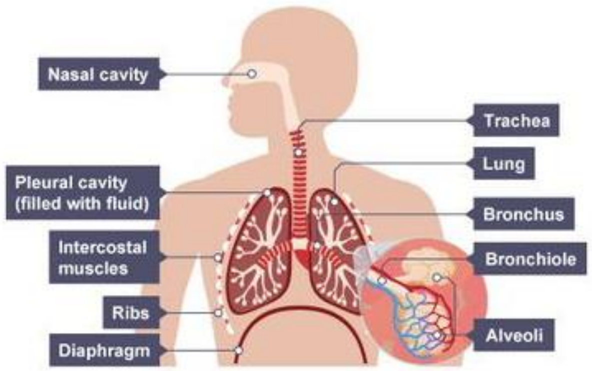
4.2.2.2 The heart and blood vessels

Right side of the heart receives deoxygenated blood **from** the body and pumps it to the lungs.

Pacemaker
Group of cells in the right atrium that control resting heart rate.



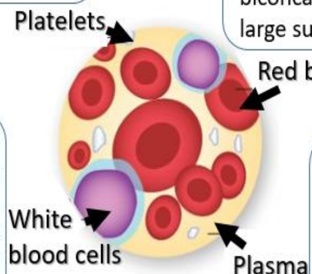
Left side of the heart sends oxygenated blood **to** the body.



4.2.2.2 The heart and blood vessels

Fragments of cells which collect at wounds & trigger clotting.

Transport oxygen to cells for respiration. No nucleus, biconcave shape to large surface area

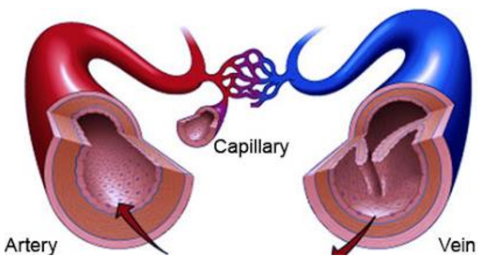


Protect the body from infection. Phagocytosis. Antibody & antitoxin production

Transports cells, hormones, antibodies, urea, carbon dioxide & products of digestion.

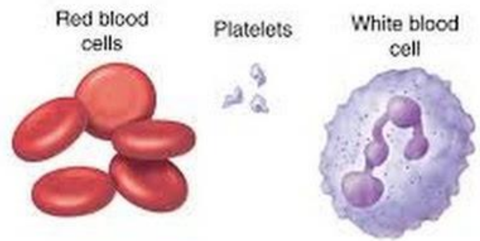
4.2.2.3 Blood

- Blood away from heart
- Thick muscular wall
- Small lumen
- Under high pressure



- Blood towards from heart
- Thinner wall
- Large lumen
- Under low pressure

4.2.2.3 Blood



Blood is a tissue consisting of plasma containing red blood cells, white blood cells and platelets

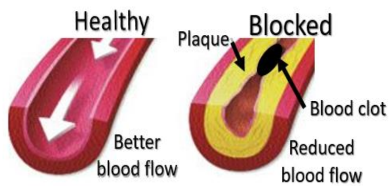
Knowledge Organiser – 4.2 Organisation

4.2.2.4 Coronary heart disease: a non-communicable disease

- **Coronary heart disease** layers of fatty material build up inside the coronary arteries, narrowing them.
- Reduces the flow of blood through the coronary arteries, resulting in a lack of oxygen for the heart muscle.
- Stents are used to keep the coronary arteries open.
- Statins are widely used to reduce blood cholesterol levels which slows down the rate of fatty material deposit.

- **Heart valves may become faulty**, preventing the valve from opening fully, or the heart valve might develop a leak.
- Faulty heart valves can be replaced using biological or mechanical valves.

- **Heart Transplants**: the case of heart failure a donor heart, or heart and lungs can be transplanted.
- Artificial hearts are occasionally used to keep patients alive whilst waiting for a heart transplant, or the heart to rest as an aid to recovery.



4.2.2.5 Health issues & types of disease

communicable, can be transferred from one organism to another, e.g. measles, food poisoning and malaria

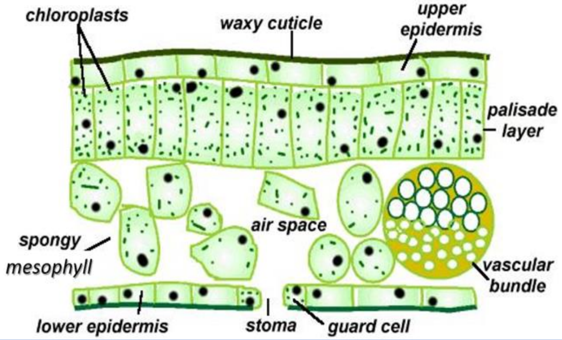
non-communicable, which are not transferred between people or other organisms, e.g.

- **cancer**
- **diabetes**
- **genetic diseases** and conditions
- heart disease
- neurological disorders

Other factors that can effect physical and mental health include:

- **diet**
- **lifestyle factors** such as alcohol and other drugs
- **stress**
- situations that may occur in a person's life

4.2.3.1 Plant tissues



Epidermis	Covers outer leaf surface for protection
Palisade mesophyll	Main site for photosynthesis. Many chloroplasts
Spongy mesophyll	Air spaces between cells allow gases to diffuse

4.2.2.6 lifestyle on non-communicable disease

Risk factors are linked to increased rate of a disease. aspects of a person's lifestyle

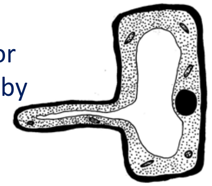
- substances in the body or environment.
- The effects of diet, smoking and exercise on cardiovascular disease.
- Obesity as a risk factor for Type 2 diabetes.
- The effect of alcohol on liver & brain function.
- Effect of smoking on lung disease & lung cancer.
- Effects of smoking & alcohol on unborn babies.
- Carcinogens, including ionising radiation, as risk factors in cancer.

4.2.2.7 Cancer

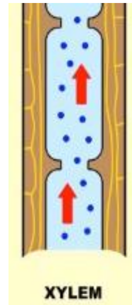
Benign tumours are abnormal cell growths contained in one area, **usually within a membrane**. They do not invade other parts of the body. **Malignant tumour** cells are cancers. Invade neighbouring tissues and **spread to different parts of the body** where they form secondary tumours.

4.2.3.2 Plant organ system

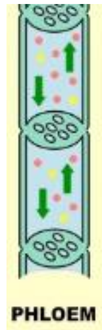
Roots, stem, leaves form plant transport organ system.



- **Root hair cells** are adapted for the efficient uptake of water by osmosis, and mineral ions by active transport.

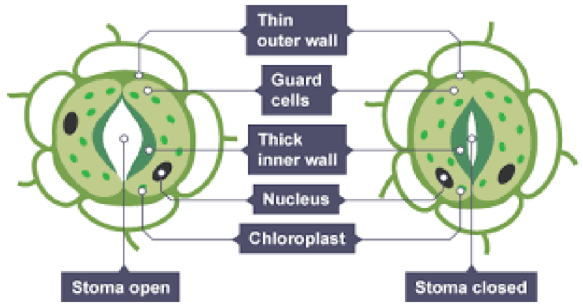


- **Xylem tissue** transports water and mineral ions from the roots to the stems and leaves.
- Made of hollow tubes strengthened by **lignin** adapted for the transport of water in the **transpiration** stream.



- **Phloem tissue** transports dissolved sugars from the leaves to the rest of the plant for immediate use or storage. This transport is called **translocation**.
- **Phloem** is composed of tubes of elongated cells. **Cell sap can move from one phloem cell to the next through pores in the end walls**.

- **Stomata** and **guard cells** control gas exchange and water loss.



Knowledge Organiser – 4.3 Infection and response

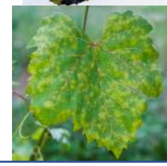
4.3.1.1 Communicable (infectious) diseases

Pathogens are microorganisms that cause infectious disease.
Pathogens may be **viruses**, **bacteria**, **protists** or **fungi**.
- They may infect plants or animals and can be spread by direct contact, by water or by air.
- Bacteria and viruses may reproduce rapidly inside the body.
- Bacteria may produce poisons (toxins) that damage tissues and make us feel ill.
- Viruses live and reproduce inside cells, causing cell damage. Viruses are not considered to be living organisms.

Pathogen	Example in animals	Example in plants	Treatment
Viruses	Measles, HIV potentially leading to AIDS	Tobacco mosaic virus	Vaccination
Bacteria	Salmonella Gonorrhoea	Agrobacterium	Antibiotics
Fungi	Athlete's foot	Rose black spot	Anti fungal medication & Fungicides.
Protists	Malaria (Spread by mosquitos)	Downy mildew	Anti malarial drugs, prevention from vector contact eg mosquito nets


Tobacco mosaic virus


Rose Black Spot


Downy mildew

4.3.1.2 Viral diseases

Measles is a **viral disease**
- Symptoms: fever and a red skin rash.
- Measles can be fatal if complications arise.
- Most young children are vaccinated against measles.
- The measles virus is spread by inhalation of droplets from sneezes and coughs.

HIV initially causes a flu-like illness.
- Unless successfully controlled with antiretroviral drugs the virus attacks the body's immune cells.
- Late stage HIV infection, or AIDS, occurs when the body's immune system becomes so badly damaged it can no longer deal with other infections or cancers.
- HIV is spread by sexual contact or exchange of body fluids such as blood which occurs when drug users share needles.

Tobacco mosaic virus (TMV) is a widespread plant pathogen
- Affecting many species of plants including tomatoes.
- Symptoms: Gives a distinctive 'mosaic' pattern of discolouration on the leaves which affects the growth of the plant due to lack of photosynthesis.

4.3.1.3 Bacterial diseases

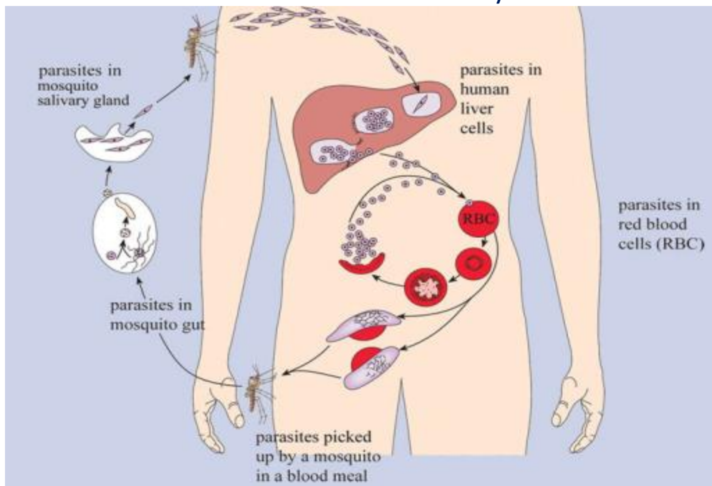
Salmonella food poisoning
- Spread by bacteria ingested in food, or on food prepared in unhygienic conditions.
- In the UK, poultry are vaccinated against salmonella to control the spread.
- Symptoms: Fever, abdominal cramps, vomiting and diarrhoea are caused by the bacteria and the toxins they secrete.

Gonorrhoea is a sexually transmitted disease (STD)
- Symptoms: thick yellow or green discharge from the vagina or penis and pain on urinating.
- Was easily treated with the antibiotic penicillin until many **resistant strains appeared**.
- Spread by sexual contact.
- The spread can be controlled by treatment with antibiotics or the use of a barrier method of contraception such as a condom.

4.3.1.4 Fungal diseases

Rose black spot is a fungal disease
- Symptoms: purple or black spots develop on leaves, which often turn yellow and drop early.
- It affects the growth of the plant as photosynthesis is reduced.
- It is spread in the environment by water or wind. Rose black spot can be treated by using fungicides and/or removing and destroying the affected leaves.

4.3.1.5 Protist diseases : Malaria Life Cycle

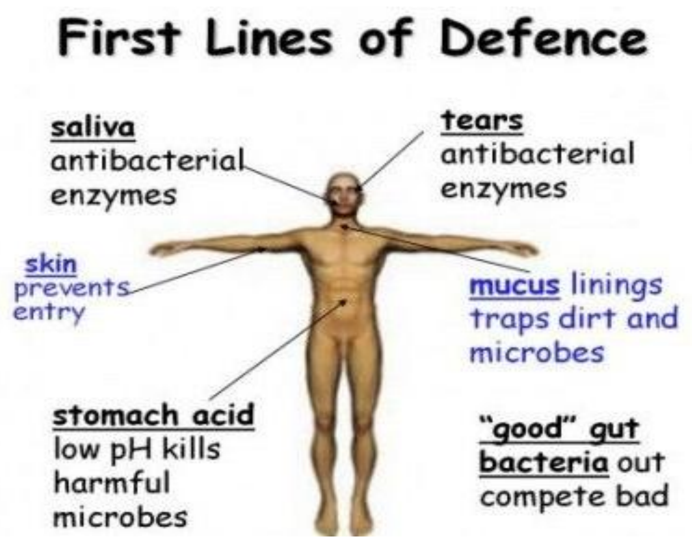


Knowledge Organiser – 4.3.1.6 Human defence systems

4.3.1.6 Human defence systems

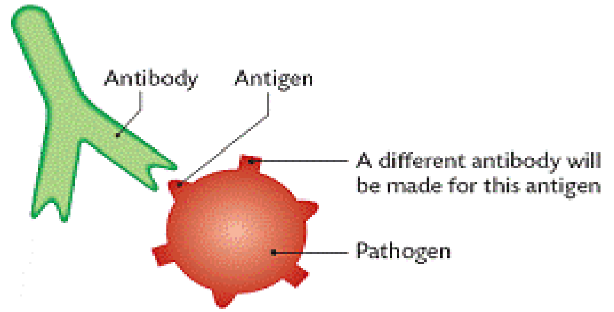
Humans have a variety of **specific** and **non specific** Human defences against invading pathogens.

Non-specific:	**Specific via white blood cells**
Skin (physical barrier)	Phagocytosis
Nose (mucus)	Antibodies
Trachea and bronchi (cilia)	Antitoxins
Stomach (acid)	



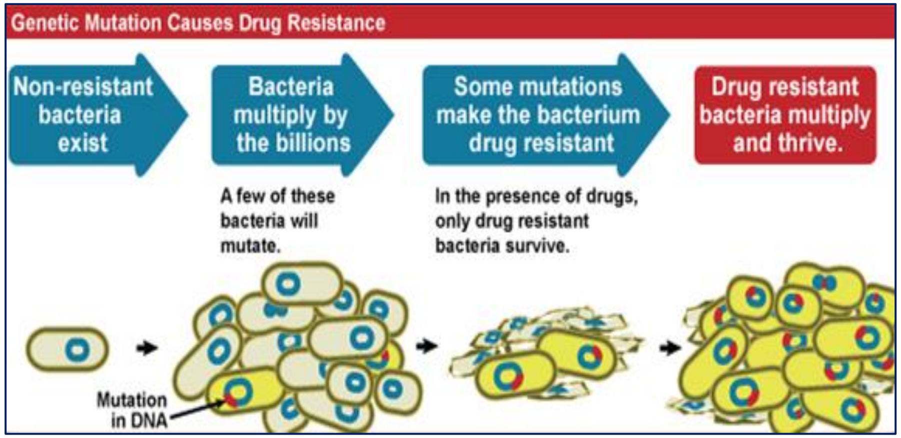
4.3.1.7 Vaccination

- Introducing small **quantities of dead or inactive pathogens** to **stimulate antibody production.**
- This leads to a quicker response in future infections.



4.3.1.8 Antibiotics and pain killers

- **Antibiotics**, such as **penicillin**, are medicines that help to cure bacterial disease by killing infective bacteria inside the body.
- Specific bacteria should be treated by specific antibiotics
- **Emergence of antibiotic resistant bacteria** is of great concern.
- **Antibiotics CANNOT kill viral pathogens**
- Painkillers and other drugs are used to treat the symptoms of disease, but do not kill pathogens.



4.3.1.9 Discovery and development of drugs

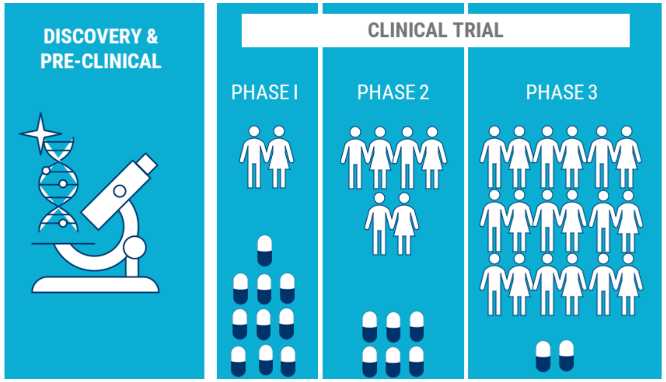
Have traditionally been extracted from Plants and microorganisms.

Digitalis – Foxgloves

Aspirin – Willow

Penicillin – Penicillium mould

- Most new drugs are **synthesised by chemists** in pharmaceutical industry
- New drugs have to be **tested** and **trialled** before use to check they are **safe and effective**.
- New drugs tested for **toxicity, efficacy and dose**



Clinical trials use healthy volunteers and patients.

- Very low doses of the drug are given at the start of the clinical trial.
- If the drug is found to be safe, further clinical trials are carried out to find the optimum dose for the drug.
- In double blind trials, some patients are given a placebo

Knowledge Organiser – 4.5 Homeostasis

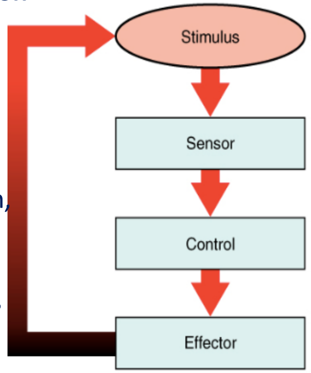
4.5.1 Homeostasis

Homeostasis is the autonomic regulation of the internal conditions of a cell or organism to **maintain optimum** conditions for function **in response to internal and external changes. E.g:**

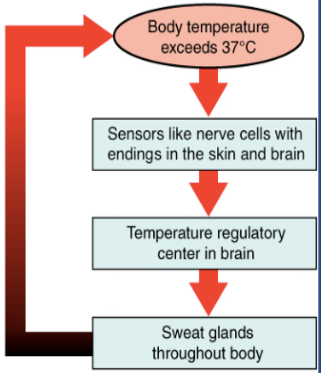
- **blood glucose concentration**
- body **temperature**
- **water** levels.

All control systems include:

- cells called **receptors**, that detect stimuli
- **coordination centres** (brain, spinal cord and pancreas) that receive and process information from receptors
- **effectors**, muscles or glands, which bring about responses which restore optimum levels.



Negative feedback loop



Body temperature regulation

4.5.2 The human nervous system

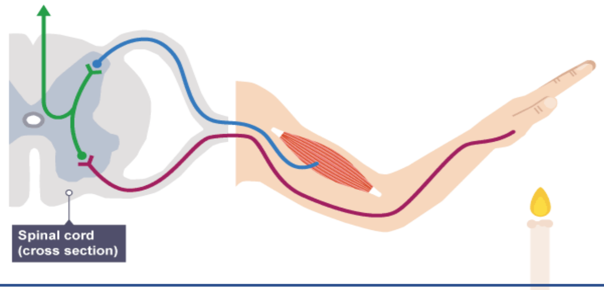
The nervous system enables humans to **react to their surroundings** and to **coordinate their behaviour**.

- This is a **protective reflex to speed up the reaction time** of pulling away from a dangerous stimulus, like putting your hand on a hot stove!
- If you had to think first it would cost valuable time and risk further damage.

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

- CNS is the brain and spinal cord.
- CNS coordinates the response of effectors eg **muscles contracting** or **glands secreting hormones**.

stimulus → receptor → coordinator → effector → response

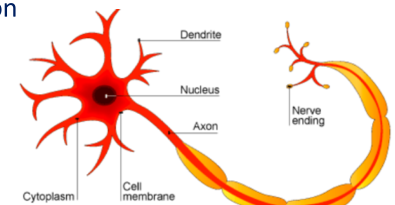


Reflex Arc

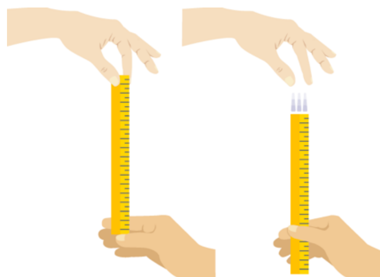
- automatic and rapid
- do not involve the conscious part of the brain.

	Definition
Enzyme	Protein which catalyses or speeds up a chemical reaction
evaporation	Process in which a liquid changes state and turns into a gas.
glucose	Simple sugar used by cells for respiration.
glycogen	The storage form of glucose in animal cells.
hormone	Chemical messenger produced in glands and carried in blood to specific organs in the body.
Insulate	To help maintain the temperature.
Insulin	hormone that regulates the level of sugar in the blood
nerve impulses	Electrical signals that travel along the nerve fibre from one end of the nerve cell to the other.
Obesity	Medical term for being very overweight, due to accumulation of body fat.
Vasoconstriction	Narrowing of the skin arterioles to reduce blood flow and reduce heat loss by radiation.
vasodilation	Increase in diameter of the skin arterioles to increase blood flow & increase heat loss by radiation.

Receptor in the skin detects a stimulus
Sensory neurone sends electrical impulses to **relay neurone**, which are located in the spinal cord. They connect sensory neurones to motor neurones.
Motor neurone sends electrical impulses to an effector.
Effector produces a response eg muscle contraction



RPA: Plan and carry out an investigation into the effect of a factor on human reaction times

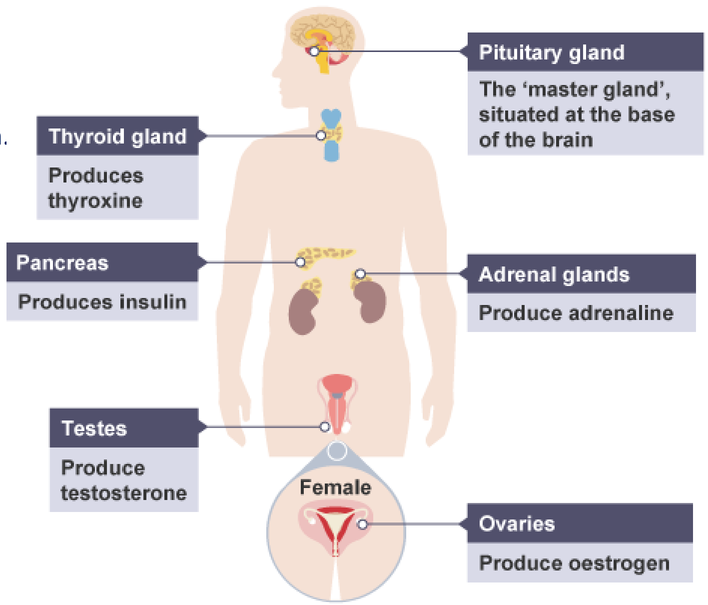


Knowledge Organiser – 4.5.3 Hormonal coordination in humans

4.5.3.1 Human endocrine system

- The **endocrine system** is composed of **glands** which **secrete chemicals** called **hormones** directly into the bloodstream.
- Hormones carried by blood to a **target organ** where it produces an **effect**.
- Compared to the nervous system the **effects are slower but act for longer**.

Pituitary gland in the brain
- '**master gland**' which secretes several hormones into the blood in response to body conditions.
- These hormones act on other glands to **stimulate other hormones** to be released to bring about effects.

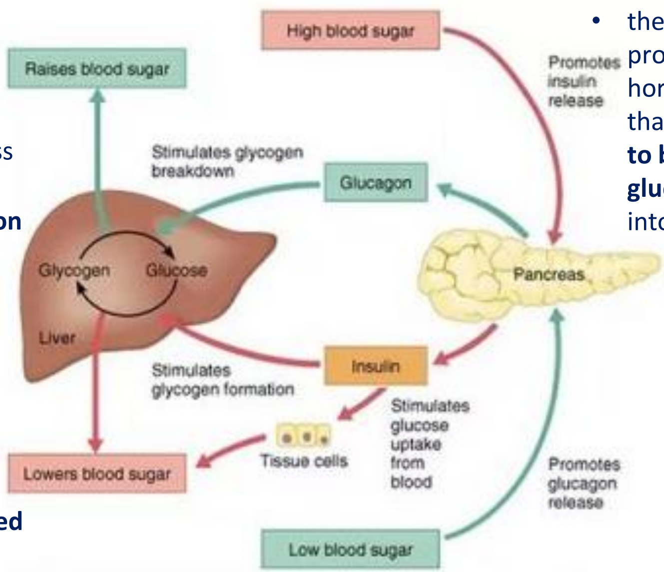


Differences between Hormonal and Nervous coordination	Nervous	Hormonal
Type of signal	Electrical (chemical at synapses)	Chemical
Transmission of signal	By nerve cells	By the bloodstream
Effectors	Muscles or glands	Target cells in particular tissues
Type of response	Muscle contraction or secretion	Chemical change
Speed of response	Very rapid	Slower
Duration of response	Short (until nerve impulses stop)	Long - Until hormone broken down

4.5.3.2 Control of blood glucose concentration

- Monitored and controlled by the **pancreas**.
- High blood glucose damages cells due to a loss of water by osmosis.

If **blood glucose concentration is too high**:
- Pancreas detects the increase
- Pancreas produces the hormone **insulin**.
- Increases **glucose absorption** in liver and muscle cells.
- **Excess glucose** is **converted** to **glycogen** for storage in liver and muscle.

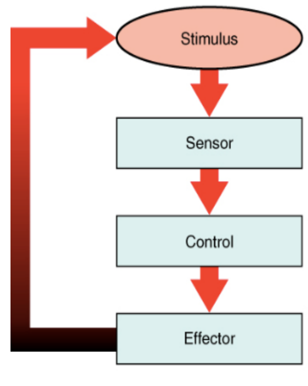


If blood glucose concentration is too low:
- the pancreas produces the hormone **glucagon** that causes **glycogen to be converted into glucose** and released into the blood.

Diabetes:
Type 1 diabetes is a disorder in which the pancreas fails to produce sufficient insulin. It is characterised by uncontrolled high blood glucose level.
Treatment:
- normally treated with **insulin injections**

Type 2 diabetes the body cells no longer respond to insulin produced by the pancreas. Obesity is a risk factor for Type 2 diabetes.
Treatment:
- A carbohydrate controlled **diet** & **Exercise** regime

Negative feedback (HT Only)
- when a stimulus produces an output which can dampen the original stimulus and prevent or reduce further output.
- Body controlling outputs once an appropriate response has been effected.
- Maintenance of blood sugar is an example of negative feedback loop.



Negative feedback loop

Knowledge Organiser – 4.5.3 Hormonal coordination in human reproduction

4.5.3.3 Hormones in human reproduction

- During puberty, reproductive hormones cause secondary sex characteristics to develop.
- **Oestrogen** is the main female reproductive hormone.
- At puberty, eggs begin to mature and 1 is released approximately **every 28 days**.
- The diagram at the bottom of the page shows hormone fluctuation during the **menstrual cycle**.

Puberty in Males

- Males start to produce testosterone at puberty.
- Testosterone is the main male reproductive hormone produced by the testes
- Testosterone stimulates sperm production.

Several hormones are involved in the menstrual cycle of a woman.

Hormone	Produced	Role
FSH (follicle stimulating hormone)	Pituitary gland	Causes an egg to mature in an ovary. Stimulates the ovaries to release oestrogen
Oestrogen	Ovaries	Stops FSH being produced (so that only one egg matures in a cycle). Repairs, thickens and maintains the uterus lining. Stimulates the pituitary gland to release LH.
LH (luteinising hormone)	Pituitary gland	Triggers ovulation (the release of a mature egg)
Progesterone	Ovaries	Maintains the lining of the uterus during the middle part of the menstrual cycle and during pregnancy.

4.5.3.4 Contraception

Fertility can be controlled by a variety of hormonal and non-hormonal methods of contraception.
These include:

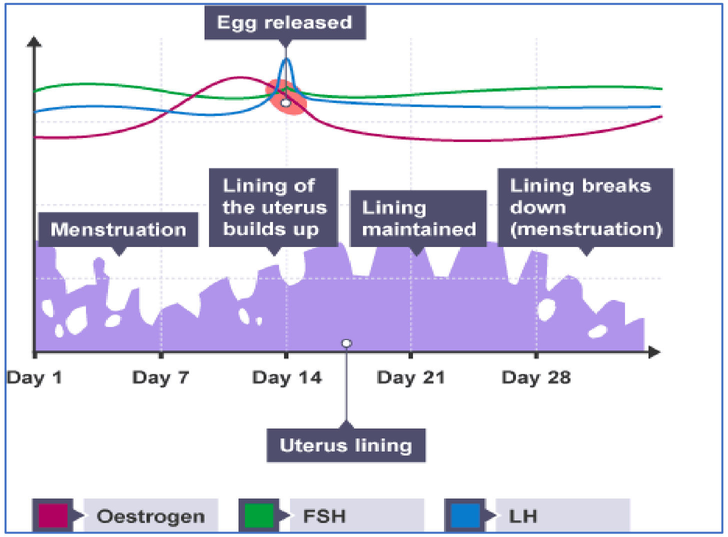
- Hormonal **oral contraceptives** inhibiting FSH production so that no eggs mature
- **injection, implant or skin patch** of slow release progesterone to inhibit the maturation and release of eggs over a long period
- **barrier methods** such as condoms and diaphragms which prevent the sperm reaching an egg
- **intrauterine devices** which prevent the implantation of an embryo or release a hormone
- **spermicidal agents** which kill or disable sperm
- **abstaining from intercourse** when an egg may be in the oviduct
- **surgical** methods of male and female **sterilisation**.

4.5.3.5 The use of hormones to treat infertility (HT only)

Fertility drugs

- Provide woman with FSH and LH in a 'fertility drug'
- She may then become pregnant in the normal way.

Fertility: The ability to reproduce.



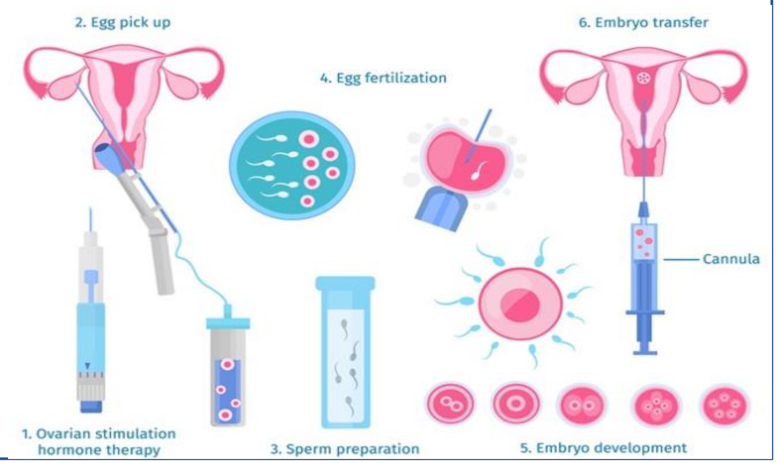
4.5.3.5 The use of hormones to treat infertility (HT only)

In Vitro Fertilisation (IVF) treatment.

- Giving a mother **FSH** and **LH** to stimulate egg maturation
- Eggs are collected and fertilised by father's sperm in the laboratory.
- Fertilised eggs develop into embryos
- Embryos are inserted into the mothers uterus (womb).

Negatives of IVF

- emotionally and physically stressful
- the success rates are not high
- can lead to multiple births, risking both babies and mother.



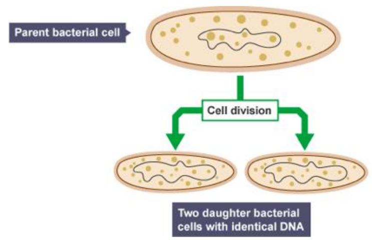
Knowledge Organiser – 4.6 Inheritance, variation and evolution

Sexual reproduction involves the joining (fusion) of male and female gametes:
- sperm and egg cells in animals
- pollen and egg cells in flowering plants.
- mixing of genetic information which leads to variety in the offspring.
- The formation of gametes involves meiosis.

Meiosis: **non-identical** offspring

Asexual reproduction involves only one parent
- No fusion of gametes.
- No mixing of genetic information.
- leads to genetically identical offspring (clones).
- Only mitosis is involved.

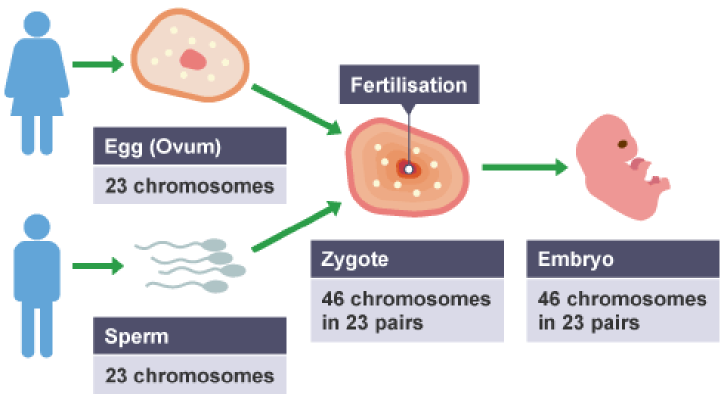
Mitosis: **identical** offspring



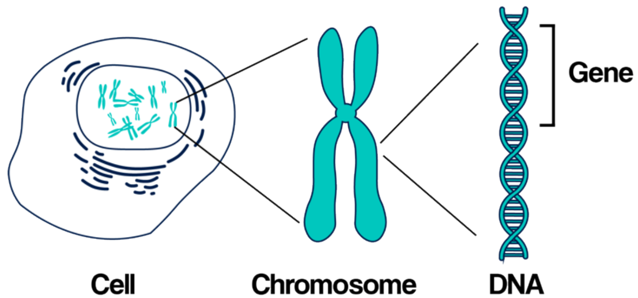
4.6.1.2 Meiosis

Sexual reproduction uses the process of **meiosis**, which creates gametes. The process of meiosis happens in the male and female reproductive organs.
Meiosis halves the number of chromosomes in gametes
Fertilisation restores the full number of chromosomes.
Cells in reproductive organs divide by meiosis to form gametes:

- **copies of the genetic information** are made
- the cell divides **twice** to form **four gametes**, each with a **single set of chromosomes (haploid)**
- all gametes are **genetically different** from each other.
- Gametes **join at fertilisation** to **restore the normal number of chromosomes**.
- The new cell divides by mitosis.
- The number of cells increases.
- As the embryo develops cells differentiate.



4.6.1.3 DNA and the genome



DNA Deoxyribonucleic acid
- The **genetic material in the nucleus of a cell** is composed of a chemical called DNA.
- DNA is a **polymer** made up of two strands forming a **double helix**.

Chromosome
- The DNA is contained in structures called **chromosomes**.
- Codes for all the characteristics of an organism.

Gene
- A gene is a small section of DNA on a chromosome.
- Each gene codes for a particular sequence of amino acids, to make a specific protein.

Genome
- genome of an organism is the entire genetic material of that organism.
- The whole human genome has now been studied and this will have great importance for medicine in the future.

Definitions	
diploid	A cell that contains two sets of chromosomes.
double helix	shape of the DNA molecule with two strands twisted together in a spiral.
gamete	Sex cell (sperm in males and ova/eggs in females).
haploid	A sex cell (gamete) containing one set of chromosomes.
heredity	Genetic information that determines an organism's characteristics, passed on from one generation to another. To do with passing genes to an offspring from its parent or parents.
mitosis	A type of cell division which produces daughter cells identical to the parent.
nucleus	The central part of an atom. It contains protons and neutrons, and has most of the mass of the atom. The plural of nucleus is nuclei.
organism	Living entity, eg animals, plants or bacteria.

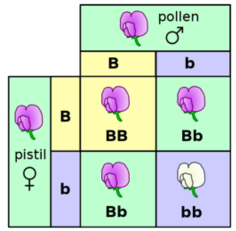
Knowledge Organiser – 4.6.1 Inheritance, variation and evolution

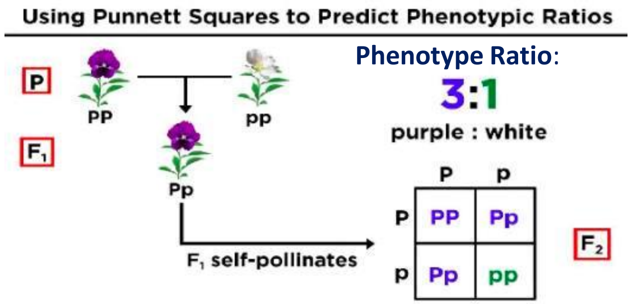
4.6.1.4 Genetic inheritance

Some **characteristics** are controlled by a single gene e.g: fur colour in mice; and red-green colour blindness in humans.

- Each **gene** may have different forms called **alleles**.
- The **alleles** present (**genotype**), operate at a molecular level to develop **characteristics** that can be expressed as a **phenotype**.
- A **dominant allele** is **always expressed**, even if only one copy is present.
- A **recessive allele** is **only expressed if two copies are present**.
- If the **two alleles** are the same the organism is **homozygous** for that trait
- If the **alleles are different** they are **heterozygous**.

Punnett square





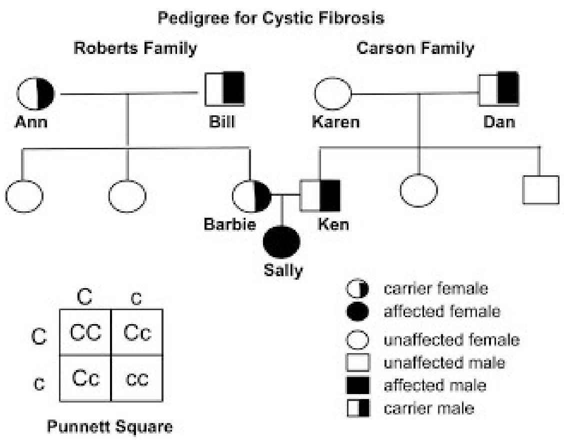
Genotype Ratio:
25% PP
50% Pp
25% pp
1:2:1 ratio

- Most **phenotype characteristics** are a result of multiple genes interacting, rather than a single gene.

4.6.1.5 Inherited disorders

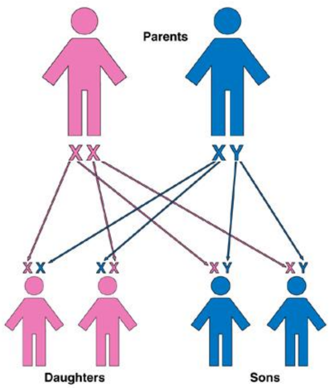
Some disorders are inherited.
These disorders are caused by the inheritance of certain alleles.

- **Polydactyly** (having extra fingers or toes) is caused by a dominant allele.
- **Cystic fibrosis** (a disorder of cell membranes) is caused by a recessive allele.



4.6.1.6 Sex determination

- Human body cells contain 23 pairs of chromosomes
- 22 pairs control characteristics only
- 1 pair carries the genes that determine sex.
- **Females:** sex chromosomes - **XX**
- **Males:** chromosomes are different - **XY**



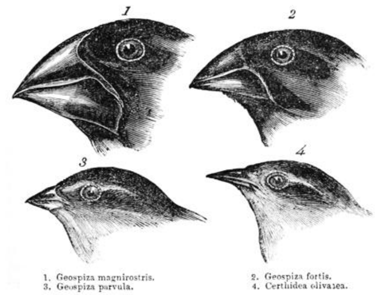
4.6.2 Variation and evolution

Differences in the characteristics of individuals in a population is called variation and may be due to differences in:

- the genes they have inherited (**genetic** causes)
- the conditions in which they have developed (**environmental** causes)
- a **combination of genes and the environment**.
- Usually extensive genetic variation within a population of a species
- All variants arise from mutations and **most have no effect on the phenotype**; **some influence** phenotype; **very few determine** phenotype.
- **Mutations occur continuously**. Very rarely a mutation will lead to a new phenotype.
- If a new phenotype is suited to an environmental change it can lead to a relatively rapid change in the species.

Evolution:

- The theory of evolution by natural selection states that **all species of living things have evolved from simple life forms that first developed more than three billion years ago**.
- Evolution occurs through **natural selection of variants** that give rise to **phenotypes** best suited to their **environment**.
- If two populations of one species become so different in phenotype that they can **no longer interbreed to produce fertile offspring** they have formed two **new species**.



Knowledge Organiser – 4.6.2 Selective breeding & Genetic Engineering

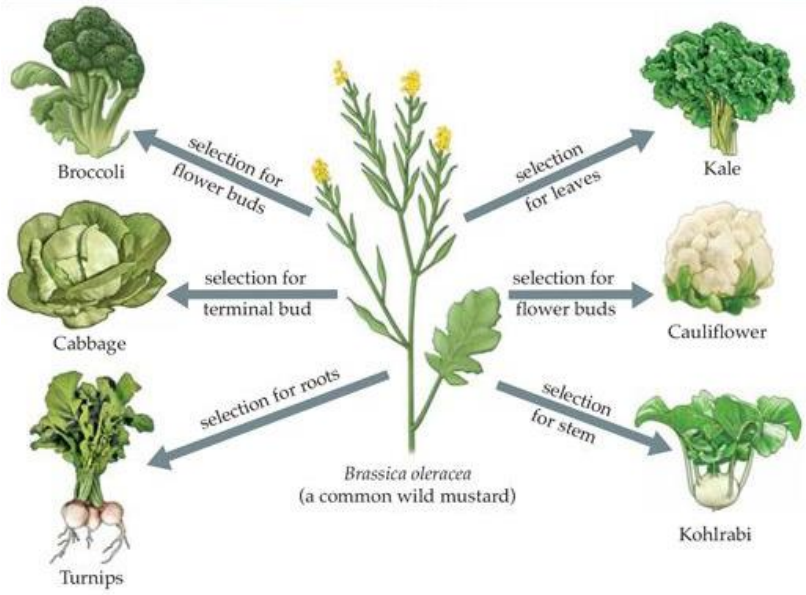
4.6.2.3 Selective breeding or Artificial selection

Selective breeding (artificial selection) is the human breeding of plants and animals for particular genetic characteristics.
Involves:

- **choosing parents with the desired characteristic** from a mixed population.
- They are **bred together**.
- From the **offspring those with the desired characteristic are bred together**.
- **continues over many generations** until **all** the offspring show the **desired characteristic.**

Characteristics might include:

- **Disease resistance** in food crops.
- Animals which produce **more meat or milk**.
- Selective breeding **can lead to 'inbreeding**' where some breeds are particularly prone to disease or inherited defects.



4.6.2.4 Genetic engineering

Genetic engineering involves modifying the genome of an organism by introducing a gene from another organism to give a desired characteristic.

- **Plant crops have been genetically engineered to be resistant to diseases** or to produce bigger better fruits.
- **Bacterial cells have been genetically engineered** to produce human **insulin** to treat diabetes.
- **Genes** from the chromosomes of humans and other organisms **can be 'cut out'** and **transferred to cells of other organisms**.

GM Crops

- Crops that have had their genes modified in this way are called genetically modified (GM) crops.
- GM crops include ones that are resistant to insect attack or to herbicides.
- GM crops generally show increased yields.

Negatives

- Concerns about GM crops include the effect on populations of wild flowers and insects.
- Some people feel the effects of eating GM crops on human health have not been fully explored.

Positives

- Modern medical research is exploring the possibility of genetic modification to overcome some inherited disorders.
- Much faster than selective breeding
- More productive crops, resistant to climate change and other environmental challenges

Process of genetic engineering (HT only):

- **enzymes** are used to **isolate** the required gene
- this **gene is inserted into a vector**, usually a bacterial plasmid or a virus
- the **vector is used to insert the gene into the required cells**
- genes are **transferred to the cells of animals**, **plants** or **microorganisms** at an early stage in their development so that they develop with desired characteristics.

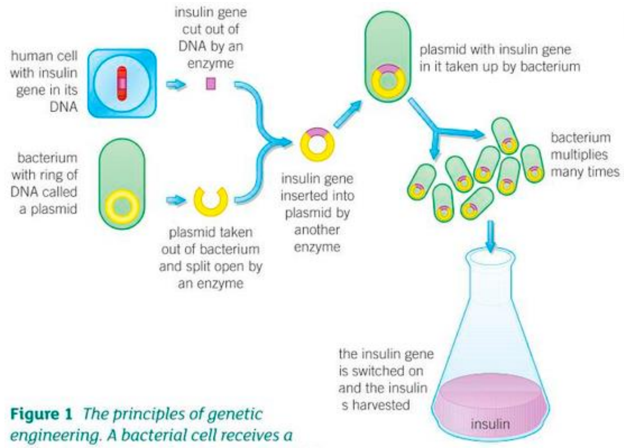


Figure 1 *The principles of genetic engineering. A bacterial cell receives a human gene so it makes a human protein – in this case, the hormone insulin*

Knowledge Organiser – 4.6.3 Development of understanding of genetics and evolution

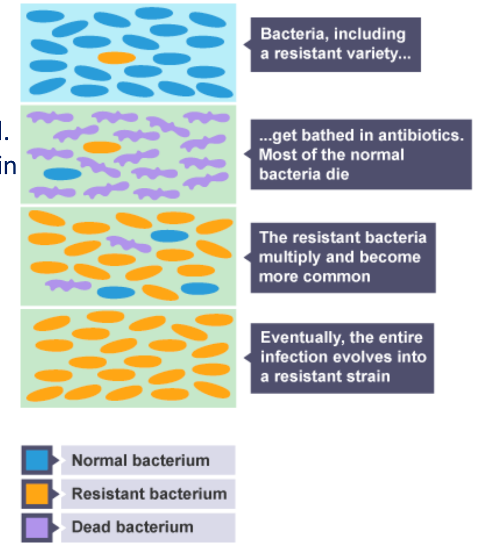
Evidence for evolution
- The theory of evolution by natural selection is now widely accepted.
- Evidence for Darwin's theory is now available as it has been shown that characteristics are passed on to offspring in **genes**.
- There is further evidence in the **fossil record**
- And by **knowledge of how resistance to antibiotics evolves in bacteria.**

Fossils are the 'remains' of organisms from millions of years ago, which are found in rocks. Fossils may be formed:
- from **parts of organisms that have not decayed** because one or more of the conditions needed for decay are absent
- when parts of the organism are **replaced by minerals as they decay**
- as **preserved traces of organisms**, such as footprints, burrows and rootlet traces.
- Fossils can how much or how little different organisms have changed as life developed .

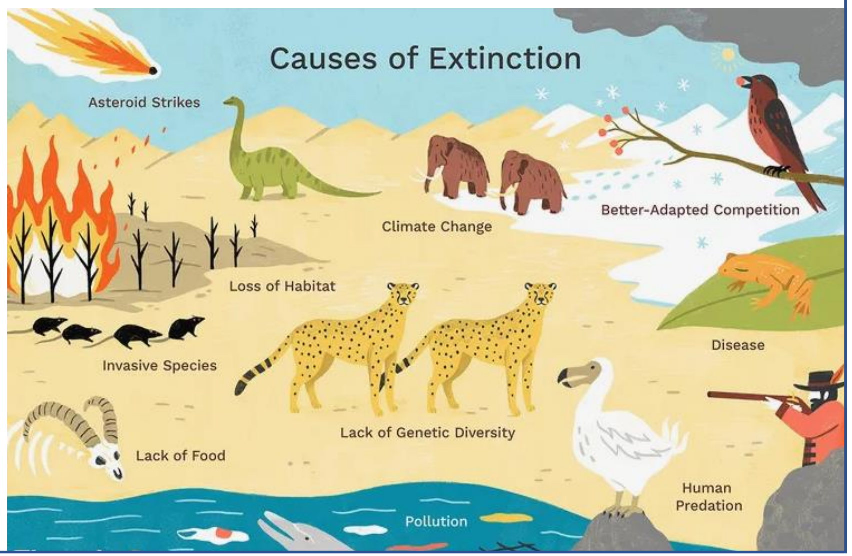
4.6.3.4 Resistant bacteria
- **Bacteria can evolve rapidly because they reproduce at a fast rate**.
  - **Mutations** of bacterial pathogens produce new strains.
  - **Some strains might be resistant to antibiotics**, and so are not killed.
  - They **survive and reproduce**, so the population of the resistant strain rises.
  - The **resistant strain will then spread because people are not immune** to it and there is no effective treatment.

E.g. MRSA is resistant to antibiotics.

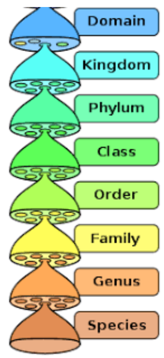
To reduce the rate of development of antibiotic resistant strains:
- doctors should not prescribe antibiotics inappropriately, eg for viral infections
- patients must complete a course of antibiotics so no bacteria survive to mutate and form resistant strains
- the agricultural use of antibiotics should be restricted.



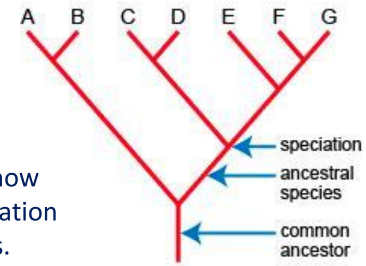
Extinctions occur when there are no remaining individuals of a species still alive.



4.6.4 Classification of living organisms
- **Traditionally** living things have been **classified** into groups **depending on their structure and characteristics** in a system developed by Carl **Linnaeus**.
- Linnaeus classified living things into **kingdom, phylum, class, order, family, genus and species.**
- Organisms are named by the **binomial system of genus and species**.

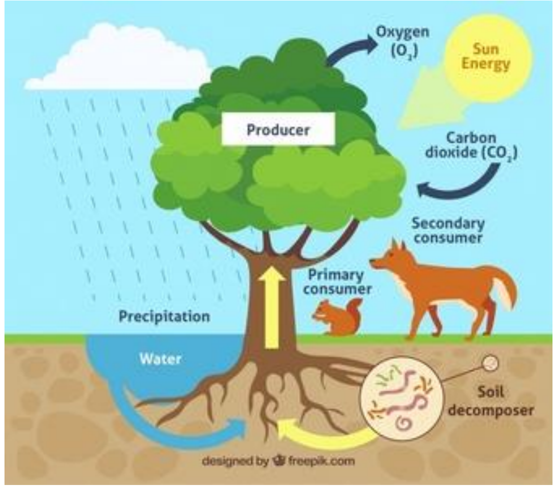


- As evidence of internal structures became more developed due to improvements in microscopes, and the understanding of biochemical processes progressed, new models of classification were proposed.
- Due to evidence available from chemical analysis **there is now a 'three-domain system'** developed by Carl **Woese**.
  - **Archaea** (primitive bacteria usually living in extreme environments)
  - **Bacteria** (true bacteria)
  - **Eukaryota** (which includes protists, fungi, plants and animals).
- **Evolutionary trees** are a method used by scientists to show how they believe organisms are related. They use current classification data for living organisms and fossil data for extinct organisms.



Knowledge Organiser – 4.7.1 Ecology Adaptations, interdependence and competition

4.7 Ecology



4.7.1.1 Communities

- An **ecosystem** is the **interaction of a community of living organisms** (biotic) **with the non-living** (abiotic) **parts of their environment**.
- **To survive and reproduce**, organisms require a supply of materials from their surroundings and from the other living organisms there.
- **Plants** in a community or habitat often **compete with each other**:
  - for light
  - space,
  - for water and mineral ions from the soil.
- **Animals** often **compete with each other**:
  - for food
  - mates
  - Territory

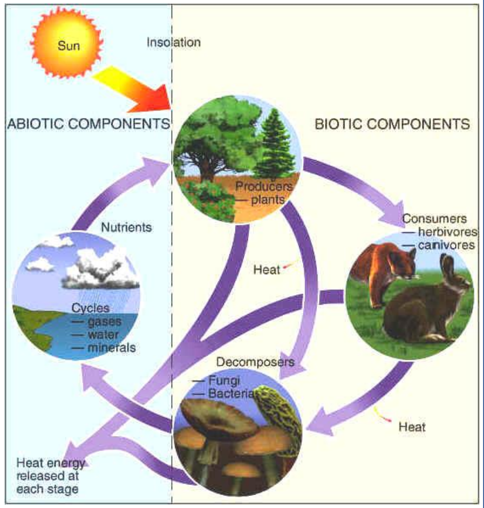
- Within a community **each species depends on other species**
- If one species is removed it can affect the whole community. This is called **interdependence**.
- A **stable community** is one where all the species and environmental factors are in balance so **that population sizes remain fairly constant**.

4.7.1.2 Abiotic factors

- light intensity
- temperature
- moisture levels
- soil pH and mineral content
- wind intensity and direction
- carbon dioxide levels for plants
- oxygen levels for aquatic animals.

4.7.1.3 Biotic factors

- availability of food
- new predators arriving
- new pathogens
- one species outcompeting another so the numbers are no longer sufficient to breed.



4.7.1.4 Adaptations

- Organisms are **adapted to live in their natural environment**
- Organisms have **features (adaptations) that enable them to survive** in the conditions in which they normally live.
- These **adaptations** may be **structural**, **behavioural** or **functional**.
- **Extremophiles** are organisms that live in environments that are very extreme, such as at high temperature, pressure, or salt concentration.

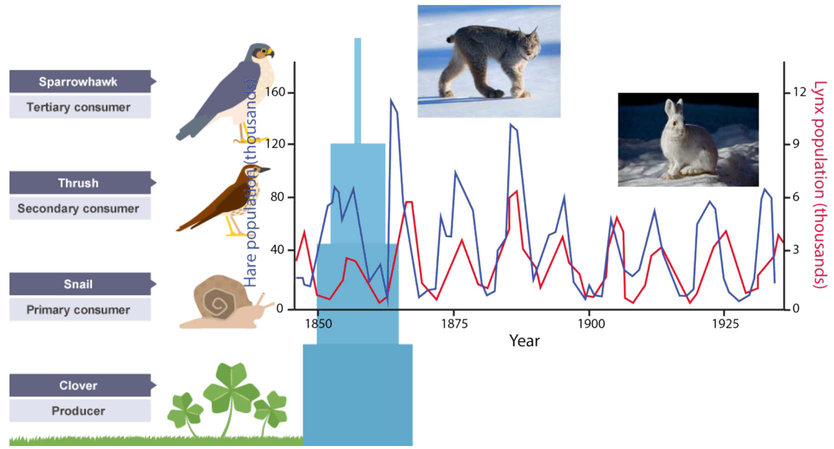
Eg Bacteria living in deep sea vents

	Definition
abiotic	Non-living elements of an ecosystem, such as climate, temperature, water, and soil type.
biotic	Living elements of an ecosystem, such as plants and animals.
community	All the organisms that live in a habitat (plants and animals).
ecosystem	The living organisms in a particular area, together with the non-living components of the environment.
food chain	A sequence (usually shown as a diagram) of feeding relationships between organisms, showing which organisms eat what and the movement of energy through trophic levels.
gene	The basic unit of genetic material inherited from our parents. A gene is a section of DNA which controls part of a cell's chemistry - particularly protein production.
indicator species	The presence, abundance or absence of these organisms provides information such as the level of pollution in the environment.
interdependence	Refers to the fact that all organisms that live in an ecosystem depend upon each other, for food, protection, shelter, etc, in order to survive.
interspecific competition	The competition which occurs between organisms of different species for a common resource.
intraspecific competition	The competition between organisms within the same species.
nitrate	The chemical absorbed from the soil by plants to produce their protein.
pathogen	Microorganism that causes disease.
population	All of the members of a single species that live within a geographical area.
predator	An animal that hunts, kills and eats other animals for food.
prey	Organisms that predators kill for food.
producer	Plants that begin food chains by making energy from carbon dioxide and water.
species	A type of organism that is the basic unit of classification. Individuals of different species are not able to interbreed successfully.

Knowledge Organiser – 4.7.2 Organisation of an ecosystem

4.7.2.1 Levels of organisation

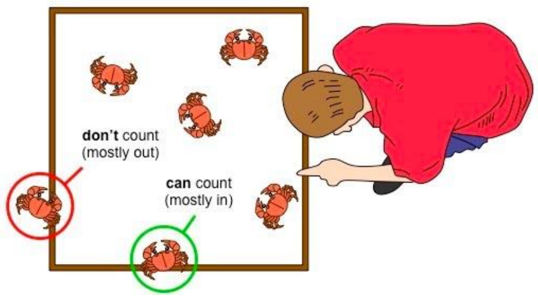
- **Photosynthetic organisms** are the producers of **biomass** for life on Earth.
- **Feeding relationships within a community can be represented by food chains**. All food chains begin with a producer which synthesises molecules. This is usually a green plant or alga which makes glucose by photosynthesis.
- **Producers** are eaten by **primary consumers**, which in turn may be eaten by **secondary consumers** and then **tertiary consumers**.
- Consumers that kill and eat other animals are **predators**, and those eaten are **prey**.
- **In a stable community the numbers of predators and prey rise and fall in cycles**.



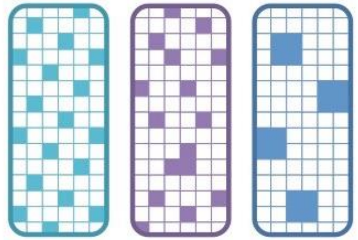
Definitions	
mean	The mean is calculated by adding all of the data and dividing by the number of items
Mode	The value that occurs most often.
median	The 'middle' value in the list of numbers
quadrat	A square frame of known area used for sampling the abundance and distribution of slow or non-moving organisms.
transect	A line created, for instance, with a tape measure, along which sampling occurs.
yield	The mass of product made in a chemical reaction. The percentage yield is a measure of the yield obtained compared to the maximum possible yield.

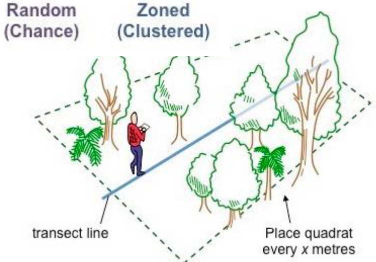
RPA: measure the population size of a common species in a habitat.
Use sampling techniques to investigate the effect of a factor on the distribution of this species.

Quadrat Counting Method

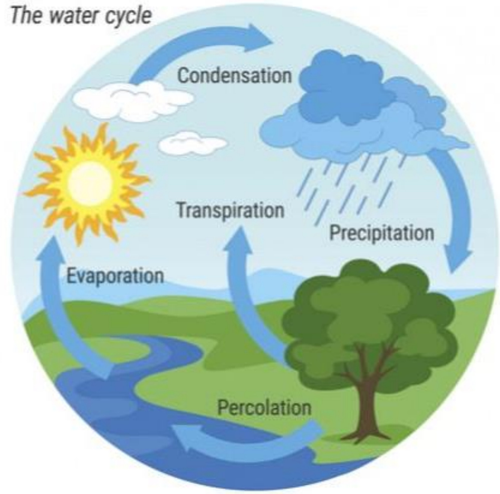


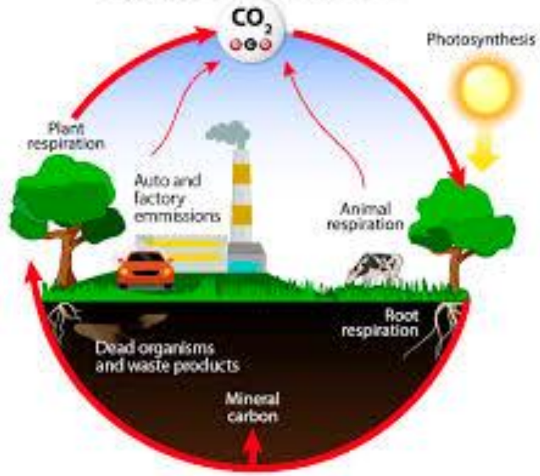
Types of Sampling Distributions





4.7.2.2 How materials are cycled





Knowledge Organiser – 4.7.3 Biodiversity and the effect of human interaction on ecosystems

4.7.3.1 Biodiversity

- **Biodiversity** is the **variety of all the different species of organisms on earth, or within an ecosystem**.
- **Greater biodiversity ensures the stability of ecosystems** by reducing the dependence of one species on another for food, shelter and the maintenance of the physical environment.
- Many human activities are reducing biodiversity

4.7.3.2 Waste management

- **Rapid growth in the human population** and an increase in the standard of living mean that increasingly **more resources are used and more waste is produced.**
- Unless waste and chemical materials are properly handled, more **pollution** will be caused.

Pollution can occur:

- in **water**, from sewage, fertiliser or toxic chemicals
- in **air**, from smoke and acidic gases
- on **land**, from landfill and from toxic chemicals.
- Pollution kills plants and animals which can **reduce biodiversity.**

4.7.3.3 Land use

- Humans **reduce the amount of land available** for other animals and plants by **building, quarrying, farming and dumping waste**.

For example:

- The **destruction of peat bogs**, and other areas of peat to produce garden compost, **reduces the area of this habitat** and thus the variety of different plant, animal and microorganism species that live there (**biodiversity**).
- The **decay or burning** of the peat **releases carbon dioxide** into the atmosphere.

4.7.3.4 Deforestation

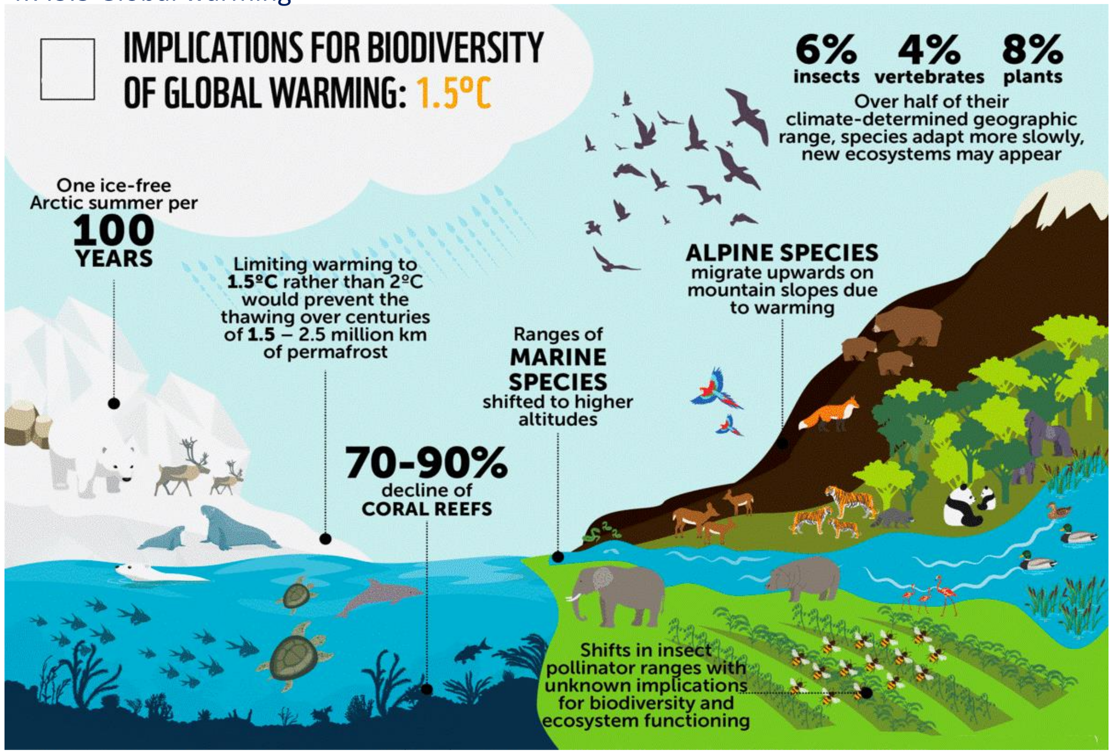
- Large-scale deforestation in tropical areas has occurred to:
    - provide land for cattle and rice fields
    - grow crops for biofuels

4.7.3.6 Maintaining biodiversity

Scientists and concerned citizens have put in place programmes to reduce the negative effects of humans on ecosystems and biodiversity.
These include:

- breeding programmes for endangered species
- protection and regeneration of rare habitats
- reintroduction of field margins and hedgerows in agricultural areas where farmers grow only one type of crop
- reduction of deforestation and carbon dioxide emissions by some governments
- recycling resources rather than dumping waste in landfill.

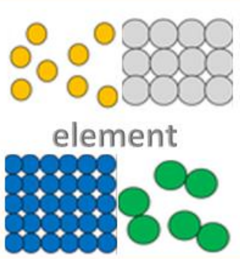
4.7.3.5 Global warming



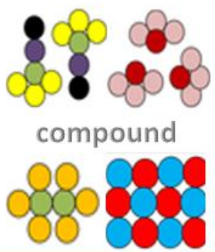
Knowledge Organiser – 5.1 Atomic structure & the periodic table

5.1.1.1 Atoms, elements & compounds

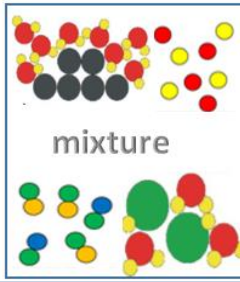
An **Atom** is the **smallest part of an element that can exist.**



Made from only one type of atom e.g. Gold is made of only gold atoms



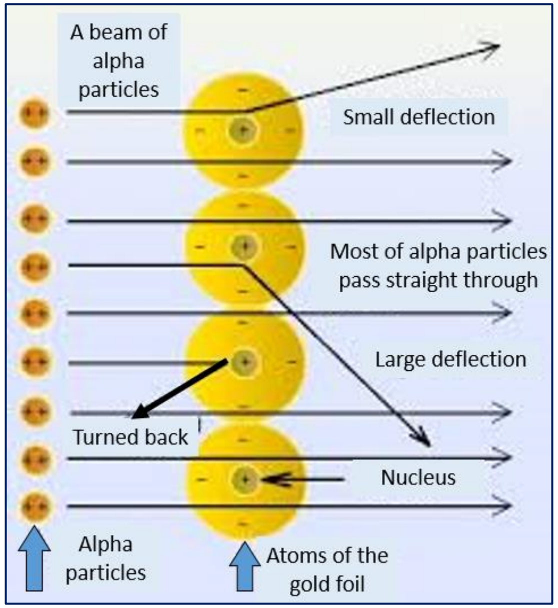
Two or more elements chemically bonded (joined) together. Separated by chemical reactions



Two or more elements that are NOT chemically combined together. Separated by physical processes

5.1.1.3 The development of the model of the atom

Ideas about atoms have changed over time. Scientists developed new atomic **models** as they gathered new experimental evidence.

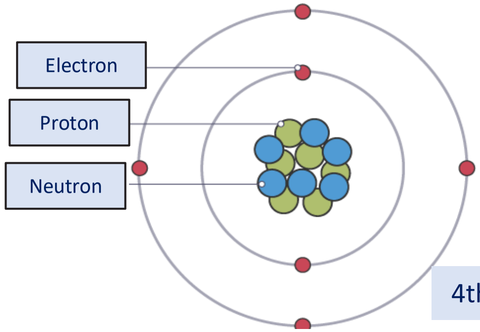


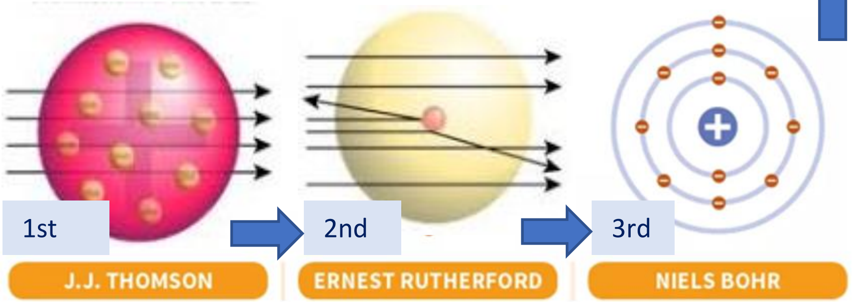
Ernest Rutherford's Gold scattering experiment

- **Positive alpha particles** fired at gold leaf
- **Most passed straight through** suggesting the atom was mainly empty space
- **Some deflected at angles** suggesting the presence of electrons
- **Some bounced straight back** suggesting a positive nucleus repelled the alpha particles.

The Nuclear Model

In 1932 James Chadwick found evidence for the existence of particles in the nucleus with mass but no charge.
These particles are called **neutrons.**
This atomic model is still used today.





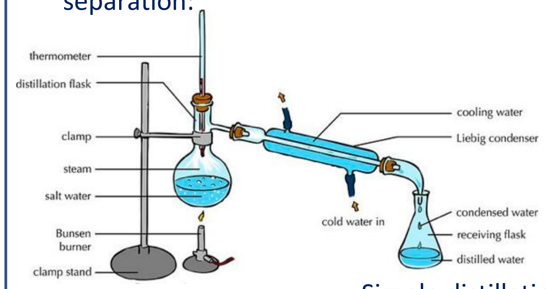
1904- **electron** discovered, placed in a sphere of positive charge (the **plum pudding model**)

1911 - gold scattering experiment discovered mass was concentrated in a central positive **nucleus** (the nuclear model)- further experiments led to discovery of **protons**

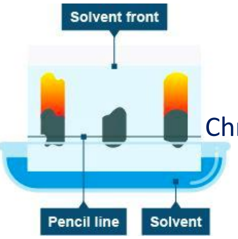
1913 - Suggested electrons orbit the nucleus in **shells**. The shells are at certain distances from the nucleus.

5.1.1.2 Mixtures

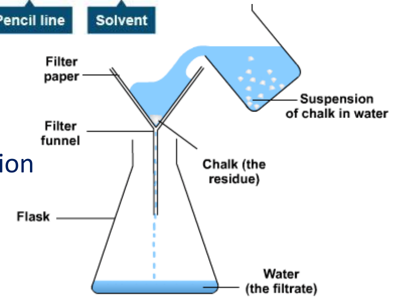
- Mixtures can be **separated by physical processes** such as **filtration, crystallisation, simple distillation, fractional distillation & chromatography**.
- These physical processes **do not involve chemical reactions** and **no new substances are made.**
- Examples of the specified processes of separation:



Simple distillation



Chromatography



Filtration

Crystallisation

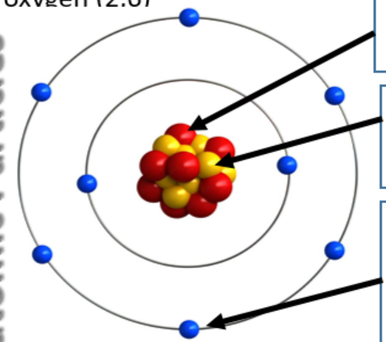
Knowledge Organiser – 5.1 Atomic structure & the periodic table

5.1.1.4 Relative electrical charges of subatomic particles & 5.1.1.7 Electron structure

Innermost, lowest energy level, **shell** has **2 electrons**.
Next shell 8, next shell 8. (2,8,8)

Electronic structure an be shown as a diagram or a number eg. oxygen (2.6)

Sub-atomic Particles



Proton: Positive subatomic particle in the nucleus. Relative mass 1, charge +1

Neutron: Neutral subatomic particle in the nucleus. Relative mass 1, Charge 0 (no charge)

Electron: Negative subatomic particle orbiting the nucleus. Very small relative mass. Charge -1. Can be represented by dots or crosses

Atomic radius: 0.1 nm

Nucleus: The centre of an atom in which most of the mass of the atom is concentrated

5.1.1.5 Size and mass of atoms

- Atoms are **very small**, having a radius of about 0.1 nm (1 x 10-10 m).
- Atomic mass number: The sum (total) of the protons and neutrons in the nucleus of an atom of an element.
- Atomic (Proton) number: The number of protons in an atom of an element. Balanced by number of electrons in an atom of that element. (so atoms have no overall charge).

Name of particle	Relative mass
Proton	1
Neutron	1
Electron	Very small

12
C
carbon
6

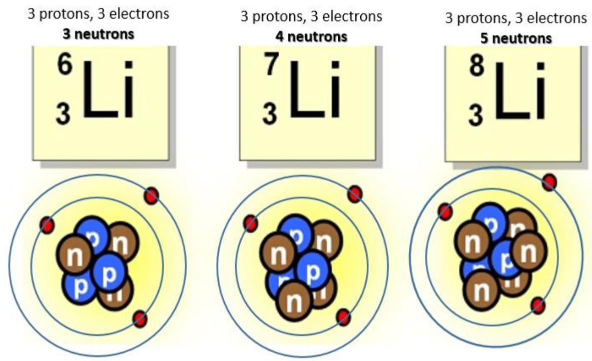
5.1.2.2 Development of the periodic table

- Early versions organized by atomic mass
- Didn't take account of isotopes
- Many elements missing
- Mendeleev ordered elements by atomic (proton) number
- Left gaps for undiscovered elements. Later discoveries proved him right.

5.1.1.6 Relative atomic mass

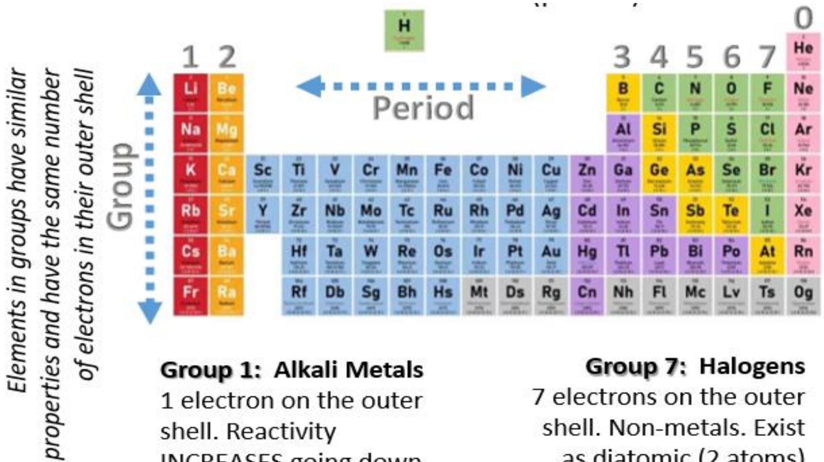
Isotopes are atoms of the same element with **different numbers of neutrons** in the nucleus.

Relative atomic mass: Average value that takes account of the **abundance** of the different isotopes of that element.



5.1.2 Periodic Table

Shows the ~100 known elements in order of atomic (proton) number



Group 1: Alkali Metals
1 electron on the outer shell. Reactivity INCREASES going down the group. Vigorous reactions with oxygen, chlorine and water.

Group 7: Halogens
7 electrons on the outer shell. Non-metals. Exist as diatomic (2 atoms) molecules. Reactivity decreases going down the group.

Group 0: Noble Gases
Have full outer shells so stable and unreactive. Boiling points increase going down the group.

5.1.2.3 Metals & Non-metals

vs

Elements that react to form positive ions are **metals.**

Elements that do NOT form positive ions are **non-metals.**

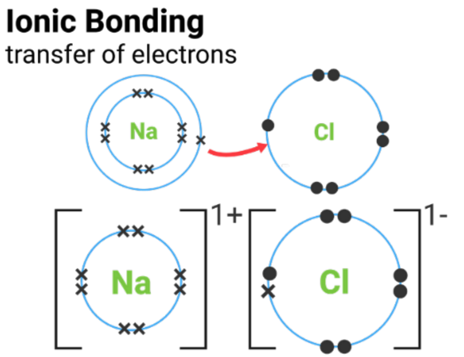
Metals	Non-metals
Good conductors of heat and electricity	Bad conductors of heat and electricity
Malleable: can be beaten into thin sheets, hammered into shape	Brittle: breaks easily if solid
Ductile: can be stretched into wires	Non-ductile: snap easily
Shiny (lustre)	Dull

Knowledge Organiser – 5.2 Structure & bonding

5.2.1.1 Chemical bonds

There are three types of strong chemical bonds: ionic, covalent and metallic.
Ionic bonding: particles are oppositely charged ions. Ionic bonding occurs in compounds formed from metals combined with non-metals
Covalent bonding the particles are atoms which share pairs of electrons. Covalent bonding occurs in most non-metallic elements and in compounds of non-metals
Metallic bonding the particles are atoms which share delocalised electrons. Metallic bonding occurs in metallic elements and alloys.

5.2.1.2 Ionic Bonding

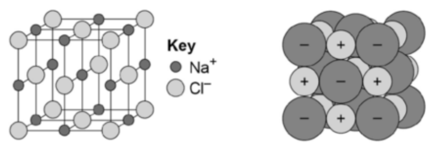


- Between a metal atom and a non-metal atom
- Metals lose electrons to form positive ions
- Non-metals gain electrons & form negative ions
- Electrons **transferred** (**ions** formed)
- Strong **electrostatic** forces
- Giant **lattice** structures
- High melting/boiling points
- If **molten** or in **solution** ions will conduct electricity

5.2.1.3 Ionic compounds

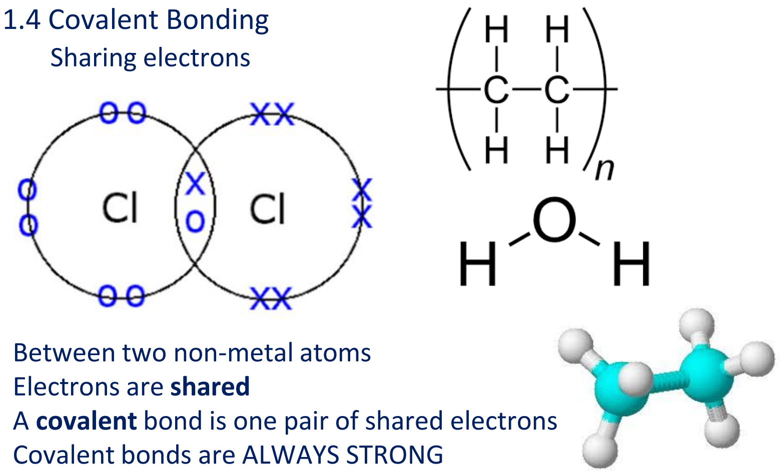
- An ionic compound is a **giant structure of ions**.
- Ionic compounds are held together by **strong electrostatic forces of attraction** between oppositely charged ions.
- These **forces act in all directions in the lattice** and this is called **ionic bonding**.

Eg: structure of sodium chloride



5.2.1.4 Covalent Bonding

Sharing electrons



- Between two non-metal atoms
- Electrons are **shared**
- A **covalent** bond is one pair of shared electrons
- Covalent bonds are ALWAYS STRONG

5.2.2.1. The three states of matter

- **Freezing** take place at the **melting point**
- **Boiling** and **condensing** take place at the **boiling point**.
- **Particle theory** can help to explain melting, boiling, freezing and condensing.
- The **amount of energy needed to change state** from solid to liquid and from liquid to gas **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.**

5.2.2.3 Properties of Ionic compounds

- have **high melting points** and **high boiling points because** of the **large amounts of energy needed to break the many strong bonds.**
- When melted or dissolved in water, ionic compounds **conduct electricity because the ions are free to move and so charge can flow**.

5.2.2.4 Properties of Small molecules

- Usually **gases or liquids** with **low melting point & low boiling point.**
- Weak **intermolecular** forces (because they are small molecules) which are overcome when substance melts or boils.
- e.g. gases, water
- Do not conduct electricity as no overall electric charge.

5.2.2.5 Polymers

- **Long** molecules with atoms linked by **strong covalent bonds**.
- Solid at room temperature as **relatively strong intermolecular forces.**
- **Repeating** units e.g. plastics

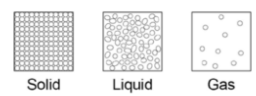
5.2.2.6 Giant covalent structures

Giant lattices

- High melting point and boiling point
- Strong covalent bonds which must be overcome to melt or boil.
- e.g. silicon dioxide, diamond, graphite

5.2.2.2. State symbols

In chemical equations, the three states of matter are shown as (s), (l) and (g).

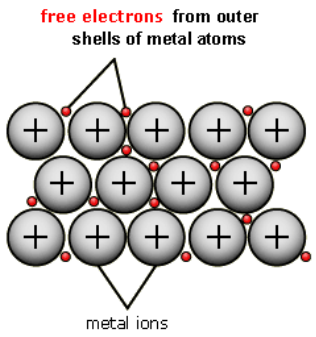


(aq) for aqueous solutions eg salt water or acid solutions.

Knowledge Organiser – 5.2 Structure & bonding

5.2.1.5 Metallic Bonding

- Bonding between atoms of a metal
- **Delocalised** electrons (negative) & metal ions (positive)
- Shared delocalised electrons form strong metallic bonds
- Delocalised electrons **conduct** heat and electricity



- Pure metals are soft: layers of atoms can slide over each other

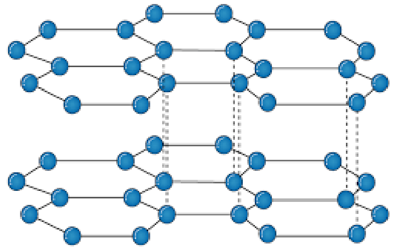
5.2.2.7 Properties of metals and alloys

- Metals have **giant structures of atoms** with **strong metallic bonding**. Therefore most metals have **high melting and boiling points.**
- In **pure metals, atoms are arranged in layers**, which allows metals to be **bent and shaped**. (malleable)
- **Pure metals** are too soft for many uses and so **are mixed with other metals to make alloys which are harder**.
- In **alloys**, different atoms **disrupt** the layers
- Alloys are **harder** than pure metals

5.2.2.8 Metals as conductors

- 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**.

5.2.3 Structure & bonding of carbon

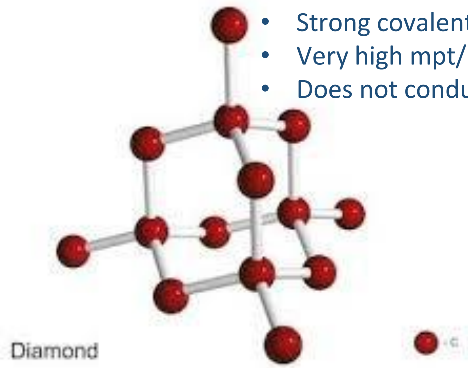


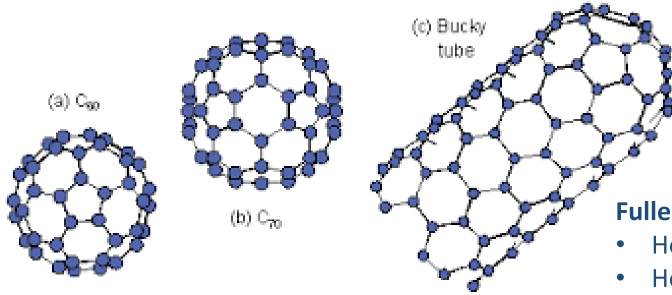
Graphite

- Giant lattice (in layers)
- Each C forms 3 bonds
- Layers of hexagonal rings with no bonds between layers
- Giving 1 delocalised electron
- Good conductor

Diamond: Giant lattice

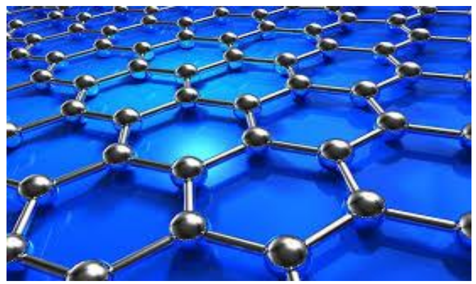
- Each C forms 4 bonds
- Strong covalent bonds
- Very high mpt/bpt
- Does not conduct electricity





Fullerenes

- Hollow shapes
- Hexagonal rings, but may also contain rings of 5 or 7 Cs
- Buckminsterfullerene (C_{60}) spherical.
- Carbon nanotubes are cylindrical. Very useful for nanotechnology, electronics



Graphene

- A single layer of graphite
- Useful in electronics and composites

Note: carbon is a non-metal so the bonds between carbon atoms must be COVALENT.

Knowledge Organiser – 5.3 Quantitative Chemistry

5.3.1.1 Conservation of mass and balanced chemical equations

Reacting masses

In all chemical reactions the **total mass of reactants used is equal to the total mass of the products** made: Reactants → Products

5.3.1.2 Relative Formula Mass (M_r)

Relative atomic mass

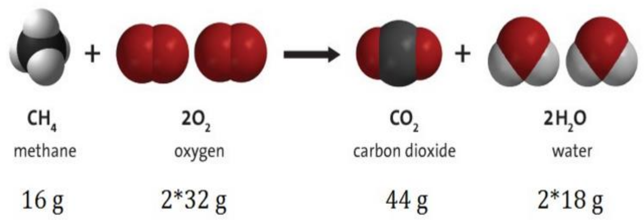
Different atoms have different masses.
Atoms have such a small mass it is more convenient to know their masses compared to each other.
Carbon is taken as the standard atom and has a relative atomic mass (A_r) of 12.

Relative formula mass

To find the relative formula mass (M_r) of a compound, you just add together the A_r values for all the atoms in its formula.

Example 1:
Find the M_r of carbon monoxide (CO).
The A_r of carbon is 12 and the A_r of oxygen is 16
So the M_r of carbon monoxide is 12 + 16 = 28.

Example 2:
Find the M_r of carbon dioxide (CO2)
The A_r of carbon is 12 and the A_r of oxygen is 16, but there are 2 atoms of oxygen in the formula.
So the M_r of Carbon dioxide is 12 + 16 + 16 = 44



Mass of reactants (80g) Mass of products (80g)

5.3.1.3 Mass change when a reactant or product is a gas

Apparent loss of gain in mass when a **gas** is a product or reactant and is **gained** or **released** to the atmosphere in an **non-enclosed system**.

5.3.1.4 Chemical Measurements

Measurements have uncertainty.
You need to be able to look at the range of measurements about the mean (average) as a measure of uncertainty.

5.3.2.5 Limiting reactants (HT only)

- In a chemical reaction involving two reactants, it is common to use an excess of one of the reactants to ensure that all of the other reactant is used.
- The **reactant that is completely used up** is called the **limiting reactant** because it limits the amount of products.

5.3.2 Amounts of substances in relation to masses of pure substances (HT only)

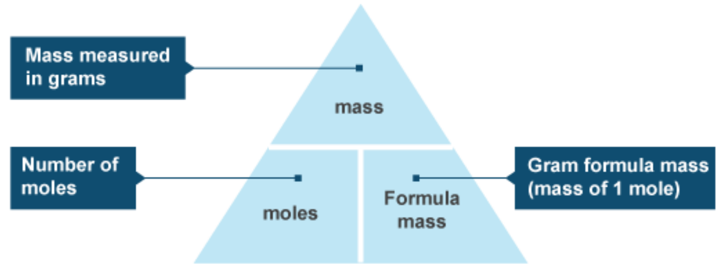
The Mole:

- The unit for amount of substance is called the **mole**, shown as **mol**. One mole of atoms, *ions* or *molecules* is around 6 × 10^{23} (6 followed by 23 zeroes). This is called Avogadro constant.
- This is the same number as the number of carbon atoms in 12 g of carbon.

This equation shows how **molar mass**, **number of moles** and **mass** are related:

number of moles = mass ÷ molar mass

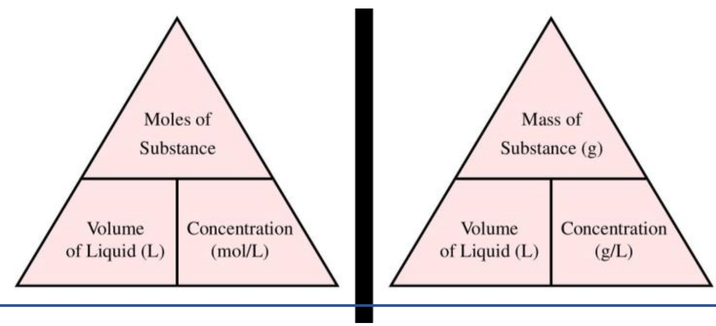
This can be rearranged to find the mass if the number of moles and molar mass are known, or to find the molar mass if the mass and number of moles are known.



Finding the number of moles

Example

What is the number of moles of carbon dioxide molecules in 22 g of CO2?
A_r of C = 12, A_r of O = 16
The relative formula mass M_r of carbon dioxide = 12 + 16 + 16 = 44
This means that the molar mass of carbon dioxide = 44 g/mol
number of moles = 22 ÷ 44 = 0.5 mol



Knowledge Organiser – 5.3 Quantitative Chemistry

Spec	Question	Answer
5.3.1.1	What is the law of conservation of mass?	The law of conservation of mass states that no atoms are lost or made during a chemical reaction so the mass of the products equals the mass of the reactants.
5.3.1.1	What does the conservation of mass mean in terms of chemical reactions?	This means that chemical reactions can be represented by symbol equations which are balanced in terms of the numbers of atoms of each element involved on both sides of the equation.
5.3.1.2	What is the relative formula mass (Mr) of a compound?	The relative formula mass (Mr) of a compound is the sum of the relative atomic masses of the atoms in the numbers shown in the formula
5.3.1.2	What happens to the sum of the relative formula masses of the reactants & products?	The sum of the relative formula masses of the reactants in the quantities shown equals the sum of the relative formula masses of the products in the quantities shown.
5.3.1.3	How can we explain a change in mass?	This can usually be explained because a reactant or product is a gas and its mass has not been taken into account.
5.3.1.3	Give 2 examples of reactions where there appears to be a change in mass	• when a metal reacts with oxygen the mass of the oxide produced is greater than the mass of the metal • thermal decompositions of metal carbonates carbon dioxide is produced and escapes into the atmosphere leaving the metal oxide as the only solid product.
5.3.1.4	When there is uncertainty about a result, what 2 things should you do?	• represent the distribution of results and make estimations of uncertainty • use the range of a set of measurements about the mean as a measure of uncertainty.
5.3.2.1	What are chemical amounts measured in and what is its unit?	Chemical amounts are measured in moles. The symbol for the unit mole is mol.

Spec	Question	Answer
5.3.2.1 HT	What is the mass of one mole equal to?	The mass of one mole of a substance in grams is numerically equal to its relative formula mass. One mole of a substance contains the same number of the stated particles, atoms, molecules or ions as one mole of any other substance.
5.3.2.1 HT	What is Avogadros number, including its value?	The number of atoms, molecules or ions in a mole of a given substance is the Avogadro constant. The value of the Avogadro constant is 6.02×10^{23} per mole
5.3.2.2 HT	How many moles of reactants and products in: Mg + 2HCl MgCl2 + H2	one mole of magnesium reacts with two moles of hydrochloric acid to produce one mole of magnesium chloride and one mole of hydrogen gas.
5.3.2.3 HT	How are the balancing numbers in a symbol equation calculated?	The balancing numbers in a symbol equation can be calculated from the masses of reactants and products by converting the masses in grams to amounts in moles and converting the numbers of moles to simple whole number ratios.
5.3.2.4 HT	What is a limiting reactant and how does the limiting reactant affect the amount of products produced?	The reactant that is completely used up is called the limiting reactant because it limits the amount of products. The effect of a limiting quantity of a reactant on the amount of products it is possible to obtain in terms of amounts in moles or masses in grams.
5.3.2.5 HT	How is the concentration of a solution measured?	The concentration of a solution can be measured in mass per given volume of solution, eg grams per dm3 (g/dm3).
5.3.3.1 HT	Why is it not always possible to obtain the calculated amount of product?	• the reaction may not go to completion because it is reversible • some of the product may be lost when it is separated • some of the reactants may react in ways different to the expected reaction.
5.3.3.1 HT	How do you calculate percentage yield?	$\% \text{ Yield} = \frac{\text{Mass of product actually made}}{\text{Maximum theoretical mass of product}} \times 100$
5.3.3.2 HT	How is percentage atom economy calculated?	The percentage atom economy of a reaction is calculated using the balanced equation for the reaction as follows: $= \frac{\text{Relative formula mass of desired product from equation}}{\text{Sum of relative formula masses of all reactants from equation}} \times 100$
5.3.4 HT	What information do you need to calculate the concentration of a soln?	If the volumes of two solutions that react completely are known and the concentration of one solution is known, the concentration of the other solution can be calculated.
5.3.5 HT	What is the volume of one mole of any gas at room temp and pressure?	. The volume of one mole of any gas at room temperature and pressure (20oC and 1 atmosphere pressure) is 24 dm3

Knowledge Organiser – 5.4 Chemical Changes

5.4.1 Reactivity of metals

Metals react with oxygen to produce **metal oxides**.
The reactions are **oxidation reactions because the metals gain oxygen**.

5.4.1.2 The reactivity series

- When metals react with other substances the metal atoms form positive ions.
- The reactivity of a metal is related to its tendency to form positive ions.
- Metals can be arranged in order of their reactivity in a reactivity series.
- The metals potassium, sodium, lithium, calcium, magnesium, zinc, iron and copper can be put in order of their reactivity from their reactions with water and dilute acids.
- A more reactive metal can displace a less reactive metal from a compound.

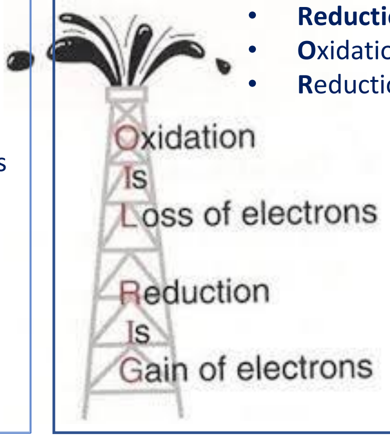
potassium	most reactive	K
sodium		Na
calcium		Ca
magnesium		Mg
aluminium		Al
carbon		C
zinc		Zn
iron		Fe
tin		Sn
lead		Pb
hydrogen		H
copper		Cu
silver		Ag
gold		Au
platinum	least reactive	Pt

5.4.1.3 Extraction of metals and reduction

- **Unreactive** metals are found as pure elements (eg gold) but most are compounds.
- Those below carbon can be **extracted** from oxides using carbon.
- Those above carbon need to be extracted using **electrolysis**.

5.4.1.4 Oxidation and reduction in terms of electrons (HT only)

- **Oxidation** involves gain of oxygen
- **Reduction** involves loss of oxygen
- **O**xidation **I**s **L**oss of electrons
- **R**eduction **I**s **G**ain of electrons



5.4.2.1 Reactions of acids with metals

Acids react with some metals to produce salts and hydrogen.

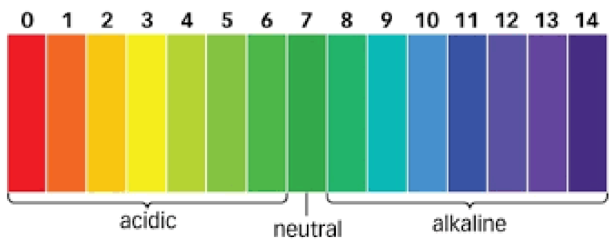
acid + metal → salt + hydrogen
acid + alkali → salt + water
acid + carbonate → salt + water + carbon dioxide

HCl - hydrochloric acid produces chlorides
HNO_3 - nitric acid produces nitrates
H_2SO_4 - sulfuric acid produces sulfates

(HT only)
- explain in terms of gain or loss of electrons, these are redox reactions
- identify which species are oxidised and which are reduced in given chemical equations.

5.4.2.2 Neutralisation of acids and salt production

- Acids are neutralised by alkalis (eg soluble metal hydroxides) and bases (eg insoluble metal hydroxides and metal oxides)



5.4.2.4. The pH scale and neutralisation

- **Acids produce hydrogen ions (H+)** in aqueous solutions.
- Aqueous **solutions of alkalis contain hydroxide ions (OH–).**
- The **pH scale**, from 0 to 14, is a measure of the **acidity** or **alkalinity** of a solution, and can be measured using **universal indicator** or a **pH probe**.
- A solution with pH 7 is neutral.
- In **neutralisation reactions** between an acid and an alkali, **hydrogen ions react with hydroxide ions to produce water.**

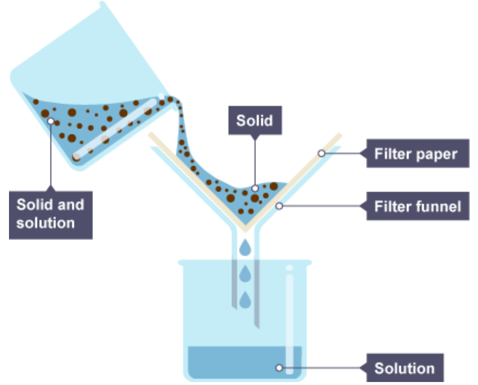
HIGHER TIER
Strong acids (HCl, HNO_3, H_2SO_4) fully **ionise**
Weak acids (ethanoic, citric, carbonic) partially ionise

Knowledge Organiser – 5.4 Chemical Changes

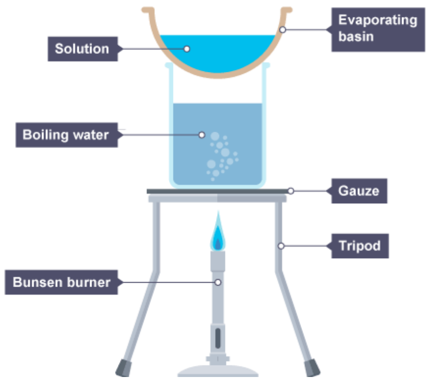
5.4.2.3 Soluble salts

- Soluble salts can be made from acids by reacting them with solid insoluble substances, such as metals, metal oxides, hydroxides or carbonates.
- The solid is added to the acid until no more reacts and the excess solid is filtered off to produce a solution of the salt.
- Salt solutions can be crystallised to produce solid salts.

RPA Preparation of a soluble salt



1. Add excess solid to acid
2. React
3. Filter off unreacted solid



4. Warm over water bath then leave to evaporate
5. Allow to crystallise. Dry the pure crystals

5.4.3. Electrolysis

5.4.3.1 The process of electrolysis

- Ionic compounds can be electrolysed when liquid or molten, as the ions are then free to move
- An electric current is passed through the electrolyte
- Positive ions move to the negative electrode (cathode)
- Negative ions move to the positive electrode (anode)
- Aluminium is extracted by electrolysis from a mixture of aluminium oxide and cryolite

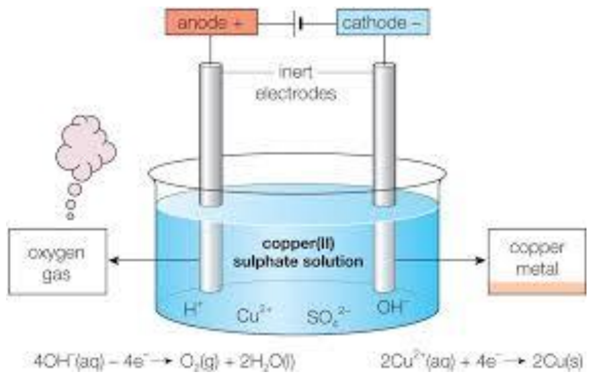
5.4.3.2 Electrolysis of molten ionic compounds

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

5.4.3.3 Using electrolysis to extract metals

- **Metals** can be **extracted** from molten compounds using **electrolysis**.
- Electrolysis is used **if the metal is too reactive to be extracted by reduction** with carbon or if the metal reacts with carbon.
- **Large amounts of energy** are used in the extraction process to melt the compounds and to produce the electrical current.
- **Aluminium** is manufactured by the **electrolysis** of a **molten mixture of aluminium oxide and cryolite using carbon** as the **positive** electrode (**anode**).

RPA Electrolysis of aqueous solution



5.4.3.4. Electrolysis of aqueous solutions

- The ions discharged when an aqueous solution is electrolysed using inert electrodes depend on the relative reactivity of the elements involved.
- At the negative electrode (cathode), hydrogen is produced if the metal is more reactive than hydrogen.
- At the positive electrode (anode), oxygen is produced unless the solution contains halide ions when the halogen is produced.
- This happens because in the aqueous solution water molecules break down producing hydrogen ions and hydroxide ions that are discharged.

5.4.3.5 Representation of reactions at electrodes as half equations (HT only)

During **electrolysis**, at the **cathode** (negative electrode), **positively charged ions gain electrons**. Ie **reductions reactions** At the **anode** (positive electrode), **negatively charged ions lose electrons**. Ie **oxidations**. Reactions at electrodes can be represented by half equations, for example:

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

and

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

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

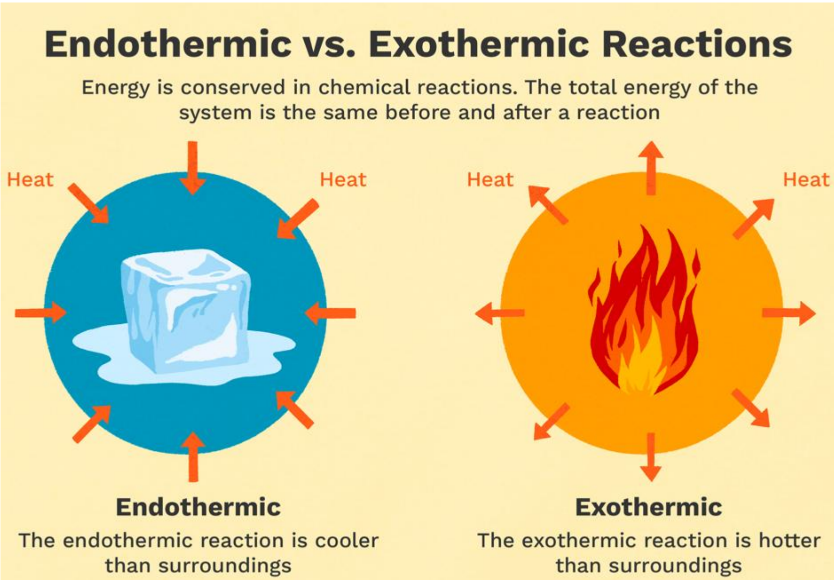
Knowledge Organiser – 5.5 Energy Changes

5.5.1 Exothermic and endothermic reactions

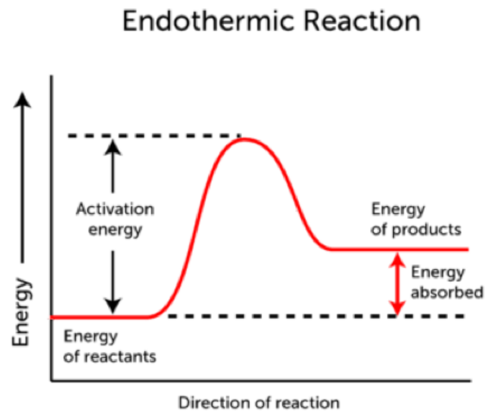
5.5.1.1 Energy transfer during Exothermic and endothermic reactions

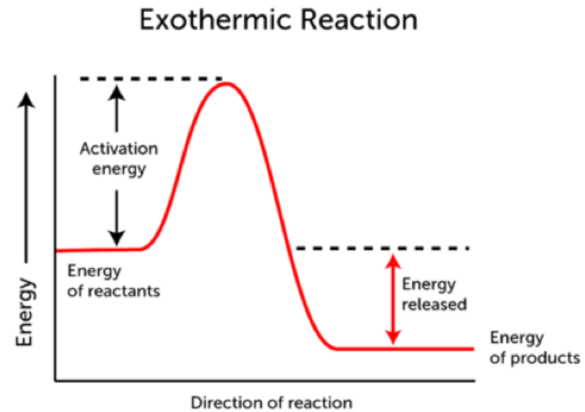
- **Energy is conserved** in chemical reactions.
- The amount of energy in the universe at the end of a chemical reaction is the same as before the reaction takes place.
- If a **reaction transfers energy to the surroundings** the **product** molecules must have **less energy than the reactants, by the amount transferred.**

- **Exothermic reactions give out energy to the surroundings. Exo = exit.**
  - Examples: combustion, neutralisation, hand warmers.
- **Endothermic reactions take in energy from the surroundings. Endo = enter.**
  - Examples: thermal decomposition, reaction of citric acid and sodium hydrogencarbonate and sports injury packs.



5.5.1.2 Reaction Profiles

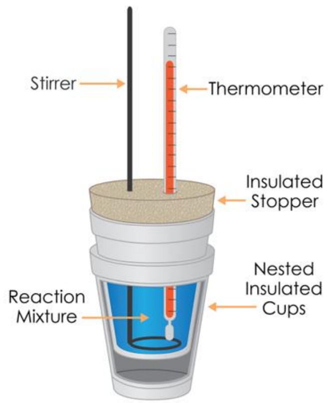




- In an **endothermic** reaction profile the **products finish higher in energy** than the reactants.
- In an **exothermic reaction** profile the **products finish lower in energy** than the reactants.

- **Activation energy** is the **minimum** energy required for a reaction to happen when particles **collide.**
- The **overall energy change** is the difference between the relative energy of the reactants and the products.

RPA Investigate the variables that affect temperature in reacting solutions



The variables you could change are:

- Type of reactant (metal, carbonate, alkali)
- Type of acid used.
- Concentration of acid.
- Size of reactant pieces (if solid).
- Concentration of alkali.

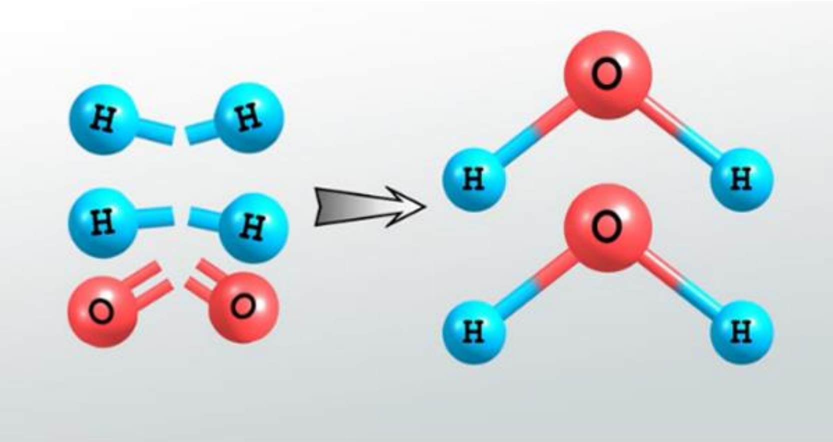
If one of these variables is changing, then all others stay the same.

Knowledge Organiser – 5.5 Energy Changes

5.5.1.3 Energy change of reactions (HT only)

During a chemical reaction:

- **Energy must be put in** to **break bonds** in the **reactants**.
- **Energy is given** out when **bonds in the products are formed**.



- If **overall energy change is negative** = **exothermic** reaction.
- If **overall energy change is positive** = **endothermic** reaction.

- In **exothermic** reactions, the **energy released from forming new bonds** is **greater** than the energy needed to break existing bonds.
- In **endothermic** reactions, the **energy needed to break existing bonds** is **greater** than the energy released from forming new bonds.

- The **difference between the sum of the energy needed to break bonds** in the reactants and the **sum of the energy released when bonds in the products are formed** is the **overall energy change of the reaction**.

Example:

Bond	Average bond energy (kJ mol^{-1})
H — H	436
O — H	463
O ═ O	498

Bonds broken:

- 2 x **H-H** = 2 x 436 = 872 kJ/mol
- **O=O** = 498 kJ/mol
- Total = 872 + 498 = 1370 kJ/mol

Bonds formed:

- 4 x **H-O** = 4 x 463 = 1852 kJ/mol
- Total = 1852 kJ/mol

Total energy change = reactants - products:

1370 kJ/mol – 1852 kJ/mol = - 482 kJ/mol

Knowledge Organiser – 5.6 The Rate & Extent of Chemical Change

5.6.1.1 Calculating rates of reactions

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

Rate is calculated by:

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

OR…

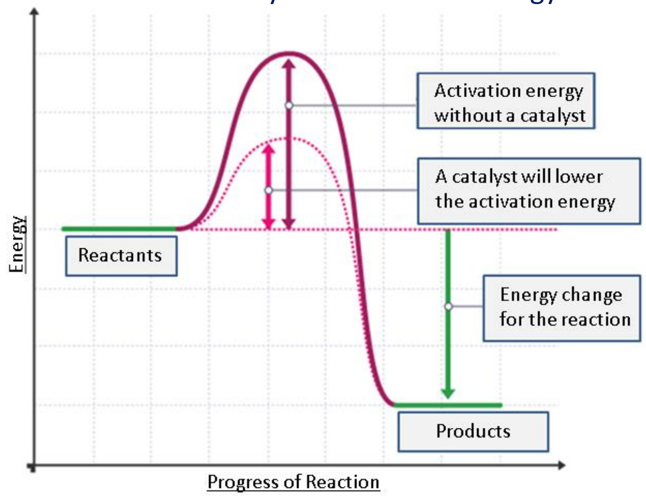
$$mean\ rate\ of\ reaction = \frac{quantity\ of\ \text{product}\ formed}{time\ taken}$$

Eg If 4 moles of a **product** were made during ten seconds, the average rate of reaction would be 4 ÷ 10 = **0.4 mol/s**

Or, if 40g of a **reactant** was used up during 10 seconds, the average rate of reaction would be 40g ÷ 10 = **4 g/s**

Or, if 50 cm^3 of **product** was made during 25 seconds, the average rate of reaction would be $50cm^3$ ÷ 25 = **$2cm^3/s$**

5.6.1.3 Collision theory and activation energy



A catalyst provides an alternative **reaction pathway**

→ that has a lower **activation energy**

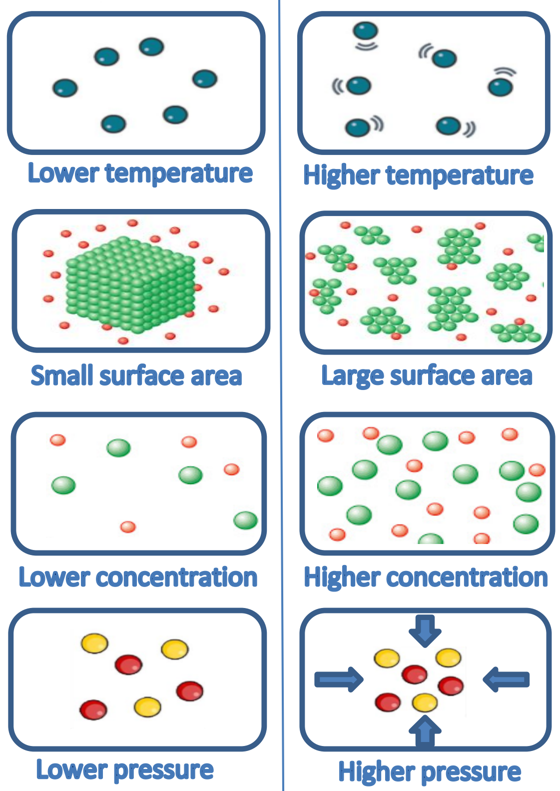
→ does not change the frequency of collisions

→ does increase the frequency of successful collisions

→ more particles have energy greater than the activation energy

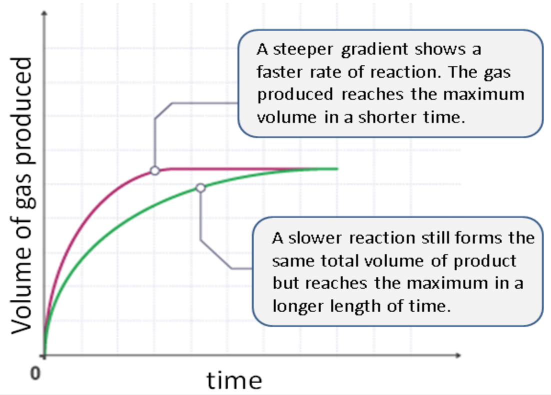
→ therefore more successful collisions

5.6.1.2 Factors affecting rates of reactions



Less chance of reactant particles colliding

More chance of reactant particles colliding



5.6.1.4 Catalysts

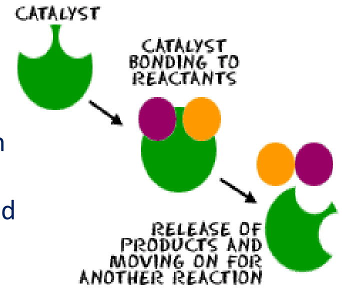
A **catalyst** is a substance that:

- **speeds up** the rate of a reaction
- **does not alter the products** of the reaction
- **not chemically changed or used up** at end of reaction
- Is **only needed in small masses**

❖ Not all reactions have suitable catalysts.

Enzymes act as catalysts in biological systems..

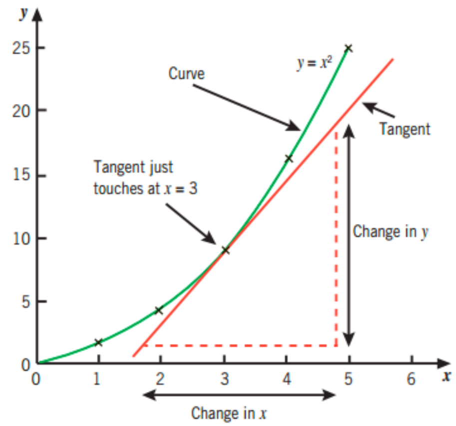
Catalysts are not included in the chemical equation for reaction as they are not used or produced in it.



5.6.1.2 Calculating gradient of a graph

For **straight** line: Draw a **triangle** against the line, divide the vertical measurement by the horizontal to get the rate of reaction.

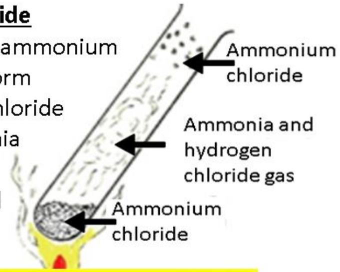
For a **curve**, draw a **tangent** against the line.



5.6.2.1 Reversible Reactions A

Heating ammonium chloride

When heated, white solid ammonium chloride decomposes to form ammonia and hydrogen chloride gas. When cooled, ammonia and hydrogen chloride react to form a white solid of ammonium chloride:

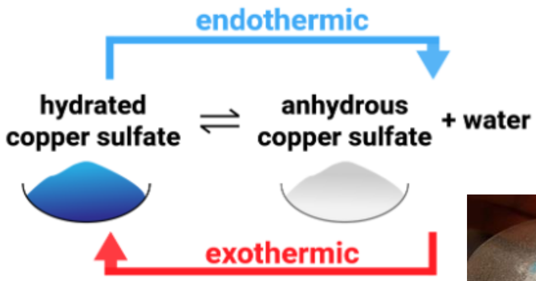


$$NH_4Cl \rightleftharpoons NH_3 + HCl$$

Knowledge Organiser – 5.6 The Rate & Extent of Chemical Change

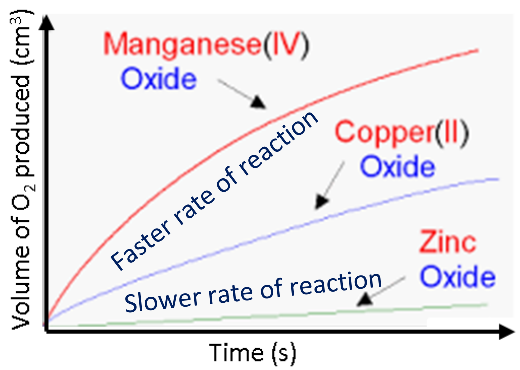
5.6.2.2 Energy changes and reversible reactions

The **reaction** between **anhydrous** copper(II) sulphate and water is used as a test for water.
The white solid turns blue in the presence of water.



Testing different catalysts

Manufacturers can try different catalysts for reactions to find the one that forms the products the quickest, therefore making more profit. The results of a trial of 3 metals salts that act as catalysts for the decomposition of H_2O_2 are below.



5.6.2.3 Equilibrium

If a reversible reaction takes place in a closed system (where no reactants can enter and no products can escape), the forwards and backwards reaction reach a state of **equilibrium**, they occur at exactly the same rate.

<u>Example of a reversible reaction:</u>
Nitrogen gas is reacted with hydrogen gas to make ammonia gas. The forward reaction (making ammonia) is **exothermic**.

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

The backwards reaction (making nitrogen and hydrogen gas is **endothermic**).

The equilibrium position is:
- ➢ to the left if the concentrations of N_2 and H_2 are greater than the concentration of NH_3
- ➢ to the right if the concentration of NH_3 is greater than the concentrations of N_2 and H_2

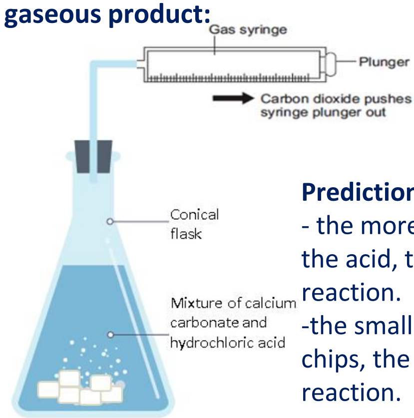
5.6.2.4 The effect of changing conditions on equilibrium (HT Only)

<u>Le Chatelier's principle</u>
The equilibrium position can be changed by changing the reaction conditions through:
- changing the **pressure**
- changing the **concentration**
- changing the **temperature**

The system will respond to counteract the change.

❖ Industry uses this principle regularly to increase the amount of product they make (for the best profits!).

RPA Finding the rate of reaction by volume of a gaseous product:

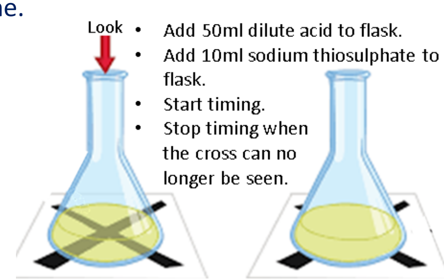


Prediction
- the more concentrated the acid, the faster the reaction.
-the smaller the marble chips, the faster the reaction.

The reaction is complete when no more gas is being produced.

Hazard	Possible harm	Possible precaution
Hydrochloric acid	Causes skin and eye irritation	Wear eye protection
Fizzing in the reaction mixture	Acidic spray or foam may damage skin and eyes	Use a large conical flask so there is plenty of space inside; do not look over the top when adding the calcium carbonate

RPA: Finding the rate of reaction by turbidity.
Sodium thiosulfate solution reacts with dilute hydrochloric acid. The **sulfur** produced forms a cloudy yellow-white **precipitate** during the reaction. The time taken for this to achieve a given cloudiness provides a way to measure the reaction time.



Prediction – the reaction is faster if the reactants are hotter or more concentrated.

Knowledge Organiser – 5.6 The Rate & Extent of Chemical Change

More details for Higher Tier - If a system is at equilibrium and a change is made to any of the conditions (temperature, concentration, pressure), then that system will respond to counteract the change. This is called **Le Chatelier's Principle.**

Changing the concentration, temperature and pressure of a reaction system can make a big change to where the equilibrium lies, and industry uses this principle regularly to increase the amount of product they make (for the best profits!).

5.6.2.5 Effect of changing concentration on equilibrium (HT Only)

Changing concentration

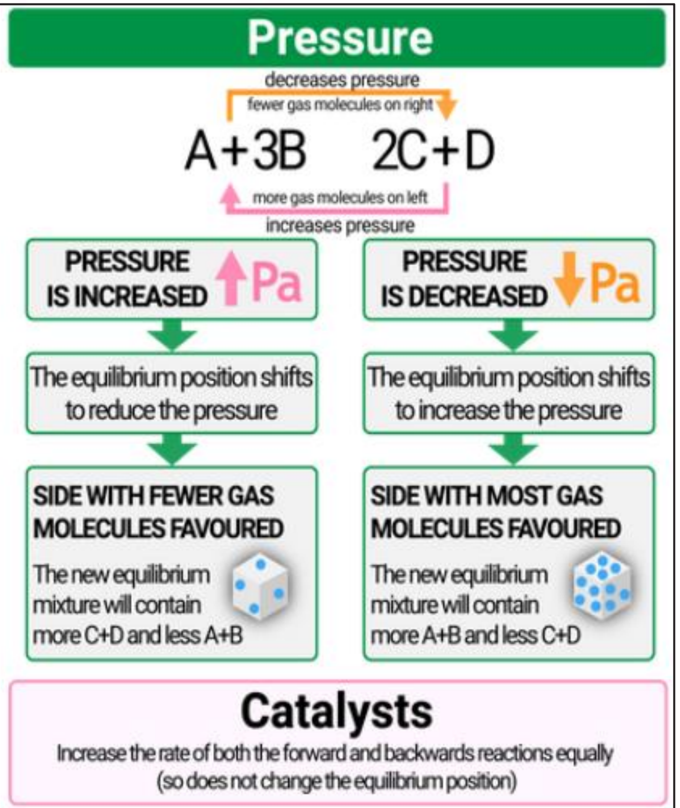
if you add more reactant, the equilibrium will shift to the right to reduce the concentration of reactant (and make more product)

if you remove some of the product, the equilibrium will shift to the right to increase the concentration of the product

5.6.2.5 Effect of changing pressure on equilibrium (HT Only)

Changing pressure

If you increase the pressure then the equilibrium will shift to reduce it (by favouring which ever side of the reaction has the fewest molecules of gas)

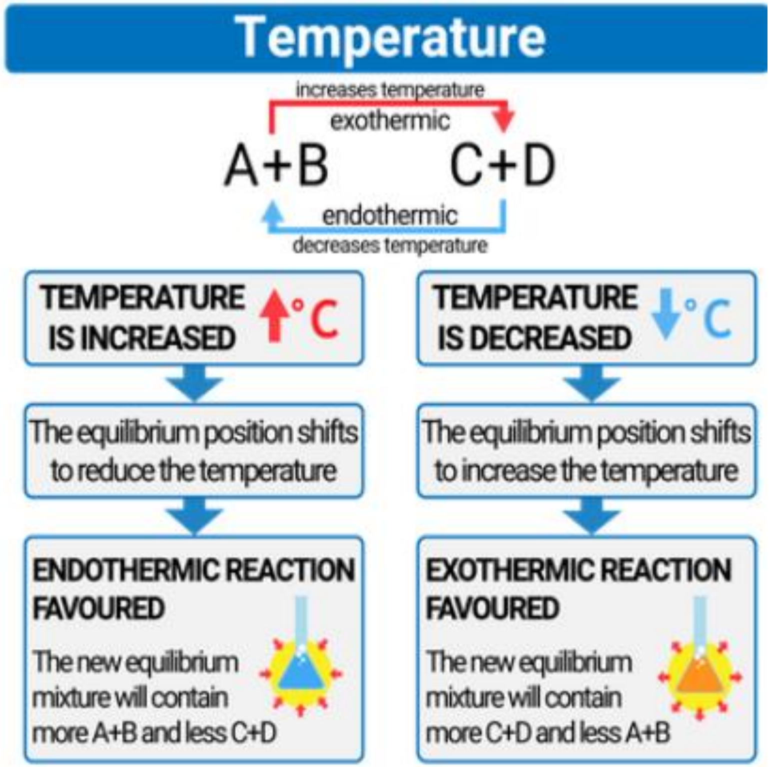


5.6.2.5 Effect of changing temperature on equilibrium (HT Only)

Changing temperature

If the temperature is increased then the equilibrium position will shift to reduce the temperature (so will favour the endothermic reaction)

If the temperature is decreased then the equilibrium position will shift to increase the temperature (so will favour the exothermic reaction)



Knowledge Organiser – 5.7 Organic Chemistry

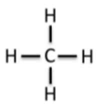
4.3.1.1 Crude oil & hydrocarbons

- **Hydrocarbons** are **compounds** that contain hydrogen and carbon **atoms** only.
- **Crude oil** is a **finite** resource that is found in the Earth's crust. It is the remains of **organisms** that lived and died millions of years ago - mainly plankton which was buried in mud.
- Crude oil is a complex **mixture** of hydrocarbons. The carbon atoms in these molecules are joined together in chains and rings.
- Crude oil is an important source of **fuels** such as petrol, diesel, kerosene, heavy fuel oil and liquefied petroleum gases, & **feedstock** for the petrochemical industry

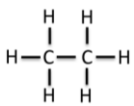
4.3.1.1 Alkanes C_nH_{2n+2}

- Saturated hydrocarbons
- contain H and C atoms
- Single covalent bonds between carbon atoms
- Majority of compounds in crude oil are alkanes

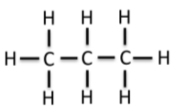
methane CH_4



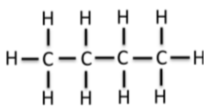
ethane C_2H_6



propane C_3H_8

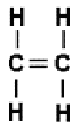


butane C_4H_{10}



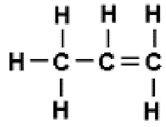
4.3.1.1 Alkenes CnH2n

- Unsaturated hydrocarbons
- Contain H and C
- A double covalent bond between some carbon atoms so they are more reactive.
- Formed from alkanes during **cracking.**



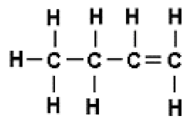
ethene

C_2H_4



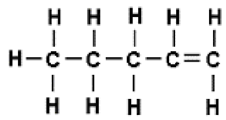
propene

C_3H_6



butene

C_4H_8



pentene

C_5H_{10}

5.7.1.2 Petrochemical industry

Petrochemical: a substance made from crude oil using chemical reactions

Solvent: The liquid in which the solute dissolves to form a solution.

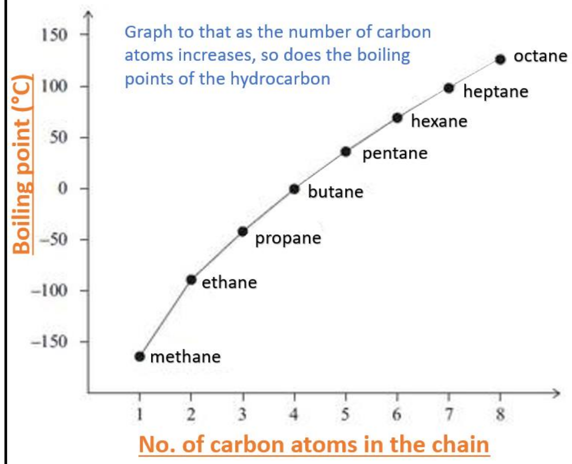
Lubricant: A lubricant is anything which reduces the friction between two surfaces.

Detergent: A mixture of chemicals which have cleaning properties when dissolved in water, and are able to dissolve grease.

Feedstock: A raw material used to provide reactants for industrial reactions.

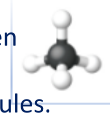
Polymer: A large molecule formed from many identical smaller molecules known as monomers.

5.7.1.3 Properties of Hydrocarbons: Alkenes

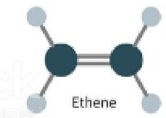


5.7.1.4 Cracking & Alkenes

Hydrocarbons can be broken down (cracked) to produce smaller, more useful molecules.



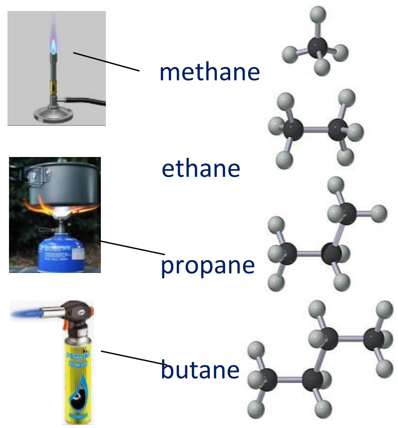
Cracking products include alkanes and an alkene.



There is a high demand for small molecules and so some of the products of cracking are useful as fuels.

5.7.1.3 Properties of Hydrocarbons: Alkanes

- If a substance is **more** viscous it is thick and sticky. Solids are most viscous.
- If a substance is **less** viscous, it is easier to pour. Gases are least viscous.



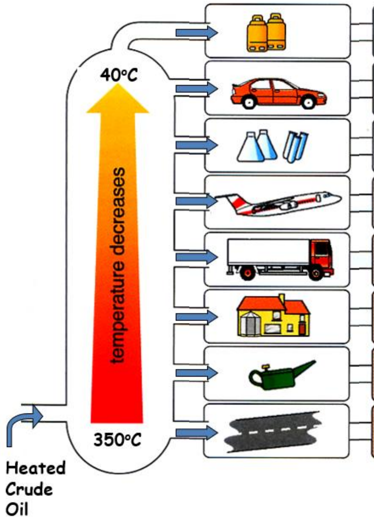
The more carbons there are in the chain, the more **viscous** the hydrocarbon. It becomes thicker. Its **viscosity** increases.

The fewer carbons there are in the chain, the more **volatile** the hydrocarbon is, therefore the easier it is to **ignite**. Its **flammability** increases.

- **Flammability** is measure of how **easy the hydrocarbon is to ignite and burn.**
- Small hydrocarbons such as methane are more **volatile**. This means they **evaporate easily**.
- This means that they **turn into a gas at a lower temperature** and can **ignite easily**

Knowledge Organiser – 5.7 Organic Chemistry

5.7.1.2 Fractional Distillation

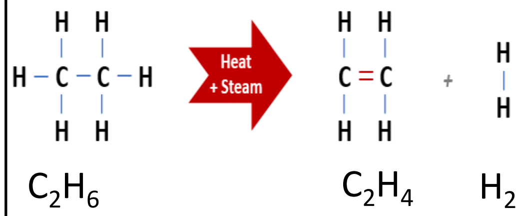


Fraction	Boiling pt.	C atoms in chain
Liquid petroleum gas	< 25°C	3
Petrol (gasoline)	25 - 60°C	8
Naphtha	60 - 180°C	10
Paraffin	180 - 220°C	12
Diesel	220 - 250°C	20
Fuel oil	250 - 300°C	40
Lubricating oil	300 - 350°C	80
Bitumen	> 350°C	120

Fractional distillation works because the **different liquids have different boiling points.** When the mixture is heated:

- **vapours rise** through a column which is hot at the bottom, and cooler at the top
- 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 to be collected

5.7.1.4 Steam Cracking



C_2H_6 → C_2H_4 + H_2

Uses a temperature of approx. 550°C and no catalyst

5.7.1.4 Thermal Decomposition

Example

$C_{10}H_{22} \xrightarrow[\text{catalyst}]{800°C} C_2H_4 + C_3H_6 + C_5H_{12}$

Decane → Ethene + Propene + Pentane

Used to make plastics (polymers) Polyethene / polypropene

Used in petrol

As a large molecule is broken into smaller ones using heat, this is another example of a thermal decomposition reaction.

5.7.1.4 Testing for double bonds

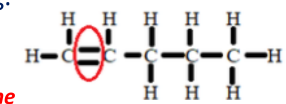
This is the way to test for a double C=C bond in a molecule.

$C_2H_4(g)$ $Br_2(aq)$ $C_2H_4Br_2(aq)$

Ethene gas is added to **bromine water**.
The bromine water is **yellow/ orange** at the start.
When it reacts with ethene is turns **colourless**.

The double **covalent** bond in the ethene opens up to join with the bromine atoms from the bromine water.

This test works with **any** hydrocarbon that has a **double bond** e.g.



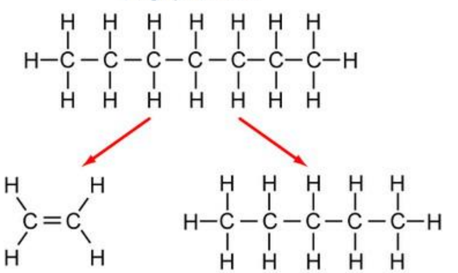
Pentene

5.7.1.4 Equations for Cracking

Hexane can be cracked to form butane & ethene:

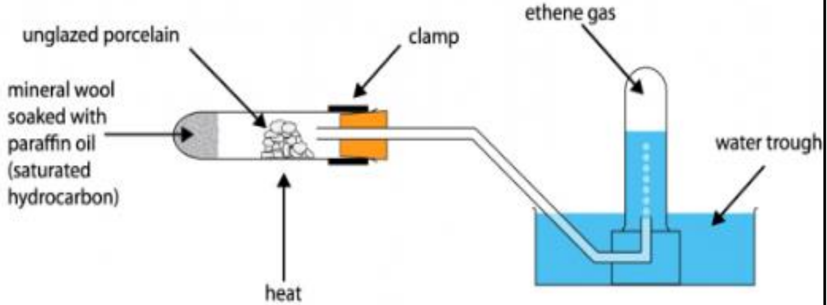
Word Equation: hexane → butane + ethane

Symbol Equation: $C_6H_{14} \rightarrow C_4H_{10} + C_2H_4$

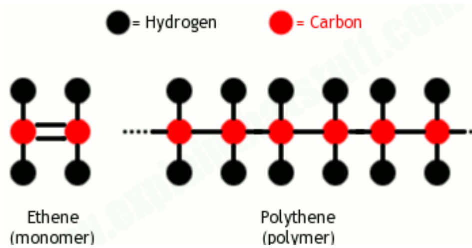


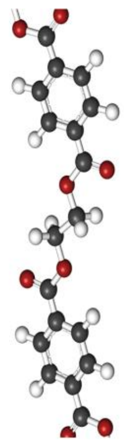
5.7.1.4 Catalytic Cracking

Uses a temperature of approx. 550 °C and a **catalyst** known as a zeolite which contains aluminium oxide and silicon oxide.



5.7.1.4 How plastics are made





Polymers, whether artificial (such as the plastic shown) or natural, are made of repeating chains of smaller chemical units (**monomers**).

Knowledge Organiser – 5.8 Chemical analysis

5.8.1.1 Pure substances

- In chemistry a **pure** substance contains only one type of element or one type of compound.
  - Example: pure water only contains H_2O.
- **Pure** substances **melt and boil** at specific **temperatures** which can be used to **identify** a substance and test if it is pure.
- In everyday life, a **pure** substance is something that has had nothing else added to it and is in its **natural** state.
  - Example: 'pure' orange juice is not chemically pure but doesn't have any chemicals added that aren't from oranges..

5.8.1.2 Formulations

A **formulation** is a mixture that has been **designed** as useful **product**.

Many products are **complex** mixtures in which each chemical has a particular purpose.

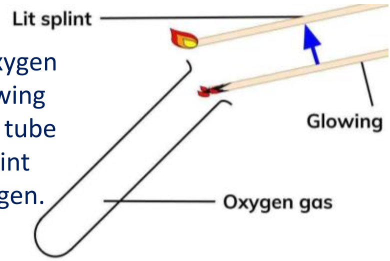
All the ingredients must be mixed in the right quantities so the product has the correct properties.

For example: Fuels, medicine, paint

5.8.2 Identification of common gases

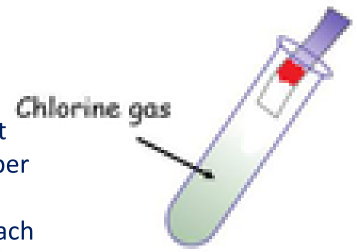
Oxygen

The test for oxygen is to put a glowing splint in a test tube of gas. The splint relights in oxygen.



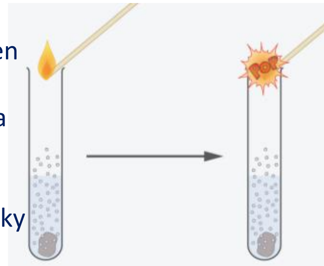
Chlorine

The test for chlorine is to put damp litmus paper in the gas. The chlorine will bleach the paper white.



Hydrogen

The test for hydrogen is to put a burning splint at the end of a test tube of gas. Hydrogen burns rapidly with a squeaky pop.



Carbon dioxide

The test for carbon dioxide is to bubble the gas through limewater (calcium hydroxide). The limewater will turn milky (cloudy).

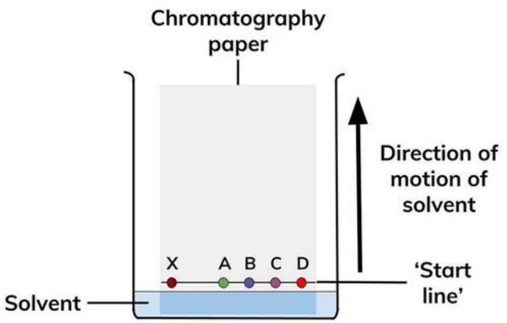
5.8.1.3 Chromatography

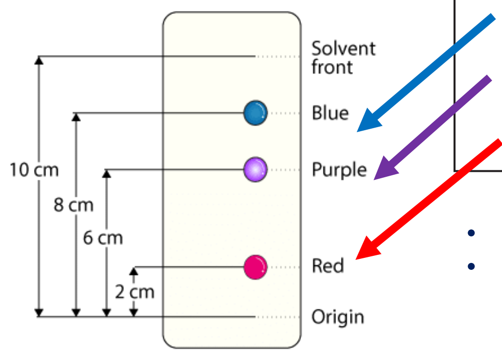
- Chromatography **separates** mixtures and can **identify** substances.
- Two phases are used:
  1. The **mobile** phase (moves) is the **solvent**.
  2. The **stationary** phase (doesn't move) is the paper.
- Separation depends on the distribution between phases. **The more soluble a substance is, the more time it spends in the mobile phase.**
- The R_f **value** is a ratio of how far the substance has travelled with regard to the solvent.

$$Rf = \frac{\text{distance travelled by the component}}{\text{distance travelled by the solvent}}$$

- Each **pure substance has a unique R_f value in each solvent which can identify it.**

RPA : Chromatography





- The start line must be drawn in pencil because ink will run.
- The solvent must start below the line otherwise your substances will leech into the solvent.

R_f of blue spot = $\frac{8}{10} = 0.8$

R_f of purple spot = $\frac{6}{10} = 0.6$

R_f of red spot = $\frac{2}{10} = 0.2$

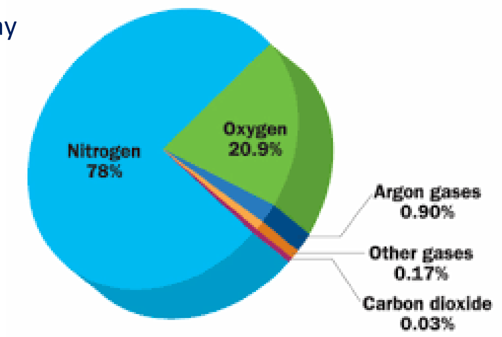
- R_f must between 0 and 1.
- In an exam you may be asked to measure these so have a ruler and measure to the nearest mm!

Chromatography can identify what substances are in a mixture.

Knowledge Organiser – 5.9 Chemistry of the atmosphere

5.9.1.1 Proportion of different gases in the atmosphere

The **atmosphere** today has remained in the same proportions for 200 million years.



5.9.1.3 How oxygen increased

Algae and plants produced the oxygen now present in the atmosphere through **photosynthesis**.

This started 2.7 billion years ago and oxygen has steadily increased allowing more plants and animals to evolve.

5.9.1.1 How carbon dioxide decreased

There are **4** main reasons carbon dioxide **decreased**:

1. **Plants and algae** used CO_2 in **photosynthesis** to produce **oxygen**.

$$6CO_2 + 6H_2O \xrightarrow{\text{Sunlight}} C_6H_{12}O_6 + 6O_2$$

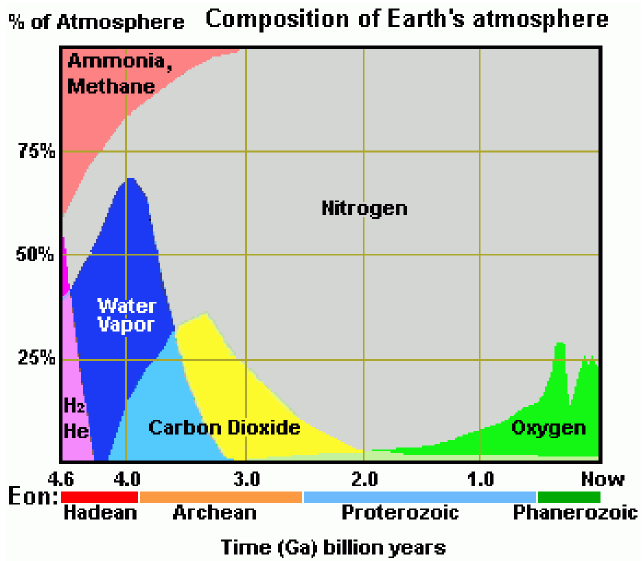
Carbon Dioxide, Water → Glucose (Energy), Oxygen

2. CO_2 was used up in the **formation of fossil fuels** (however, we are letting it back out!)
3. CO_2 is trapped when **sedimentary rocks formed**.
4. CO_2 **dissolved** in the newly formed **oceans.**

5.9.1.2 The Earth's early atmosphere

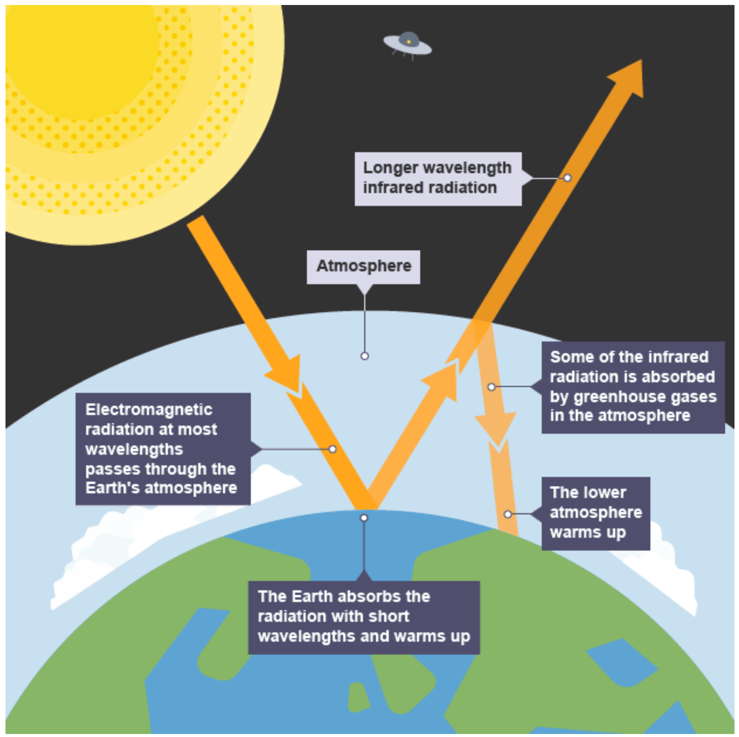
There are several theories about what was in the **early atmosphere** because we are looking 4.6 billion years ago. The main theory suggests:

- Initially a large amount of **volcanic** activity released gases to form the early atmosphere
- These gases were a mixture of mainly **carbon dioxide** and **water** with some **nitrogen**, **methane** and **ammonia**.
- Water vapour then **condensed** to form oceans.



5.9.2.1 Greenhouse gases

Greenhouse gases keep temperatures on Earth high enough to support life. The 3 main gases are **CO_2, methane and water vapour**.



5.9.2.2 Human activities which contribute to an increase in greenhouse gases in the atmosphere

Humans are increasing the levels of CO_2 and methane.

- **Carbon dioxide** can be increased through **burning fossil fuels** and **deforestation**.
- **Methane** levels can be increased by **mass livestock farming** and **rice farming**.

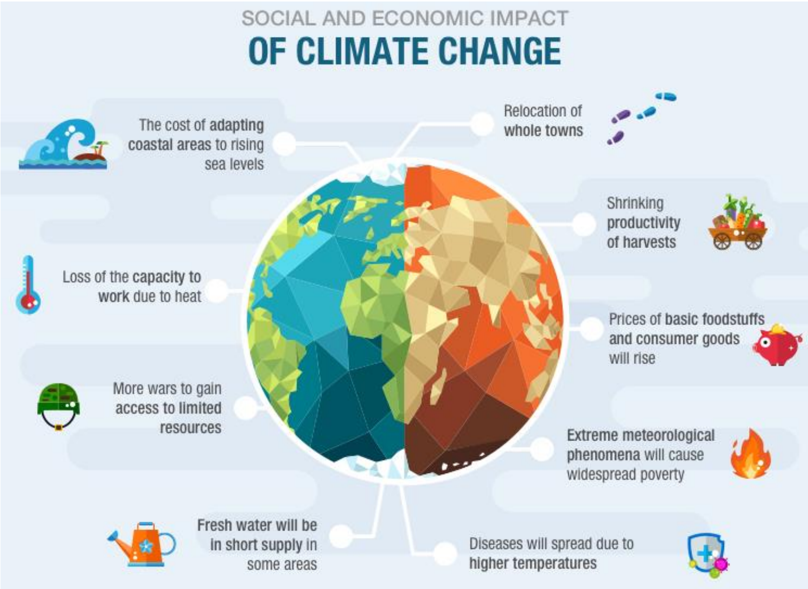
To know the fact from fiction about global warming we must look at **peer-reviewed articles**.
Simplified models can often be misrepresented in the media or maybe **biased**.

Knowledge Organiser – 5.9 Chemistry of the Atmosphere

5.9.2.3 Global Climate Change

An increase in average global temperatures is a major cause of **climate change**. Climate change could cause:

- **Melting ice** which could cause rising sea levels and flooding.
- **Ocean acidification** which could damage sea life.
- **More extreme weather** which could lead to housing damage, wildfires, droughts, flooding etc.
- **Changing climate temperatures** could mean different crop seasons and migrating species.



5.9.2.4 The carbon footprint and its reduction

The **carbon footprint** is the total amount of **CO_2** and other greenhouse gases **emitted** over the **full life cycle** of a product, service or event. To reduce a carbon footprint you need to reduce the amount of CO_2 and methane you produce.

Find out yours → https://footprint.wwf.org.uk/#/

5.9.3.1 Atmospheric pollutants and their sources

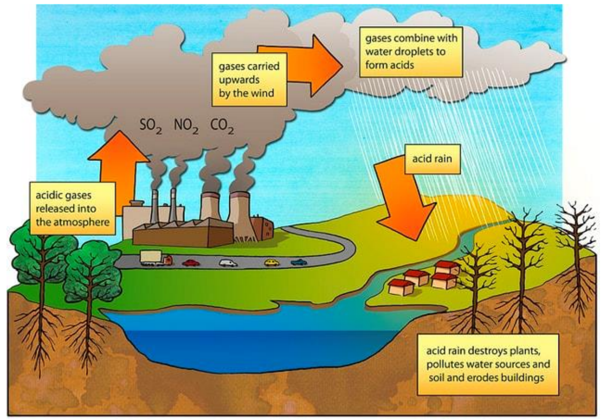
Most **pollutants** come from **combusting fuels**.

Products released can be **CO_2, H_2O, carbon monoxide, sulphur dioxide, and nitrogen oxides**.

Fuels may also produce solid **particulates** of carbon (soot).

5.9.3.2 Properties and effects of atmospheric pollutants

Product	Carbon monoxide	Sulphur dioxide and nitrogen oxides	Particulates
Problem ?	Colourless, odourless, toxic gas.	Cause acid rain and respiratory problems.	Cause global dimming and health problems.



Knowledge Organiser – 5.10 Using resources

5.10.1.1 Using the Earth's resources

Humans use the Earth's resources to provide **warmth, shelter, food and transport**. Natural resources provide **food, timber, clothing, and fuels**.
Finite (non-renewable) resources are processed to provide **energy and materials**. These include **fossil fuels** and **metals**.
Renewable resources can provide **energy** and **materials** as well. These include **solar power** and **sustainable crop growth**.

5.10.1.3 Waste water

Urban life and **industry** produces a lot of **waste water**. This water must be treated (**cleaned**) before going back into the environment.

- **Sewage waste** requires removal of **organic matter** and **harmful microbes**. This treatment includes:
  - **Screening** and **grit removal**.
  - **Sedimentation** to produce sewage **sludge** and **effluent**.
  - **Anaerobic** digestion of sewage **sludge**.
  - **Aerobic** biological treatment of **effluent**.
- **Industrial** waste require removal of **organic matter** and **harmful chemicals**.

5.10.1.2 Potable water

Water is **essential** for life. Humans need water with **low levels** of dissolved **salts** and **microbes**. **Safe** water is called **potable water** (**not** the same as **pure** water. In the UK **rain** collects in **lakes and rivers**. Potable water is produced by:

- Choosing the right body of **fresh** water.
- Passing the water through **filter beds**.
- **Sterilising** using **chlorine**, **ozone**, or **UV** light.

If there isn't much fresh water, **sea water** can be **desalinated** by **distillation** or **reverse osmosis** but this takes a lot of **energy**.

Potable water RPA

This practical involves **testing** a sample of water then **purifying** the sample.
Step 1: To analyse the water, you use **universal indicator** to test the **pH** of 10 cm^3 of the water samples. You then evaporate **10 cm^3** of the samples and record the **mass** of **solids** that were **dissolved** in the water.
Step 2: Distilling the water. Set up the distillation equipment and **gently boil** the water. Collect the distilled water in a **cooled tube**. Test the **purity** of this water by finding the **boiling point.**

5.10.2.1 Life cycle assessments

Life cycle assessments (LCAs) are done to assess the environmental impact of products in each of the following stages:

- **Extracting** and **processing** raw materials.
- **Manufacturing** and **packaging**.
- **Use** and **operation** during its lifetime.
- **Disposal** at the end of its useful life, including **transport** and **distribution** at each stage.

It's easy to put numbers on the use of **water, resources, energy** sources, and some **waste** production. However, it is less easy to giving numbers to **pollutant effects**, so it is down to **judgement**.
This means that LCA is **not** a purely objective process, there is a **little guesswork**.

LCAs can be used to **evaluate** a product but **companies** may **leave parts out** to give a **misleading** representation for **advertising** (**biased**)

5.10.2.2 How to reduce resource use

By using less limited materials, the impact on the environment can be reduced. There are three ways to lessen environmental impact:

✓ Reduce use of limited resources. Metals, glass, building materials, clay ceramics and most plastics come from limited raw materials. The fuels for the processes come from limited resources. Mining from the Earth causes environmental impact.

✓ Reuse. Some products, such as glass bottles, can be reused. Glass bottles can be crushed and melted to make different glass products. Other products cannot be reused so are recycled.

✓ Recycle. Metals, plastics, glass and other materials can be melted and recasted into new products meaning no new materials are needed. Some materials need a lot of separation.

Knowledge Organiser – 5.10 Using resources

Comparative LCAs
Used to evaluate which of two alternative products will have a lower negative impact on the environment. For example, we can compare plastic carrier bags and paper carrier bags:

Life cycle stage	Plastic carrier bags	Paper carrier bags
Raw materials	Crude oil is a finite resource; fractional distillation, cracking and polymerisation all require a lot of energy.	Can be made from recycled paper, or from trees. Making paper from trees requires more energy than recycling paper, but much less than making plastics.
Manufacture	Cheaper to make large quantities of bags from plastic.	More expensive to make bags from paper because the handles must be glued on.
Use	Lower impact on the environment because plastic bags are usually stronger so they can be reused many times.	Relatively short lifetime; can only be reused a limited number of times.
Disposal	Can sometimes be collected and recycled; if disposed of as litter, they do not biodegrade; in landfill, may take decades or centuries to degrade.	Can be recycled easily; if disposed of in landfill, they biodegrade quickly.

Biological methods of metal extraction (HT)
The Earth's supply of metal **ores** is limited. Eg, high-grade copper ores are becoming harder to find and mine. There are some alternative methods to extract **metals** from low-grade copper ores that use living **organisms**.
These have advantages and disadvantages compared to the usual **extraction** methods.

Phytomining
Plants absorb **mineral ions** through their **roots**. **Phytoextraction** makes use of this:

- plants are grown on a **low-grade ore**
- the plants **absorb metal ions** through their roots and **concentrate** these ions in their **cells**
- the plants are **harvested** and **burnt**
- the **ash** left behind contains **metal compounds**

Phytoextraction is slow but it:

- reduces the need to obtain **new ore** by **mining**
- **conserves** limited supplies of **high-grade ores**
- reduces the amount of **rock waste** that must be disposed of after **traditional** mining
- Can be used to "clean up" industrial wastelands

Bioleaching
Certain **bacteria** can break down **low-grade ores** to produce an **acidic solution** containing **copper ions**. The solution is called a **leachate** and the process is called **bioleaching**.

Bioleaching does **not need high temperatures** but it produces **toxic substances**, including **sulfuric acid**, which damage the **environment**.

Processing the metal compounds
Iron is **more reactive** than copper. It can **displace copper** from the **leachate**. For example:

iron + copper sulfate → iron(II) sulfate + copper

$Fe(s) + CuSO4(aq) \rightarrow FeSO4(aq) + Cu(s)$

Since **iron is cheaper** than copper, the use of **scrap iron** is a **cost-effective** way to produce copper from the **leachate**.

Alternatively, the copper compounds can be **dissolved** and the solution **electrolysed** to produce **copper metal.**

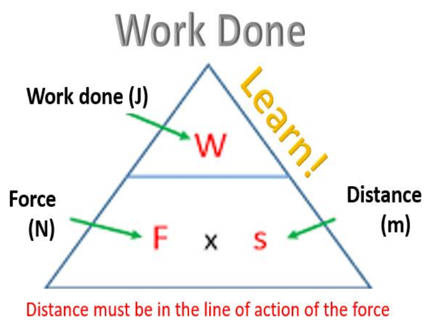
Knowledge Organiser – 6.1 Energy

joule (J) = unit of energy

6.1.1.1 Energy stores and systems

Energy store	Description	Examples
Magnetic	The energy stored when **repelling poles have been pushed closer** together or when **attracting poles have been pulled further apart.**	Fridge magnets, compasses, maglev trains which use magnetic levitation.
Internal (thermal)	Total kinetic and potential energy of the particles in an object, eg **the vibrations - also known as the kinetic energy - of particles**. In **hotter objects, the particles have more internal energy** & vibrate faster.	Human bodies, hot coffees, stoves or hobs. Ice particles vibrate slower, but still have energy.
Chemical	The energy **stored in chemical bonds**, such as those between molecules.	Foods, muscles, electrical cells.
Kinetic	Energy of a **moving object**.	Runners, buses, comets.
Electrostatic	The energy stored when **repelling charges have been moved closer together** or when attracting charges have been pulled further apart.	Thunderclouds, Van De Graaff generators.
Elastic potential	The energy stored when an **object is stretched or squashed**.	Drawn catapults, compressed springs, inflated balloons.
Gravitational potential	The energy of an **object at height**.	Aeroplanes, kites, mugs on a table.
Nuclear	The energy stored in the **nucleus of an atom.**	Uranium nuclear power, nuclear reactors.

- When a **force** causes a body to move, work is being done on the object by the force.
- Work is the measure of energy transfer when a force (*F*) moves an object through a distance (*d*).
- When work is done, **energy** has been transferred from one energy store to another.
- Therefore Energy transferred = work done



Quantity	Unit
Current	A
Energy	J
Mass	kg
Power	W
Time	s
Temp	°c
Height	m
Velocity	m/s
Extension	m
Spring constant	N/m
Force	N
Gravitational field strength	N/kg
Specific heat capacity	J/kg°C

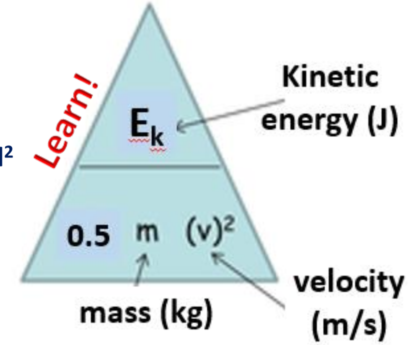
6.1.1.2 Changes in energy

Kinetic energy of a moving object can be calculated using the equation:

kinetic energy = 0.5 × mass × speed²

$E_k = \frac{1}{2} m v^2$

- kinetic energy, *Ek*, in joules, J
- mass, *m*, in kilograms, kg
- speed, *v*, in metres per second, m/s

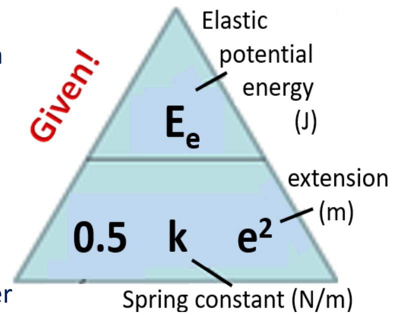


Elastic potential energy stored in a stretched spring can be calculated using the equation (assuming the limit of proportionality has not been exceeded:

elastic potential energy = 0.5 × spring constant × extension²

$E_e = \frac{1}{2} k e^2$

- elastic potential energy, *Ee*, in joules, J
- spring constant, *k*, in newtons per metre, N/m
- extension, *e*, in metres, m

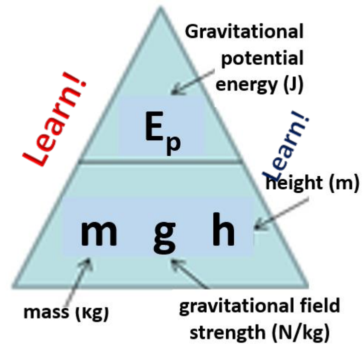


Gravitational potential energy gained by an object raised above ground level can be calculated using the equation:

g.p.e. = mass × gravitational field strength × height

Ep =mgh

- gravitational potential energy, *Ep*, in joules, J
- mass, *m*, in kilograms, kg
- gravitational field strength, *g*, in newtons per kilogram, N/kg
- height, *h*, in metres, m



Gravitational field strength is 9.8N/kg on Earth.
(g will be given in the exam).

Knowledge Organiser – 6.1 Energy

6.1.1.3 Energy changes in systems

The amount of energy stored in or released from a system as its temperature changes can be calculated using the equation:

change in thermal energy = mass × specific heat capacity × temperature change

$$\Delta E = m\,c\,\Delta\theta$$ **Given!**

- change in thermal energy, ΔE, in joules, J
- mass, m, in kilograms, kg
- specific heat capacity, c, in joules per kilogram per degree Celsius, J/kg °C
- temperature change, $\Delta\vartheta$, in degrees Celsius, °C

Specific heat capacity

- This is the amount of energy needed to raise the temperature of 1kg of a material by 1°C

$E = m \times c \times \Theta$

Energy (J)

Mass (kg)

Specific heat Capacity (J / kg °C)

Change in temperature (°C)

6.1.1.4 Power

Power is defined as the rate at which energy is transferred or the rate at which work is done.

- power, P, in watts, W
- energy transferred, E, in joules, J
- time, t, in seconds, s
- work done, W, in joules, J

An energy transfer of 1 joule per second is equal to a power of 1 watt

$$\text{power (W)} = \frac{\text{work done (J)}}{\text{time taken (s)}}$$

$$\text{power (W)} = \frac{\text{energy transferred (J)}}{\text{time taken (s)}}$$

Learn!

Example

Two electric motors are used to lift a 5 N weight through a vertical height of 6 m.
Motor A does this in 5 seconds.
Motor B does this in 10 seconds.

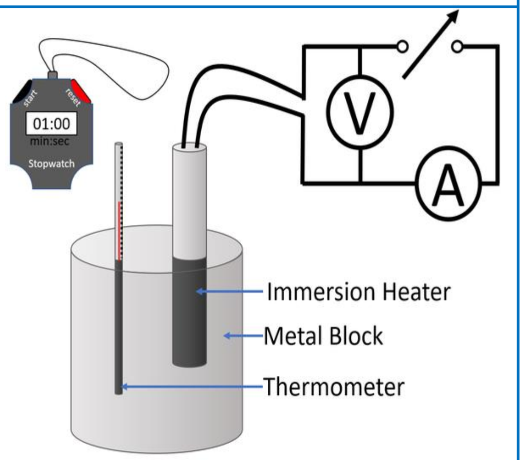
For both motors the work done is:
W = F x d = 5N x 6m = 30J

For motor A: $P = \frac{W}{t} = \frac{30J}{5s} = \underline{6W}$

For motor B: $P = \frac{W}{t} = \frac{30J}{10s} = \underline{3W}$

Motor B is twice as powerful as motor A.

RPA: an investigation to determine the specific heat capacity of one or more materials. The investigation involve linking the decrease of one energy store (or work done) to the increase in temperature and subsequent increase in thermal energy stored



Method:
1. Place the immersion heater into central hole at top of block.
2. Place the thermometer into smaller hole and add drops of oil into the hole to ensure thermometer is surrounded by hot material.
3. Fully insulate the block by wrapping it loosely with cotton wool.
4. Record the temperature of the block.
5. Connect the heater to the power supply and turn it off after ten minutes. After ten minutes the temperature will still rise even though the heater has been turned off and then it will begin to cool.
6. Record the highest temperature that it reaches and calculate the temperature rise during the experiment.

Improving accuracy:
- Place the metal block on a heatproof mat to reduce the thermal energy lost to the table surface by conduction.
- Wrap the metal block in a thermal insulator to reduce the thermal energy lost to the air.
- Place the electronic balance on a flat, level surface to get an accurate reading of the mass.

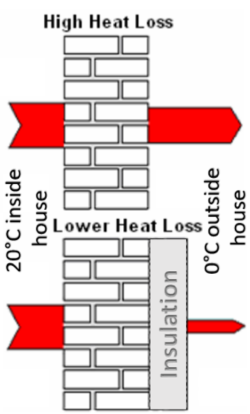
Improving precision:
- Use a data logger rather than a thermometer to reduce the random error & add more decimal places.
- Ensure the immersion heater and block begin at room temperature to reduce the error in repeat readings.
- Ensure the same thickness and type of insulator is used for every repeat measurement reduce anomalies.

Knowledge Organiser – 6.1 Energy

6.1.2.1 Energy transfers in a system

Energy cannot be created or destroyed, only transformed from one form to another (**Law of conservation of energy**).
"**Work done**" is another way of describing energy transfer.

- where there are energy transfers in a **closed system**, there is **no net change to the total energy.**
- In all system changes energy is dissipated, so that it is stored in less useful ways. This energy is often described as being 'wasted'.
- Unwanted energy transfers can be reduced, eg. through lubrication and the use of thermal insulation.
- The higher the thermal conductivity of a material the higher the rate of energy transfer by conduction across the material.



The rate of cooling of a building is affected by the **thickness** and **thermal conductivity of its walls.**
Higher thermal conductivity = higher rate of energy transfer = house cools down quicker.

6.1.2.2 Efficiency

$$\frac{\text{Useful energy output}}{\text{total energy input}} \times 100\%$$

Learn!

OR

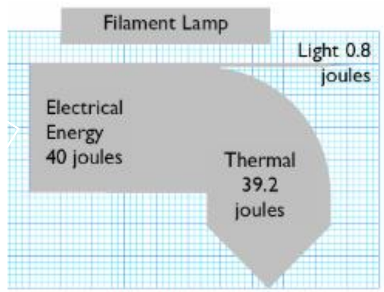
$$\frac{\text{Useful power output}}{\text{total power input}} \times 100\%$$

Efficiency can be represented as a decimal or percentage. It has to be <100% (or <1.0) as all energy transfers involve wasted energy.

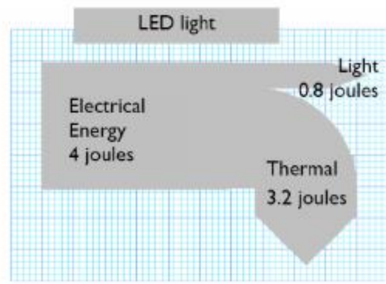
In a closed system there is no net change to the total energy

Total IN = total OUT

Increase efficiency by insulating or streamlining/ lubricating to reduce friction.



$\frac{0.8}{40} \times 100 = 2\%$

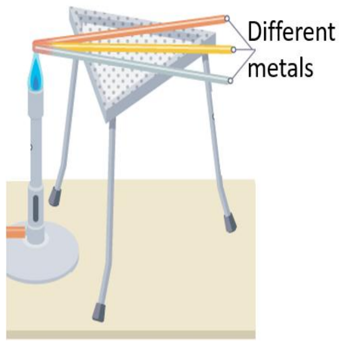


$\frac{0.8}{4} \times 100 = 20\%$

The LED is 10 x more efficient than the filament lamp

Investigate thermal conductivity using rods of different materials (NOT RPA)

Whichever rod gets hottest first at the other end is the best conductor. The material that **heats the quickest** is said to have a higher thermal conductivity



6.1.3 National and Global energy resources

- Main energy resources available for use on Earth include: fossil fuels (coal, oil and gas), nuclear fuel, biofuel, wind, hydro-electricity, geothermal, the tides, the Sun and water waves.
- A **renewable energy** resource is one that is **being** (or can be) **replenished** as it is used.
- A **Non-renewable energy** source **cannot be replaced** after it has been used. It is **finite**
- The uses of energy resources include: transport, electricity generation and heating.

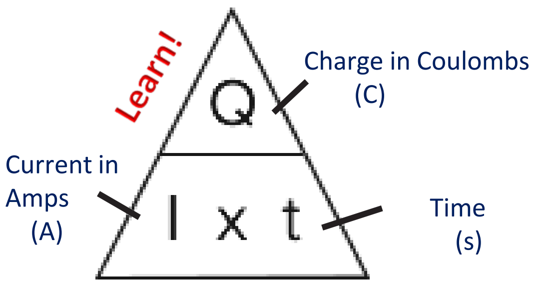
	Positives	Negatives
Fossil fuel (coal/oil/gas)	Reliable, cheap to run and mine	Finite, atmospheric pollution (CO_2, SO_2, NO_x)
Nuclear	Reliable, No CO_2, lots energy released	Long-lasting toxic waste, finite
Wind	Infinite, free, no atmospheric pollution	Unreliable (not always windy), visual pollution, costly to build, sometime noisy
Sun	Infinite, free, put on buildings/ in fields	Costly to set up, pollution from batteries
Geothermal	Infinite, free, no atmospheric pollution	Products from ground may contain toxic elements
Tidal	Barrages reduce flooding eg Thames, free, no pollution, reliable(2 tides/day)	Disturb ecology and shipping lanes, costly to build
Biofuel	Can be regrown, cheap, carbon neutral	Use up land that could grow food/ livestock
Hydroelectricity	No atmospheric pollution, free	High rainfall needed, floods valleys therefore habitats/ villages destroyed
Water Waves	No atmospheric pollution, free	Disturb ecology and shipping lanes, costly to build, unreliable (sea does not always have waves)

Knowledge Organiser – 6.2 Electricity

6.2.1.2 Electrical charge and current

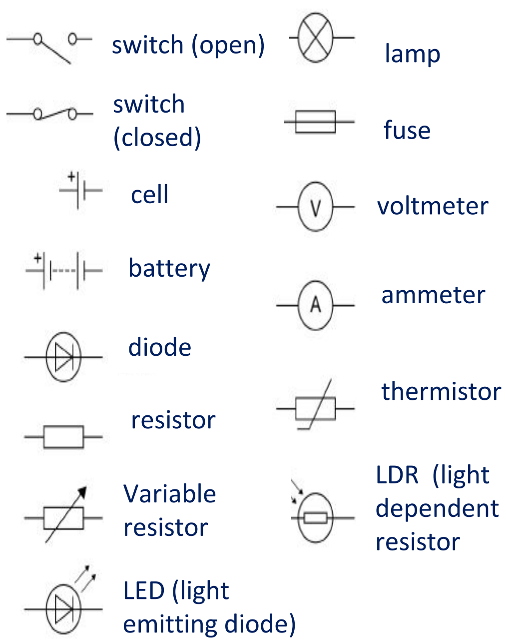
Electric current is a flow of electrical charge.
Size of current is **rate of flow of electrical charge**.

Charge flow, current and time are linked by the equation:
charge flow = current × time



- Current has **same value at any point in a single closed loop**.
- Measured with **Ammeter**

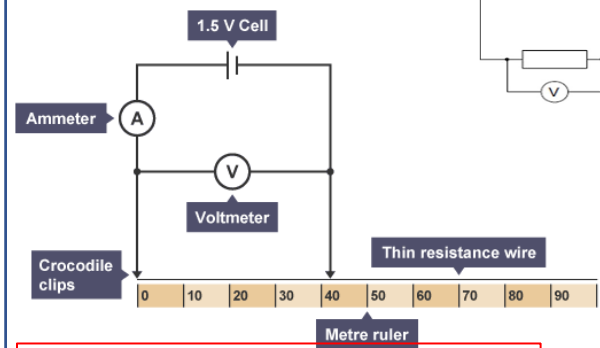
6.2.1.1 Standard circuit diagram symbols



RPA: use circuit diagrams to set up and check appropriate circuits to investigate the factors affecting the resistance of electrical circuits.

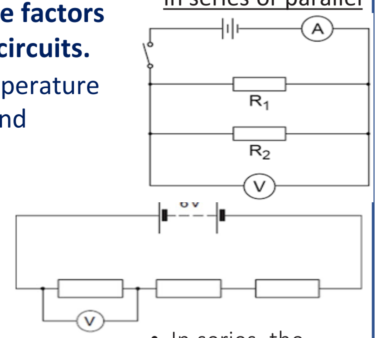
- the length of a wire at constant temperature
- combinations of resistors in series and parallel.

IV: Length of a wire



Hazard	**Consequences**	**Control measures**
Heating of wires	Minor burns	Set up circuit before closing the switch

IV: resistors in series or parallel



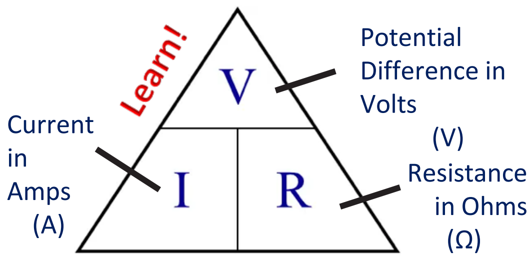
- In series, the resistance of the network is equal to the sum of the other resistances.
- In parallel, the resistance of the network is less than either of the other resistances.

6.2.1.3 Current, resistance and potential difference

- **Potential difference** is the amount of work energy required to move an electric charge (Coulomb) from one point to another
- Current (*I*) through a component depends on the **resistance** (*R*) of the component and the **potential difference** (*V*) **across the component**.
- The **greater the resistance** of the component the **smaller the current for a given potential difference (pd) across the component**.
- Measured with **Voltmeter**
- **Voltmeter must be connected in parallel**

Current, **potential difference** and **resistance** can be calculated using the equation:

potential difference = current × resistance



Resistance

- **Metal atoms (ions)** in a **wire have delocalised electrons** which are free to move and **carry the charge**.
- **Electrons moving** around the circuit **collide with the ions**.
- This is called **resistance**.

Units of resistance = ohms, Ω

Components with high resistance often **get hot** (e.g. filament lamp).

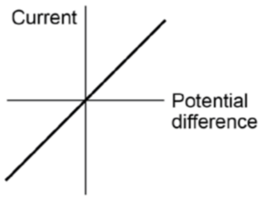
- **Electrons colliding** with the ions **transfer energy** as **heat** and **light**.
- **Causes the ions to vibrate more, increasing** the **resistance** even more.
- This makes it harder for the electrons to pass through without collisions.

E.g. What is the resistance of a component if 12 V causes a current of 2 A through it?
R = V / I = 12V / 2A = 6Ω

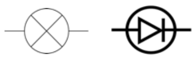
Knowledge Organiser – 6.2 Electricity

6.2.1.4 Resistors

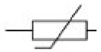
- **Current through an ohmic conductor** (at a constant temperature) is **directly proportional to the potential difference** across the resistor.
- **Resistance remains constant as the current changes.**

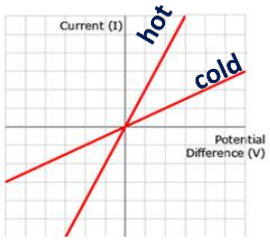


- **Resistance of components such as lamps, diodes, thermistors** and **LDRs** is **not** constant; it **changes with the current through the component**.
- SEE RPA

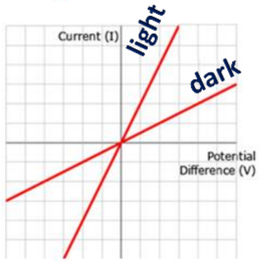


- **Resistance of a thermistor decreases as the temperature** increases.
- Low temperature = High resistance
- Used in heat activate fire alarms and thermostats





- **Resistance of an LDR decreases** as **light intensity increases**
  Low light levels = high resistance.
- An **LDR** can be used in lights that come on when it's dark.



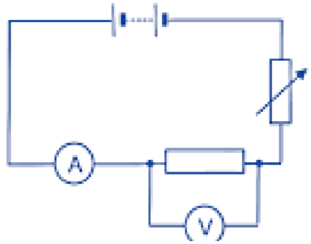
Unit	symbol
Potential difference	V
Current	A
Energy	J
Work done	J
Charge	C
Time	s
Power	W
Resistance	Ω

<u>**Charge**</u> is a property of a body which experiences a force in an electric field. **Charge** is measured in **coulombs** (C).

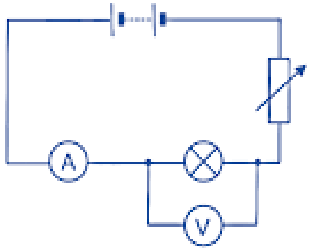
Since electrons are so small and one electron will not have much of an effect anywhere, it is more useful to refer to packages of electrons. <u>One coulomb of charge</u> is a package equivalent to 6,250,000,000,000,000,000 electrons.

<u>One volt</u> is the **potential difference when one coulomb** of **charge** transfers one **joule** of energy.

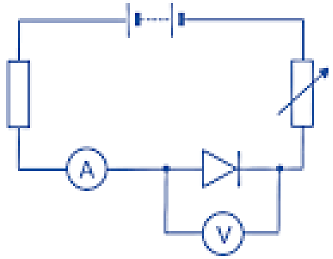
RPA: use circuit diagrams to construct appropriate circuits to investigate the I–V characteristics of a variety of circuit elements, including a filament lamp, a diode and a resistor at constant temperature



The current through a **resistor** at constant a constant temperature is <u>directly proportional</u> to the potential difference across the resistor.



The resistance of a **bulb** <u>increases</u> as the temperature of the filament increases.



The current through a **diode** flows <u>in one direction.</u> It has very <u>high resistance</u> in the opposite direction.

6.2.2 Series and Parallel circuits

For components connected in series:

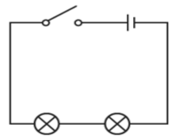
- same **current (A)** through each component
- total **potential difference (V)** of the power supply is **shared between components**
- total resistance of two components is the sum of the resistance of each component.

  *R*total = *R*1 + *R*2 resistance, *R*, in ohms, Ω

For components connected in parallel:

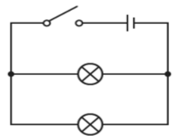
- **potential difference** across each component is the **same**
- **total current** through the whole circuit is **sum of the currents** through the separate components
- **total resistance** of **two resistors is less** than the **resistance** of the **smallest individual resistor.**

Series



	A	V
Series	Same	Shared
Parallel	Shared	Same

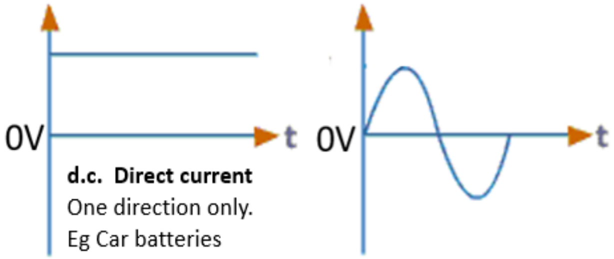
Parallel



Knowledge Organiser – 6.2 Electricity

6.2.3 Domestic uses and safety

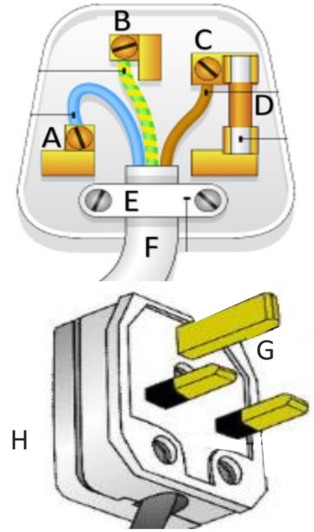
6.2.3.1 Direct and alternating potential difference



d.c. Direct current
One direction only.
Eg Car batteries

a.c. Alternating current
In the UK, electricity has a p.d. of 230V & a frequency of 50Hz (it changes direction 50 times a second).

6.2.3.2 Mains electricity



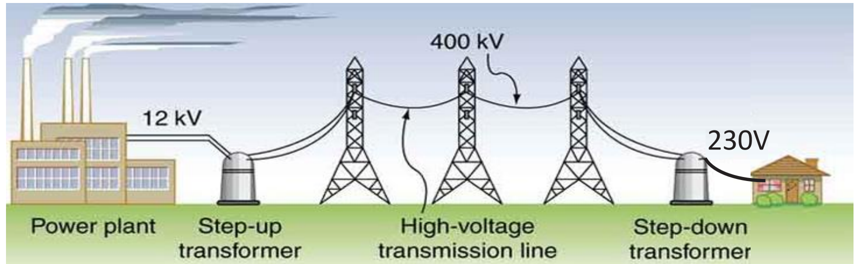
A= neutral wire, close to 0V.
B= earth wire, 0V, only carries current if there's a fault, stops appliance becoming live.
C= live wire, 230V between earth and live.
D= Fuse, internal wire melts when current is too big so breaks the circuit.

E= cable grip
F= three-core cable, copper wire = flexible and good conductor, plastic coating.
G= brass pins, hard wearing, good conductor
H= plastic casing is an insulator

- a live wire may be dangerous even when a switch in the mains circuit is open
- It is dangerous to provide any connection between the live wire and earth.

6.2.4 Energy Transfers

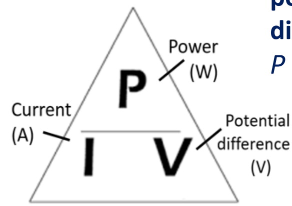
6.2.4.3 The National Grid



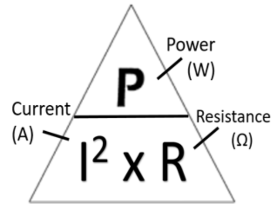
- Network of cables and transformers linking power stations to consumers
- Step-up transformers = higher potential difference
- Reduced energy loss because resistance is lower in cables (high volts = fewer amps for same power)
- Step-down transformers = decrease potential difference to safe level for domestic use (about 230V in UK)
- Underground cables protected from bad weather but get damaged by diggers in building projects

E.g. What is the potential difference between two points if 5 C of charge shifts 10 J?
V= E/Q
= 10J / 5C
= **2 volts**

6.2.4.1 Power



power = potential difference × current
$P = V I$

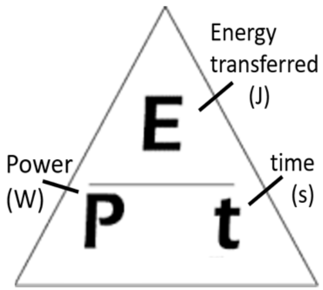


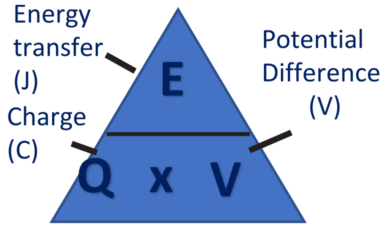
power = current² × resistance
$P = I^2 R$

- power, P, in watts, W
- potential difference, V, in volts, V
- current, I, in amps, A
- resistance, R, in ohms, Ω

6.2.4.2 Energy transfers in everyday appliances

- The rate at which energy is transferred by an appliance is called the **power**.
- Also known as "**work done**" by the components in the circuit when charge flows.
- The energy transferred by an appliance depends on how long it is switched on for and the power of the appliance.





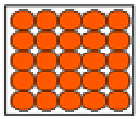
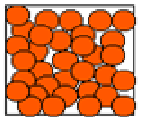
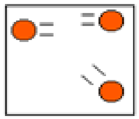
- energy transferred, E, in joules, J
- power, P, in watts, W
- time, t, in seconds, s
- charge flow, Q, in coulombs, C
- potential difference, V, in volts, V

Knowledge Organiser – 6.3 Particle model of matter

6.3.1.1 Density of materials

The particle model can be used to explain the different states of matter differences in density.

Calculation	Equation	Symbol equation	Units
Density	Density = $\frac{\text{mass}}{\text{volume}}$	$\rho = \frac{m}{v}$	Density = kg/m^3 Mass = kg Volume = m^3

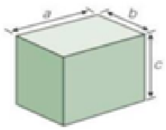
Solid	Liquid	Gas
Particles closely packed - vibrate - Little energy - Very strong forces of attraction	Particles touching, - Move past each other - Some energy - Relatively strong forces of attraction	Particles very far apart - Move very fast - Lots of energy - Weak forces of attraction
		

Key Terms	Particle Model of Matter Definitions
condensation	A change of state in which gas becomes liquid by cooling.
energy	The capacity for doing work
evaporation	The process in which a liquid changes state and turns into a gas.
freeze	A change of state in which liquid becomes solid by cooling.
Internal energy	The total kinetic energy and potential energy of the particles in an object. Heating changes the energy stored within the object by increasing the energy of the particles that make up the system.
Kinetic energy	Energy which an object possesses by being in motion
Melting	The process that occurs when a solid turns into a liquid when it is heated
Specific heat capacity	The amount of energy needed to raise the temperature of 1 kg of substance by 1°C
Specific latent heat	The amount of energy needed to melt or vaporise 1 kg at its melting or boiling point
Sublimation	When a solid turns straight into a gas on heating, without becoming a liquid first, or when a gas turns straight into a solid, without becoming a liquid.
Temperature	How warm or cold something is
Thermal energy	Scientific term for heat energy

RPA: Measuring volume of irregular objects and calculating density

Method 1: Regular solid volume

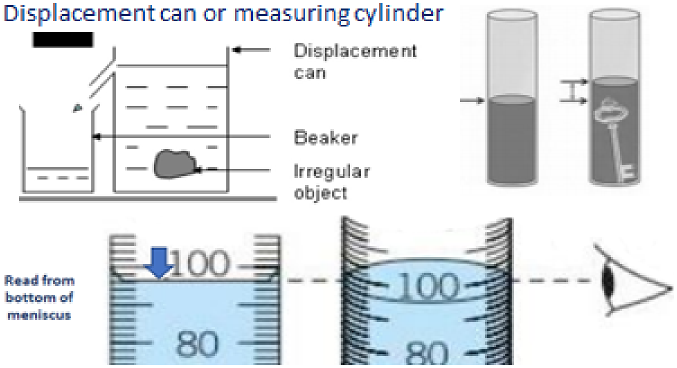
Length x width x height



Sphere: $\frac{4}{3}\pi(\frac{d}{2})^3$

Method 2: Stone or other irregular shaped object volume

Displacement can or measuring cylinder

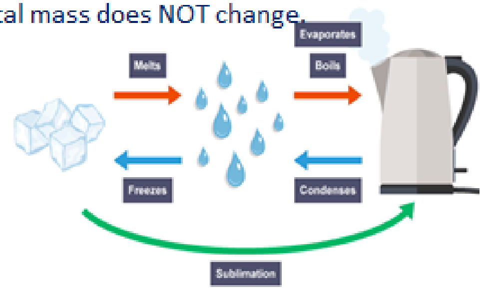


Measure mass of object and then use density equation.

6.3.1.2 Changes of State

Conservation of mass

- The number of particles does not change during a change of state, only their spacing and arrangement.
- Total mass does NOT change.



- Change of state is **physical**.
- The material **recovers its original properties** if the change is reversed.

6.3.1.3 Internal Energy

- **Internal Energy:** Energy is stored inside a system by the particles that make up the system. Internal energy is the **total kinetic energy** and **potential energy** of **all the particles** that make up a system.
- Heating **increases** the energy of the particles
- Either **raises the temperature** of the system **or produces a change of state.**

6.3.2.2 Temperature changes in a system and specific heat capacity

The change in temperature of a system depends on:

- the amount of **thermal energy** transferred to the system
- the mass of the substance
- the nature of the substance itself

change in thermal energy = mass × specific heat capacity x temperature change

$$\Delta E = mc\Delta\theta$$

Units Used:-

- change in thermal energy, ΔE, in joules, J
- mass, m, in kilograms, kg
- specific heat capacity, c,
- in joules per kilogram per degree Celsius, J/kg °C
- temperature change, $\Delta\theta$, in degrees Celsius, °C.

Knowledge Organiser – 6.3 Particle model of matter

6.3.2.3 Changes of heat and 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 **does not change the temperature.**
- **specific latent heat** of a substance is the amount of energy required to **change the state of one kilogram of the substance** with no change in temperature.

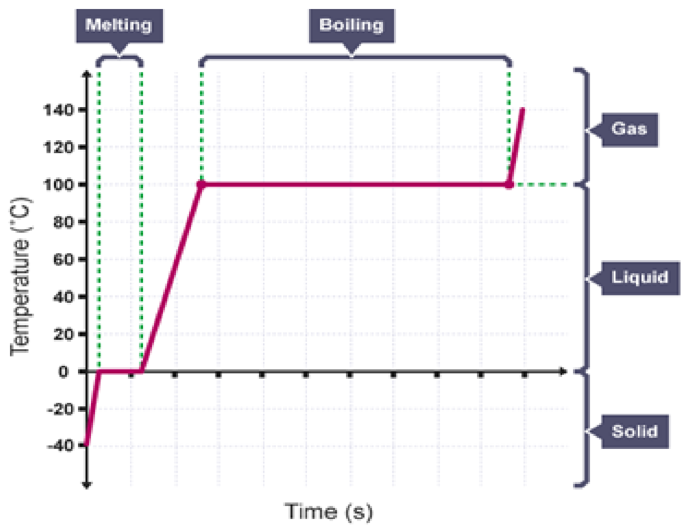
energy for a change of state = mass × specific latent heat

$$E = mL$$

- energy, E, in joules, J
- mass, m, in kilograms, kg
- specific latent heat, L, in joules per kilogram, J/kg
- **specific latent heat**, L, in joules per kilogram, J/kg

Specific latent heat of fusion – change of state from solid to liquid

Specific latent heat of vaporisation – change of state from liquid to vapour



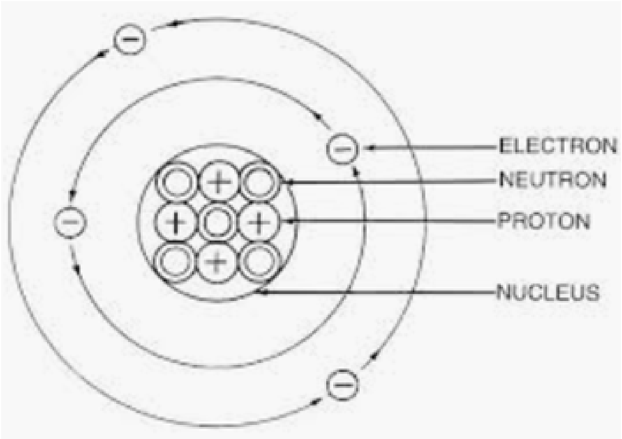
6.3.3.1 Particle motion in gases

- Molecules of gas in **constant random motion**
- **Temperature** of gas related to average **kinetic energy** of the molecules
- Changing the **temperature** of a gas, held at constant volume, changes the **pressure** exerted by the gas

Knowledge Organiser – 6.4 Atomic Structure

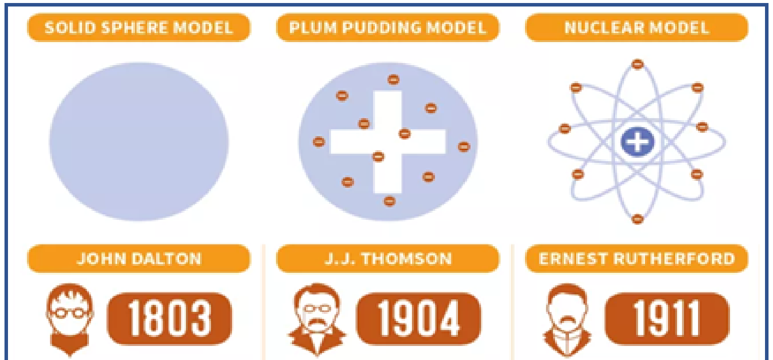
6.4.1.1 The structure of an atom

Atoms are very small, having a radius of about **1 x 10^{-10} metres.** They make up all of the matter around us. The basic structure of an atom consists of a **positively charged nucleus** composed of **protons** and **neutrons** surrounded by **negatively charged electrons.**



The electrons are arranged at different distances from the nucleus known both as **shells** and **energy levels.** They are the represented by the circles around the nucleus on the diagram.

Electron arrangements can change with **absorption** of electromagnetic radiation or **emission** of electromagnetic radiation.

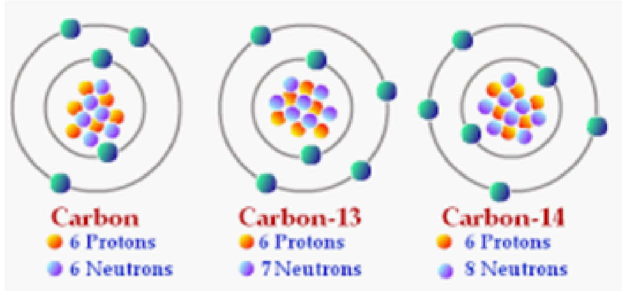


6.4.1.2 Mass number, atomic number and isotopes

The numbers on the periodic table are called the **mass number** and the **atomic number.**
The atomic number (proton number): Smaller number, tells you the number of protons are in an atom of that element. There will be the same number of electrons as protons.
Mass number: larger number, tells you how many neutrons and protons combined are in that atom.
Calculate neutrons by taking away the atomic number from the mass number.

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

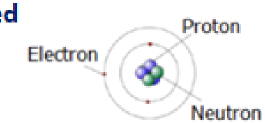


Isotopes: Versions of same element (same number of protons) with **different numbers** of **neutrons** in their nuclei.
Atoms turn into **positive ions**, if they lose one or more outer electron(s)

6.4.1.3 The development of the model of the atom

- **Experimental evidence** may lead to a scientific model changing over time. Atoms were originally thought to have been **solid spheres of matter.**
- The **discovery** of the **electron** led to the **plum pudding model** which suggested a **positive ball of charge** containing negative particles.

- Rutherford's **alpha particle scattering** experiment (using gold leaf) led to the conclusion that the **mass of an atom** was **concentrated** with **a positively** charged **nucleus.**
- This **nuclear model replaced**
- the previous one.



- Niels Bohr adapted the nuclear model by suggesting that **electrons orbit the nucleus at specific distances.**
- Later experiments identified positive particles which were called **protons.**
- The experimental work of James **Chadwick** provided the evidence to show the existence of **neutrons within the nucleus.**

Sub-atomic particle	Mass	Charge	Position in Atom
Proton	1	+1	Nucleus
Neutron	1	0	Nucleus
Electron	$\frac{1}{2000}$	-1	Orbiting in shells

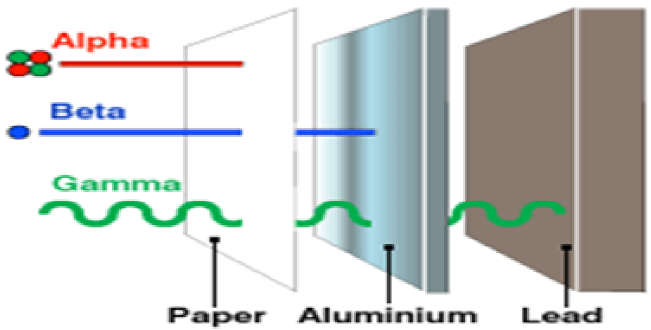
Knowledge Organiser – 6.4 Atomic Structure

6.4.2.1 Radioactive decay and nuclear radiation

Some atomic **nuclei** are **unstable,** radiation is given out and the nucleus becomes more stable. This is a **random process** called **radioactive decay.**

- **Alpha particles** consist of two neutrons and two protons (same as a helium nucleus)
- **Beta particles** consist of a high speed electron ejected from the nucleus as a neutron turned into a proton.
- **Gamma rays** are electromagnetic radiation form the nucleus.
- **Neutron** emission is a decay process where one or more neutrons are ejected from a nucleus. It can occur in nuclei that are neutron rich/proton poor. As only one or more neutrons are lost, the atom becomes a different isotope of the original element.

Each type of radiation has **a different range** and **penetration power;** Alpha has the **highest ionising power** although having the shortest range and is least penetrating.



- **Activity** is the rate at which a source of unstable nuclei decays.
- Activity is measured in **becquerel** (Bq)
- **Count-rate** is the number of decays recorded each second by a detector (e.g. Geiger-Muller tube).

6.4.2.2 Nuclear equations

Are used to represent radioactive decay.
Alpha decay causes both the mass and charge of a nucleus to decrease. $^{4}_{2}He$

Beta decay causes the charge to increase
But does not change the mass of the nucleus $^{0}_{-1}e$

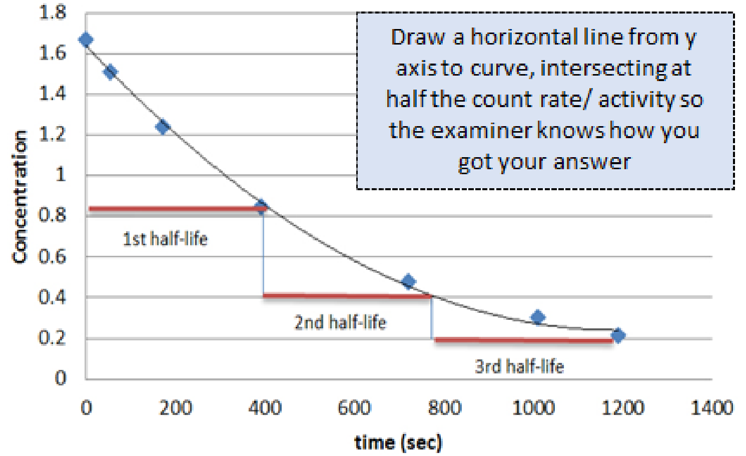
Gamma ray emission does not cause a change in the mass or charge of a nucleus.

$$^{235}_{92}U \xrightarrow[\text{an alpha particle}]{\text{decay by releasing}} {}^{4}_{2}\alpha + {}^{231}_{90}Th$$

$$^{14}_{6}C \xrightarrow[\text{an beta particle}]{\text{decay by releasing}} {}^{0}_{-1}\beta + {}^{14}_{7}N$$

$$^{235}_{92}U \xrightarrow[\text{a gamma wave}]{\text{decay by releasing}} {}^{0}_{0}\gamma + {}^{235}_{92}U$$

6.4.2.3 Half-lives and the random nature of radioactive decay



(HT Only) Calculating half life.
Question:
The half-life of cobalt-60 is 5 years. If there are 100 g of cobalt-60 in a sample, how much will be left after 15 years?
15 years is three half-lives so the fraction remaining will be $\left(\frac{1}{2}\right)^3 = \frac{1}{8} = 12.5g$

As a ratio of what was present originally compared to what was left, this would be 100:12.5 or 1:0.125

A **half-life** is either:-
- the time it takes for the number of nuclei of a radioactive isotope in a sample to halve

or
- the time is takes for the count rate from that sample to fall to half of its initial level.

6.4.2.4 Radioactive contamination

Irradiation: Exposing an object to **nuclear radiation**, the object **does not** become **radioactive** but it can still **damage cells.**

Irradiation	Contamination
Occurs when an object is exposed to a source of radiation outside the object	Occurs if the radioactive source is on or in the object
Doesn't cause the object to become radioactive	A contaminated object will be radioactive for as long as the source is on or in it
Can be blocked from the object with suitable shielding	Once an object is contaminated, the radiation cannot be blocked from the object
Stops as soon as the source is removed	It can be very difficult to remove all of the contamination

Radioactive Contamination: **Unwanted** presence of **materials** containing **radioactive atoms** on other materials.

Knowledge Organiser – 6.5 Forces

6.5.1.1 Scalar and vector quantities

Scalar quantities have **magnitude (size)** only.

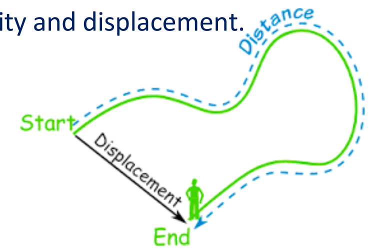
- Represented by a **number**.

Example: speed and distance.

Vector quantities have **magnitude** and **direction**.

- Represented by a **number** and an **arrow**.

Example: velocity and displacement.



6.5.1.2 Contact and non-contact forces

A **force** is a **push** or **pull** that acts on an object when it interacts with another object.

A force is a vector quantity.

- **Contact** forces – the objects are **touching** each other.
  Example: friction, air resistance, and tension.
- **Non-contact** forces – the objects are **separated**.
  Example: magnetic and gravitational force.

6.5.1.3 Gravity

Weight is the force acting on an object due to gravity.

This can be calculated by:

Weight (N) = **mass (kg)** x **gravitational field strength (N/kg)**

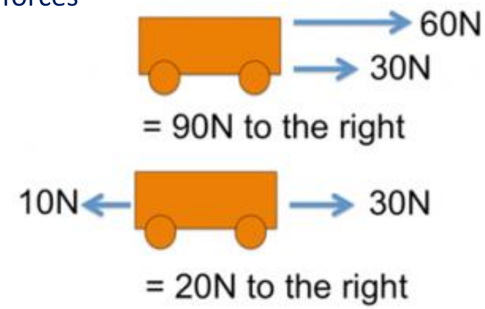
$$W = m \times g$$

The weight of an object acts at an object's '**centre of mass'**.

The weight and mass of an object are **directly proportional**.

Weight is measured using a **newtonmeter**.

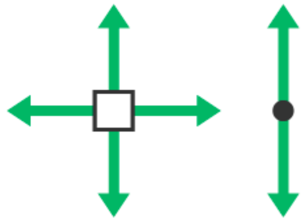
6.5.1.4 Resultant forces



Forces acting in **opposite** directions will leave behind an overall force called a **resultant** force.

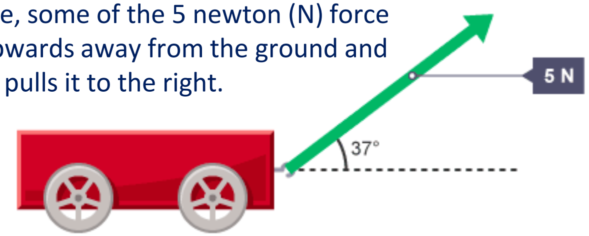
6.5.1.4 HT only

Free body diagram: models the forces acting on an object. The object or 'body' is usually shown as a box or a dot. The forces are shown as thin arrows pointing away from the centre of the box or dot.



Resolving forces: Two forces can be added together to find a resultant force. A single force can be resolved (broken down) into two component forces at right angles to each other.

In the diagram of a toy trailer below, when a child pulls on the handle, some of the 5 newton (N) force pulls the trailer upwards away from the ground and some of the force pulls it to the right.



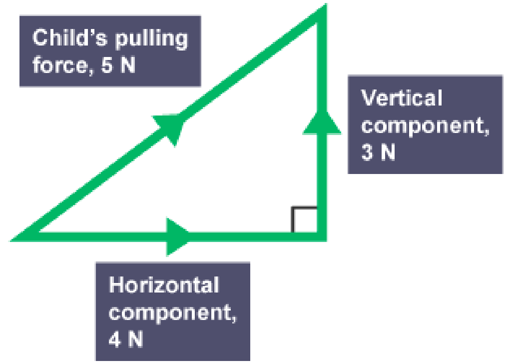
Vector diagrams: can be used to resolve the pulling force into a **horizontal component** acting to the **right** and a **vertical component** acting **upwards**.

Draw a right-angled triangle to scale, in which each side represents a force.

For the toy trailer example above, draw:

- a line representing the 5 N force at 37°
- a horizontal line ending directly below the end the first line
- a vertical line between ends of the two lines
- arrow heads to show the direction in which each force acts

Measure the lengths of the horizontal and vertical lines. Use the scale for the first line to convert these lengths to the corresponding forces.



Knowledge Organiser – 6.5 Forces

6.5.2 Work Done and Energy Transfer

When a **force** causes an object to move a **distance**, **work** is done on that object.

Work done (J) = **Force (N)** x **distance (m)**
W = **F** x **s**

- work done, *W*, in joules, J
- force, *F*, in newtons, N
- distance, *s*, in metres, m
- One joule of work is done when a force of one newton causes a displacement of one metre.
- 1 joule = 1 newton-metre

6.5.3 Forces and elasticity

- To change the shape of a stationary object (by stretching, bending or compressing), **more than one force has to be applied**
- 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)** x **extension (m)**
F = **k** x **e**

- Force, F, in newtons, N
- spring constant, k, in newtons per metre, N/m
- extension, e, in metres, m
- Also applies to the **compression** of an elastic object, where 'e' would be the compression of the object.

- A force that stretches (or 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.**

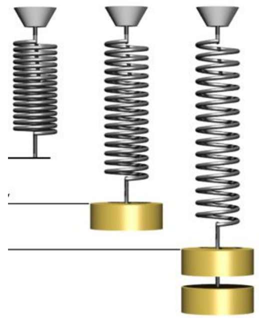
elastic potential energy = 0.5 × spring constant × extension²

$$1.E_e = \frac{1}{2} k e^2$$

RPA: Investigate the relationship between force and extension for a spring

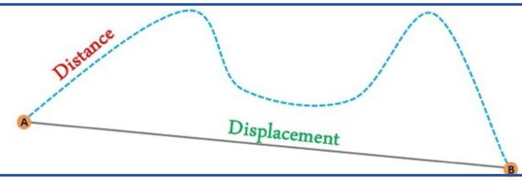
When a force acts on an **elastic** object, the object will extend a proportional amount until it is **permanently deformed** (won't return to original shape).

By **adding** more **weight** to a spring and measuring its **extension**; the extension of a spring can be found.
You may also have to use the equation in the equation sheet to find the elastic potential energy.



6.5.4.1.1 Distance and displacement

Displacement is how far an object moves in a straight line from start to finish**.** It is **vector**.
Distance is how far an object moves. It is **scalar**.



6.5.4.1.2 Speed

- Speed is a **scalar** quantity. The speed of moving objects often varies greatly.
- The typical speed of sound is 330 m/s.
- The speed at which a person can walk, run or cycle depends on many factors including: age, terrain, fitness and distance travelled.
- Typical values may be taken as:
  - walking- 1.5 m/s
  - running- 3 m/s
  - cycling- 6 m/s.

For an object travelling at a constant speed:

Speed (m/s) = **distance (m)** ÷ **time (s)**
v = **s** ÷ **t**

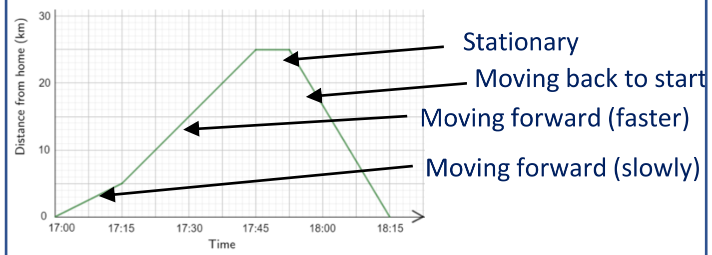
6.5.4.1.3 Velocity

Velocity is the **speed** in a **direction**.
It is a **vector**.

(HT only) Motion in a **circle** involves **constant speed** but **changing velocity**.

6.5.4.1.4 Distance-time relationship

- If an object moves along a straight line, the distance travelled can be represented by a distance–time graph.
- The speed of an object can be calculated from the gradient of its distance–time graph



(HT only) 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

Knowledge Organiser – 6.5 Forces

6.5.4.1.5 Acceleration

Average acceleration can also be calculated using:

Acceleration (m/s²) = change in velocity (m/s) ÷ time (s)

a = Δv ÷ t

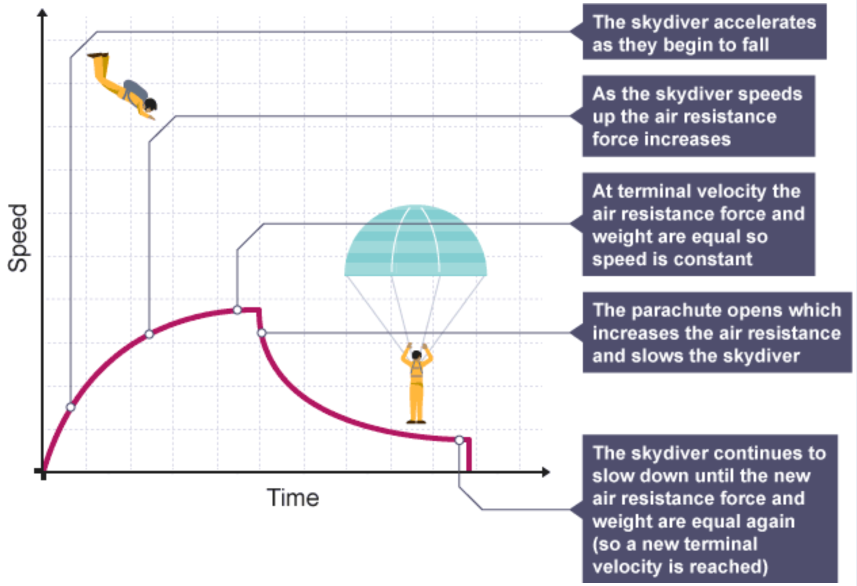
- acceleration, a, in **metres per second squared**, m/s2
- change in velocity, Δv, in **metres per second**, m/s
- time, t, in **seconds**, s

- An object that **slows down** is **decelerating**.
- The **acceleration** of an object can be calculated from the **gradient of a velocity–time** graph.

Uniform acceleration can also be calculated using:

$$(final\ velocity)^2 - (initial\ velocity)^2 = 2 \times acceleration \times distance$$

- final velocity, v, in metres per second, m/s
- initial velocity, u, in metres per second, m/s
- acceleration, a, in metres per second squared, m/s2
- distance, s, in metres, m



6.5.4.2.1 Newton's first law

An object will not move or change speed unless a force acts on it.

- A stationary object will stay **stationary**.
- A moving object will continue at a **constant speed**.

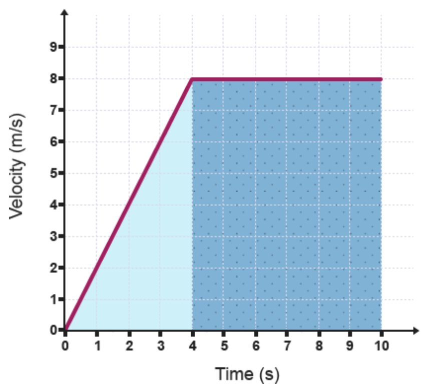
(HT only) The **tendency of an object to stay still** or stay at a **constant speed** is **inertia**.

6.5.4.2.3 Newton's third law

When two objects interact, the forces they exert on each other are **equal and opposite**.

6.5.4.1.5 Acceleration (HT Only)

HT only: The distance travelled by an object (or displacement of an object) can be calculated from the area under a velocity-time graph.



6.5.4.2.2 Newton's second law

The **acceleration** of an object depends on mass and force.

- If the mass **increases** and the force **stays the same**; the acceleration **decreases**.
- If the mass **stays the same** and the force **increases**; the acceleration **increases**.

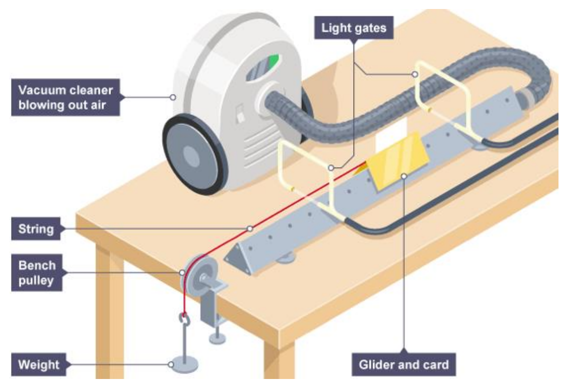
Force (N) = mass (kg) x acceleration

F = m x a

(HT only) **inertial mass:**

- measure of **how difficult it is to change the velocity** of an object
- the **ratio of force over acceleration**.

RPA investigate the effect of varying the force on the acceleration of an object of constant mass, and the effect of varying the mass of an object on the acceleration produced by a constant force.



Knowledge Organiser – 6.5 Forces

6.5.4.3.1 Stopping distance

The stopping distance of a vehicle is the sum of the drivers **reaction time** (**thinking distance**) and the **braking distance**.
Greater speed = greater stopping distance

6.5.4.3.2 Reaction time

Reaction times vary from person to person but are usually in the range of **0.2 s to 0.9 s**.

A drivers reaction time is affected by **tiredness, distractions, drugs** and **alcohol**.

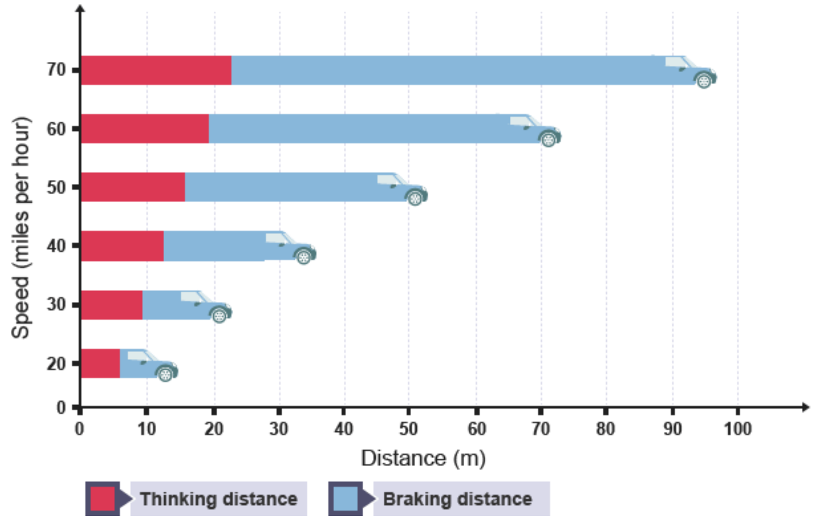
There are different ways to measure reaction times.

- One simple method involves dropping a ruler between someone's open thumb and forefinger.
- The higher the reaction time needed to grasp the falling ruler, the further the ruler falls before being stopped.

6.5.4.3.3 Factors affecting braking distance 1

The braking distance of a car can be affected by:

- **wet** or **icy road conditions**
- **faulty tires** or **brakes**.



6.5.4.3.4 Factors affecting braking distance 2

When a force is applied to the brakes of a vehicle, work done between the **brakes** and the **wheel** reduces the **kinetic energy** of the vehicle.

- This would increase the **temperature** of the brakes.
- **Large decelerations** may lead to brakes **overheating** and maybe the **loss control**.

6.5.5. Momentum (HT only)

Momentum is a property of moving objects.
Momentum can be calculated by the equation:
Momentum (kg m/s) = mass (kg) x velocity (m/s)
p = m x v

- momentum, *p*, in kilograms metre per second,
- kg m/s mass, *m*, in kilograms, kg
- velocity, *v*, in metres per second, 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**.

- Conservation of momentum explains why a gun or cannon recoils backwards when it is fired.
- When a cannon is fired, the cannon ball gains forward momentum and the cannon gains backward momentum.
- Before the cannon is fired (the 'event'), the total momentum is zero. This is because neither object is moving.
- The total momentum of the cannon and the cannon ball after being fired is also zero, with the cannon and cannon ball moving in opposite directions.

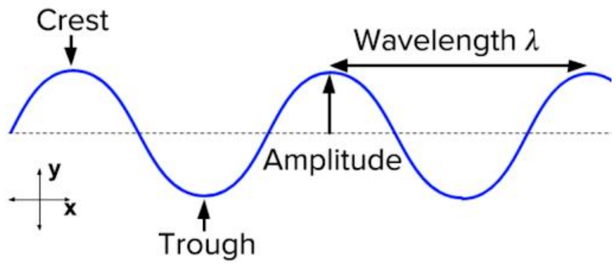
Knowledge Organiser – 6.6 Waves

6.6.1.1 Transverse and longitudinal waves

Waves can either be **transverse** or **longitudinal**.

1) Transverse waves

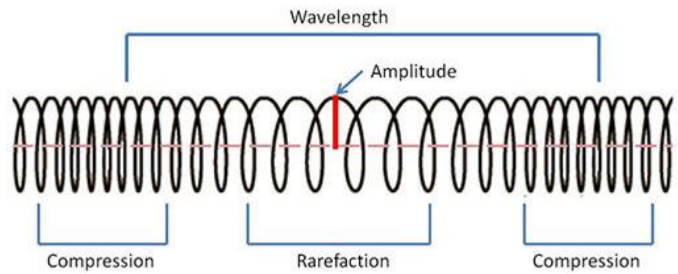
In **transverse** waves, the particles in the wave move **perpendicular** to the direction of the wave.
An example is a ripple on water or an electromagnetic wave.
It is the wave that travels NOT the water.



Remember: the waves move not the particles!

2) Longitudinal waves

In **longitudinal** waves, the particles in the wave move **parallel** to the direction of the wave. An example is a sound wave.



Remember: the waves move not the particles!

6.6.1.2 Properties of waves

Amplitude: the maximum displacement of a point on a wave from the undisturbed point.

Wavelength: the distance between a point on a wave and the same point on the next wave. Measured in metres (m).

Frequency: the number of waves passing a point each second. Measured in Hertz (Hz)

Period: time span of one wave in seconds

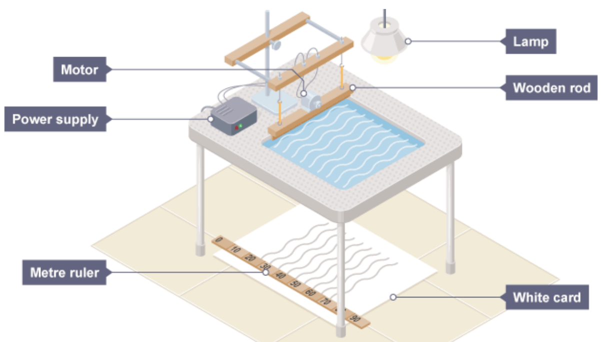
$$Period\ (T) = \frac{1}{Frequency\ (f)}$$

period, T, in seconds, s
frequency, f, in hertz, Hz

Wave speed is the speed at which the energy is transferred (or the wave moves) through the medium. Measured in m/s

$$Wave\ speed\ (v) = frequency\ (f) \times wavelength(\lambda)$$

<u>RPA: Measuring frequency, wavelength and speed of waves in solid and a liquid</u>



Wavelength: Measure the length of a number of waves then divide by the number of waves to calculate the wavelength. It may be more practical to take a photograph of the card.

Frequency: Count the number of waves passing a point in ten seconds then divide by ten to record frequency.

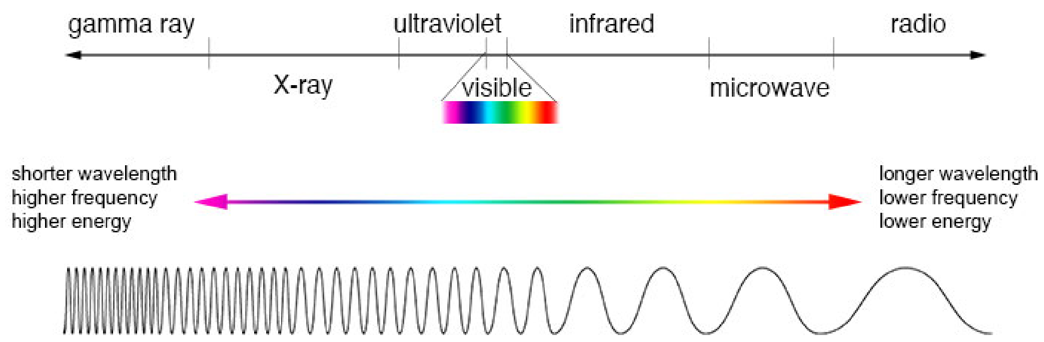
Wave speed: Calculate the speed of the waves using

$$Wave\ speed\ (v) = frequency\ (f) \times wavelength(\lambda)$$

Knowledge Organiser – 6.6 Waves

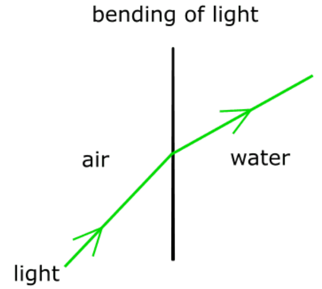
6.6.2.1 Types of electromagnetic waves

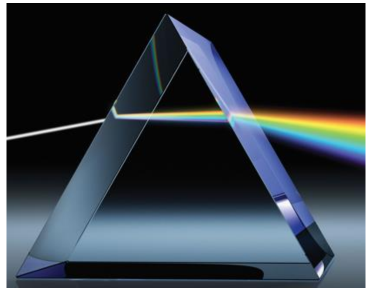
Electromagnetic waves are **transverse** waves that transfer energy from a source to an absorber.
All electromagnetic waves travel at the same speed as each other through a vacuum or air.



6.6.2.2 Properties of electromagnetic waves 1

- (HT only) **Different substances** may **absorb**, **transmit**, **refract** or reflect electromagnetic waves in ways that **vary with wavelength.**
- (HT only) When electromagnetic waves meet a barrier of a **different density** they **change speed** and therefore direction. This is **refraction**..





6.6.2.3 Properties of electromagnetic radiation 2

Changes in **atoms and atomic nuclei** can generate or absorb electromagnetic radiation. Gamma rays, X-rays and ultraviolet waves are **ionising** and can have **hazardous effects** on human body tissues. The effect depends on the **dose and type** of radiation.

- UV rays can age skin prematurely and increase risk of skin cancer.
- Gamma rays and X-rays can mutate genes and cause cancer.

(HT only) **Radio waves** can be produced by **oscillations** in **electrical circuits**.
(HT only) When radio waves are absorbed they **may create an alternating current** with the same frequency as the radio wave itself, so **radio waves can themselves induce oscillations in an electrical circuit**.

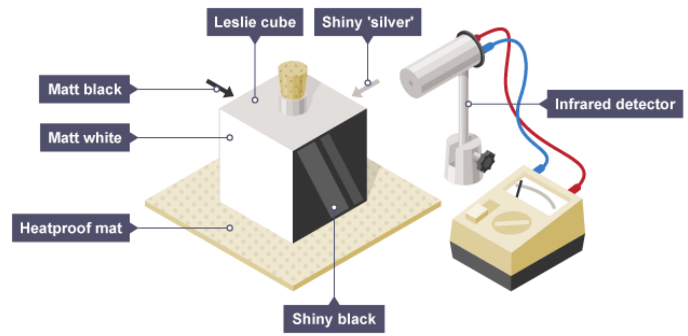
6.6.2.4 Uses and applications of electromagnetic waves

Different types of electromagnetic radiation have many uses:

- **Radio waves** – TV and radio
- **Microwaves** – Satellite communications and cooking food
- **Infrared** – Heating, cooking, and thermal cameras
- **Visible** – Fibre optic communication
- **Ultraviolet** – energy efficient lamps and sun tanning
- **X-ray and Gamma** – Medical imaging and treatment

(If higher tier you need to explain why each type of wave is suitable)

_RPA: Investigating the absorption or emission of IR radiation by nature of surfaces



1. Fill the **Leslie cube** with boiling water and replace the lid.
2.Leave for one minute to allow the surfaces to heat up.
3.Use the **infrared detector** to measure the intensity of infrared radiation emitted from each surface.

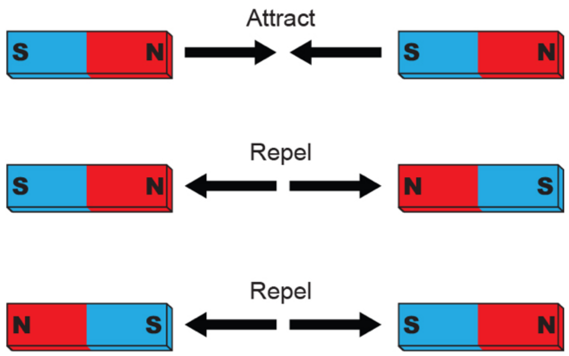
The **matte black surfaces emit** the **most** IR radiation.
The **shiny silver emits the least.**

Knowledge Organiser – 6.7 Magnetism and Electromagnetism

6.7.1.1 Poles of a magnet

The poles of magnet are where the magnetic forces are strongest. Two close together magnets will exert a non-contact force on each other.

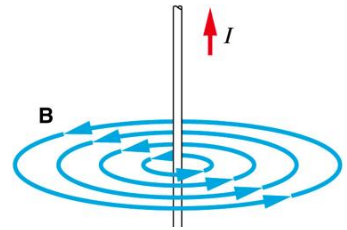
- Two opposite poles will attract (north and south).
- Two similar poles will repel (north and north or south and south).

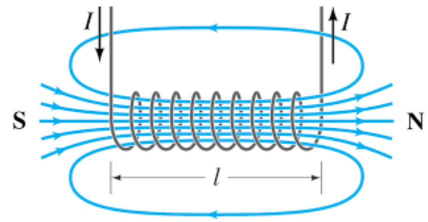


A **permanent** magnet **produces** its own magnetic field.
An **induced** magnet becomes a magnet when inside a magnetic field.
Induced magnets lose their magnetism easily.

6.7.2.1 Electromagnetism

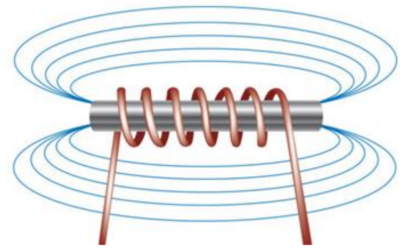
When a current flows through a wire a magnetic field is produced. The higher the current, the stronger the field.





If the wire is wrapped into a coil called a **solenoid** the magnetic field becomes **strong** and **uniform**. The magnetic field around a solenoid has a similar shape to that of a bar magnet.

Adding an iron core to a **solenoid** increases the strength of the magnetic field and turns it into an electromagnet.



How can we increase the strength of an electromagnet?

- **Increase the current**
- **Increase** the **size** and **number** of **coils**.

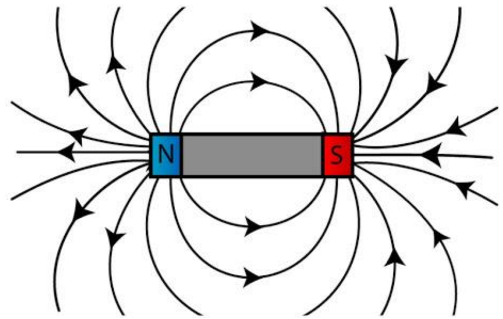
6.7.1.2 Magnetic field

magnetic field : the region around a magnet where a force acts on another magnet or on a magnetic material (iron, steel, cobalt and nickel)

The **field** of a **magnet** always **flows from the north pole to** the **south** pole.

The **strength** of the **field increases as the distance from the magnet decreases**.

Magnetic materials **always attract** a magnet and include **iron, cobalt, nickel, and steel**.



A **compass** is a small bar magnet that is attracted to the **Earth's magnetic field**. A compass can be used to draw a magnets field.

Knowledge Organiser – 6.7 Magnetism and Electromagnetism

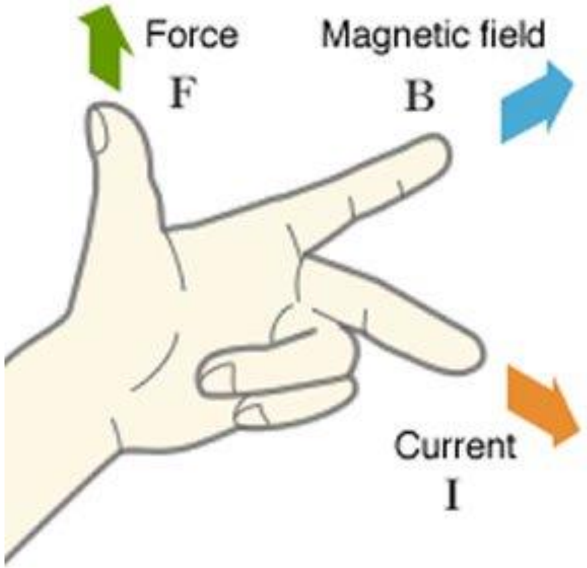
6.7.2.2. Fleming's left-hand rule (HT)

The **motor effect** when a conductor carrying a current is placed in a magnetic field the magnet producing the field and the conductor exert a force on each other.

The force on a given length of wire in a magnetic field increases when:

- The current in the wire increases.
- The strength of the magnetic field increases.

The force is greatest when the direction of the current is 90^{O} to the direction of the magnetic field.



For a conductor at right angles to a magnetic field and carrying a current:

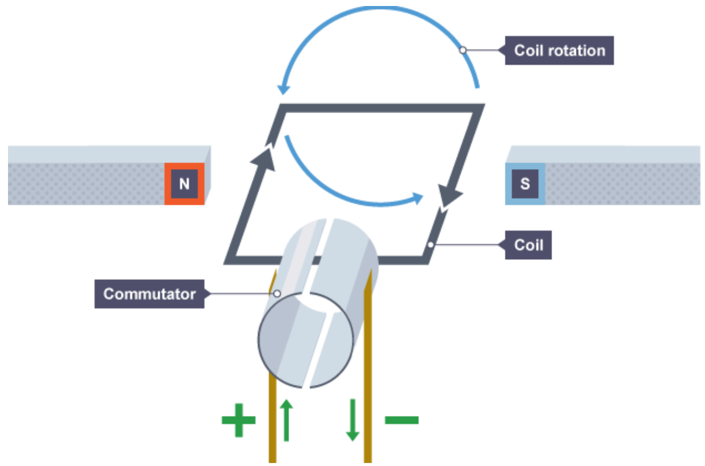
$$F = B \times I \times l$$

F = force measured in Newtons (N)
B = Magnetic flux density in tesla (T)

I = current in amperes (A)
l = Magnetic flux density in tesla (T)

6.7.2.3 Electric motors (HT)

A coil of wire carrying a current in a magnetic field tends to rotate. This is the basis of an electric motor.



Starting from the position shown in the diagram of the **dc motor**:

1. 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
2. the coil rotates anti-clockwise because of these forces
3. When the coil is vertical, it moves parallel to the magnetic field, producing no force. This would tend to make the motor come to a stop, but two features allow the coil to continue rotating:
   - the momentum of the motor carries it on round a little
   - a **split ring commutator** changes the current direction every half turn
4. Once the conducting brushes reconnect with the commutator after a half turn:
5. current flows in the opposite direction through the wire in the coil
6. each side of the coil is now near the opposite magnetic pole
7. This means that the motor effect forces continue to cause anti-clockwise rotation of the coil.