AQA Combined Science: **Trilogy**

Year 10
Knowledge organiser booklet
Paper 1

PHYSICS

P1 Energy

P2 Electricity

P3 Particle model

P4 Atomic structure

Name:

P1 Energy

Energy Stores
There are 8 energy stores:

Store	Stored in…
Kinetic	moving objects
Gravitational potential	objects raised above ground
Elastic potential	Stretched or compressed objects
Thermal	All objects due to particle movement
Chemical	Substances (foods, fuels) that can release energy in a chemical reaction
Nuclear	The nucleus of atoms
Magnetic	Magnets attracting or repelling
Electrostatic	Separation of charges

Conservation of energy law:
Energy is NEVER created or destroyed

Energy is transferred by different pathways – by heating or when work is done

When energy is transferred, some is often transferred to the environment – this is wasted or dissipated energy

Efficiency
Tells us how much of the energy is transferred usefully.

$$\text{Efficiency} = \frac{\text{Useful output energy transferred by the device}}{\text{Total input energy supplied to the device}}$$

$$\text{Efficiency} = \frac{\text{Useful power out}}{\text{Total power in}}$$

Wasted energy always ends up in the **thermal store** of the surroundings

Calculating energy stores

The energy stored in a raised object can be calculated using:

GPE = mass x height x gravitational field strength
GPE= mgh

The energy stored in a moving object can be calculated using:

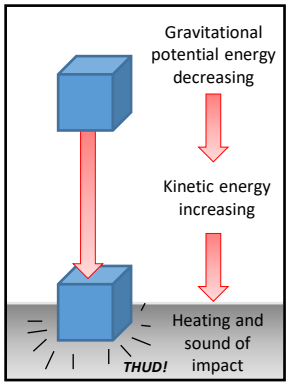
$KE = \frac{1}{2} \text{ mass} \times \text{velocity}^2$
$KE = \frac{1}{2} m v^2$

Energy stored in a stretched or compressed object can be calculated using :

$E = \frac{1}{2} \text{ spring constant} \times \text{extension}^2$
$E = \frac{1}{2} k e^2$

Transfers of energy:

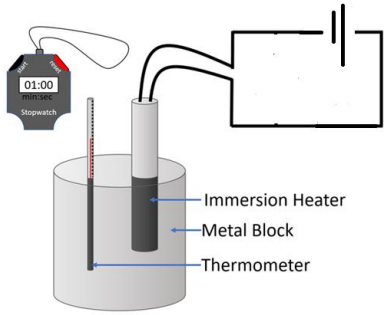
E.g. An object above ground has GPE.
If that object falls:
1. Decreases its GPE store
2. Increases its KE store as it falls
3. Waste energy transferred to the environment by heating and sound



Specific heat capacity
The amount of energy needed to change the temperature of 1Kg of a substance by 1ºC
It is calculated by:
E = specific heat capacity x mass x temp change
E = SHC x m x θ

Units for SHC are J/Kg/°C
Different materials have different specific heat capacity values.

This can be investigated using the equipment below:



- Energy is supplied to the block by the immersion heater over a fixed time period (e.g 5 mins)
- The thermometer measures the temperature of the block at the start and the end of the experiment
- The stopwatch measures the time
- If the power of the heater is known (e.g 50W) the energy transferred to the block can be found using the equation:

Energy (J) = Power (W) x time (s)

The specific heat capacity of different materials can be investigated by:
- changing the metal **(independent variable)**
- measuring the temperature increase **(dependent variable)**
- Keeping the energy supplied, mass and insulation the same **(control variables)**

Insulating the block reduces energy transferred to the thermal store of the environment, improving accuracy

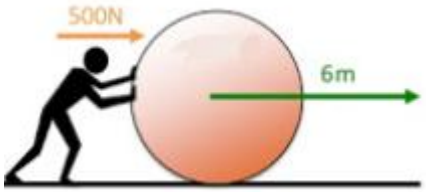
Power and work done

Work done = energy transferred

Energy transferred mechanically is calculated:

Work done = force x distance

W (J) = F (N) x s (m)



Work done = 500N x 6m

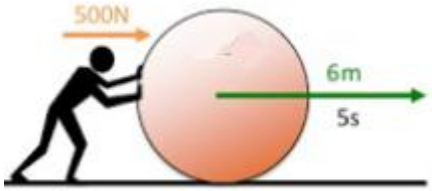
= 3000 J

Power = energy transferred per second

1 Watt = 1 Joule per second

Power = energy transferred ÷ time

P (W) = e (J) ÷ t (s)



Power = Energy ÷ time

= 3000 J ÷ 5 s

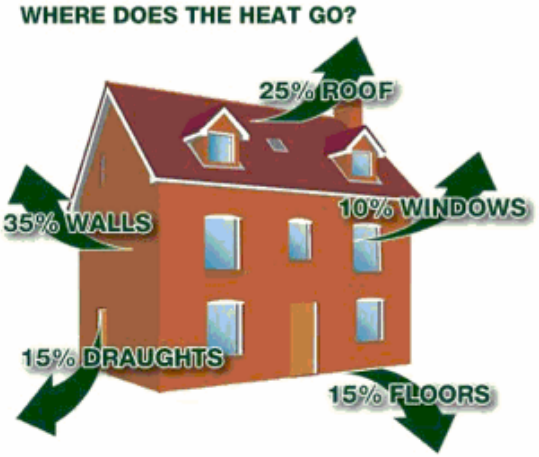
= 600W

A more powerful appliance transfers more energy per second, eg:

Reducing unwanted energy transfers

Reducing wasted energy means lower costs

Materials that conduct heat well have a high **thermal conductivity**.



Reducing energy transfers in homes

- Double glazing
- Thick walls
- Walls made of materials with low thermal conductivity
- Insulation – wall and loft

Reducing energy transfers in appliances:

- Lubrication – reduces friction

- Streamlining – reduces air resistance

Energy resources

We use energy resources for electricity generation, transport and heating

Non-renewable – ones that are being used faster than they can be replaced and will run out.

Example	+	-
Coal, oil, natural gas	Reliable method of generating electricity	Release CO_2 which contributes to global warming
nuclear	No CO_2 released	Produces radioactive nuclear waste

Renewable resources:

Ones that will not run out , they are being replenished as they are used

Example	+	-
Solar	No CO_2 released	Don't work at night or well on cloudy days
wind	No CO_2 released	Doesn't work if it isn't windy
Hydro	No CO_2 released	Damage to habitats
Geothermal	No CO_2 released	Only found in specific places
waves	No CO_2 released	Damage to habitats
Biofuel	Carbon neutral	Uses crop land to grow new forests

P2 – Electricity

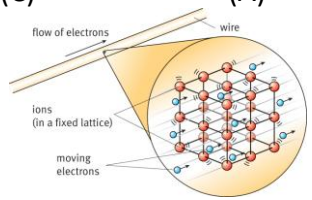
Current, resistance and potential difference

Electrical current is the flow of electrical charge.
Current is measured in amps (A), charge is measured in Coulombs (C).
The size of the current depends on the rate of the flow of charge – ie how many coulombs of charge per second.

Q = I t

Charge = Current x time

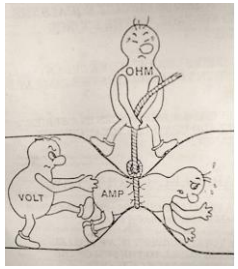
(C) (A) (s)



Ohms Law

The current through a component depends on the potential difference and the resistance of the component.

If a component has high resistance, the current will be smaller for a given potential difference



potential difference = current x resistance

V = I R

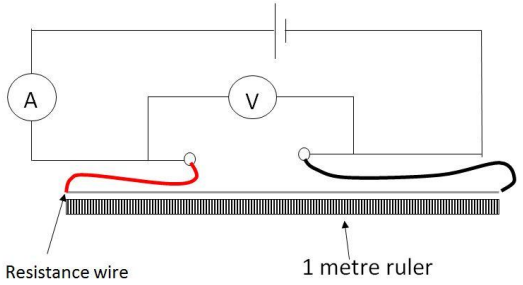
pd is measured in volts (V), resistance in Ohms (Ω)

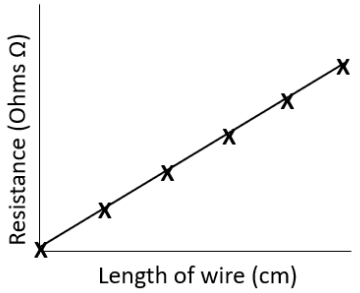
Hypothesis 'the length of the wire affects resistance'

Independent variable – length of wire
Dependent variable – resistance
Control variables – type of wire, temperature of the wire, diameter of the wire

1. Set up the circuit as shown, with an ammeter in the circuit and a voltmeter connected across the wire
2. Use crocodile clips to change the length of the wire in the circuit
3. Make the wire 10cm long and read the current and pd. Switch off the current between readings or the wire will got hot, increasing the resistance.
4. Repeat for 20, 30, 40, 50 cm. (5 minimum)
5. Calculate resistance using Ohms Law R = V/I

Plot length of wire (IV) against resistance (DV)



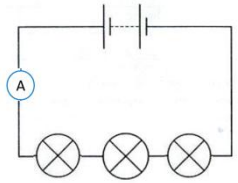


The relationship is directly proportional

Series and parallel circuits

Series circuits:

A series circuit is one single loop

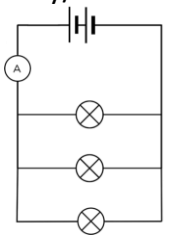


In a series circuit:

- the current is the same at all points in the circuit.
- potential difference is shared between components (equally if components are identical resistance)
- total resistance = sum of all resistors

Parallel circuits

A parallel circuit consists of more than one loop from the battery/cell.

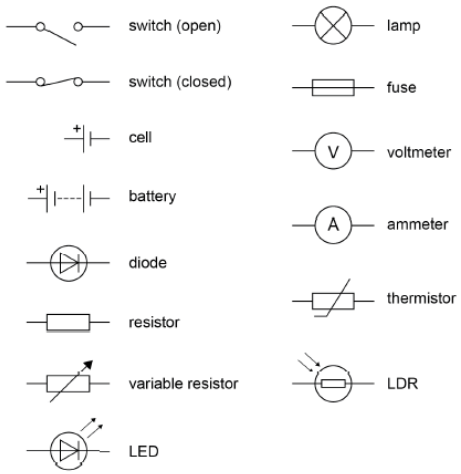


In a parallel circuit:

- The current is shared amongst the branches
- The potential difference is the same across all components
- Resistance in the whole circuit is LESS than that of the smallest resistor

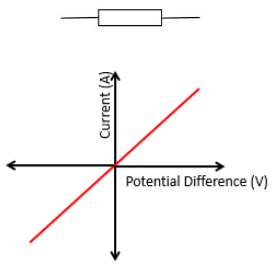
P2 – Electricity

Components

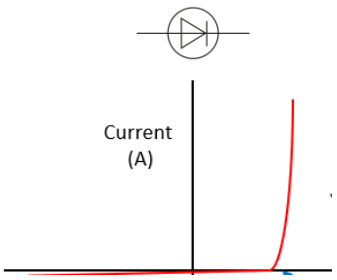


- A **diode** only allows current to flow one way in a circuit
- A **resistor** is a component that provides a fixed resistance in the circuit – e.g a 5 Ω resistor
- A **variable resistor** is a component whose resistance can be changed (e.g a dimmer switch)
- A **thermistor** is a resistor whose resistance changes with temperature – the higher the temperature the lower the resistance
- An **LDR** (light dependent resistor) has resistance that changes
- An LED (light emitting diode) is a light that only allows the flow of current one way

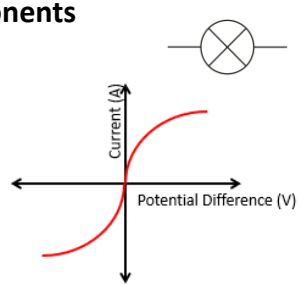
Current, potential difference and resistance for different components



A fixed (ohmic) resistor
has fixed resistance
current is directly proportional to potential difference
Resistance remains constant (at constant temp)

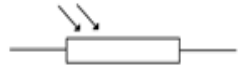


A diode very high resistance in one direction.
Only when the potential difference is positive does current flow

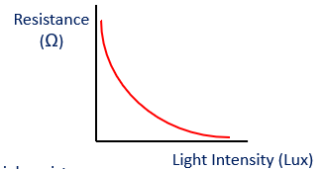


A filament bulb contains a thin wire that glows as current flows.
As the pd increases, the current initially increases.
However, at higher pd, the wire gets hot
The ions in the wire move faster and collide with the moving charges
Resistance increases, so current stops increasing

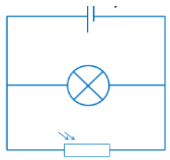
LDR



A light dependent resistor has varying resistance.
As the light intensity increases, the resistance decreases



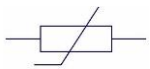
LDRs can be used to switch on lights at night time.



In this circuit, when it is day time, the resistance in the LDR is low, so all current flows through the LDR.

As light levels fall, resistance increases, until eventually there is less resistance in the bulb than the LDR, so current flows through the bulb – switching it on.

Thermistor



As the temperature increases, the resistance in a thermistor decreases.

P2 – Electricity

Domestic use of electricity

There are two types of electrical supply – direct (DC) and alternating current (AC)

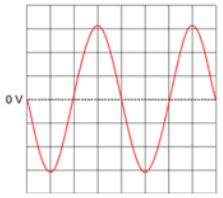
AC

The pd changes direction and magnitude, giving alternating current

The number of times the change of direction happens per second is the frequency.

UK mains is AC - **230V**

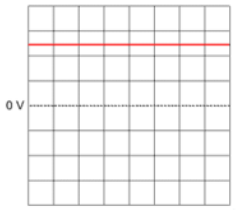
Frequency of **50 Hz**

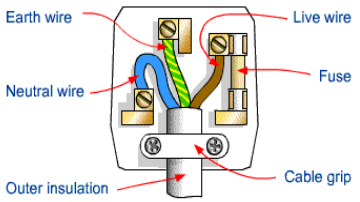


DC

A direct pd produces current that flows in one direction

Batteries supply DC



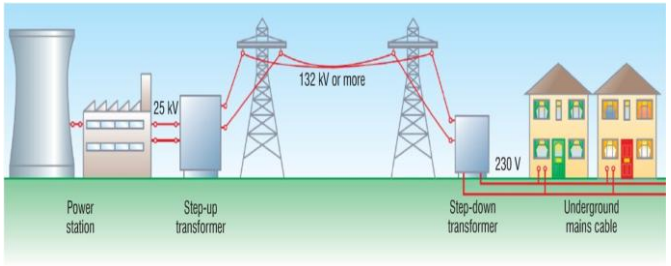


Electrical appliances are connected using 3 core cable

- Brown – live wire, with pd of 230V
- Blue – neutral, 0V, completes the circuit
- Yellow and green – Earth wire, is at 0V unless there is a fault, when it will become live

The National Grid

The National Grid is a system of cables and transformers connecting power stations to homes and businesses



The National Grid uses very high pd and low current.

High current causes heating in the wires and would result in large energy losses.

Step up transformers increase the pd from the power station (to around 400000V) so that low current can be used to transmit power.

This means the wires don't get hot, so less energy is lost.

Near homes and businesses, step down transformers reduce the pd to 230V for safety.

Appliances in the home and power

Power is measured in Watts (W) or kW

Power can be calculated by using:

Power = Voltage x current

P = IV

Power = current^2 x resistance

$P = I^2 R$

Appliances transfer energy.

Energy is measured in Joules (J) or kJ

The energy transferred can be calculated by using:

Energy = charge flow x potential difference

E = Q V

Energy = power x time

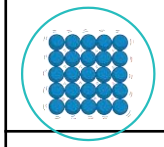
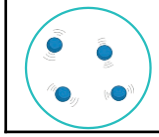
E = p t

For example

A kettle transfers energy from the thermal store of the filament in the kettle to the thermal store of the water inside.

Some energy is transferred to the thermal store of the surroundings.

Particle model of matter

State	Pattern	Energy and movement	Forces between particles
Solid 	Ordered and all touching	Vibrate around fixed positions	Strong forces between particles
Liquid	Random and touching	Move around randomly	Weaker than in a solid
Gas 	Random and far apart	Move around randomly	Weak forces of attraction

Models	+	-
Particle diagrams	Easy to see/draw arrangement	• Can't see the forces between particles • Particles look like flat circles rather than 3D spheres • Movement isn't shown
Kinetic models (eg marbles or animations)	Easy to see particle arrangement Can see the movement of particles	Can't see forces between particles

Density

Density is mass per cm^3

It can be calculated using:

Density = mass ÷ volume

ρ = m ÷ V

Required practical – measuring the density of different materials.

For regular solids :

Mass measured by **top pan balance**

Volume measured by measuring **length x breadth x height**

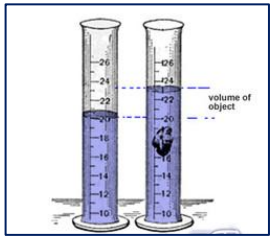
For irregular solids:

Mass measured by **top pan balance**

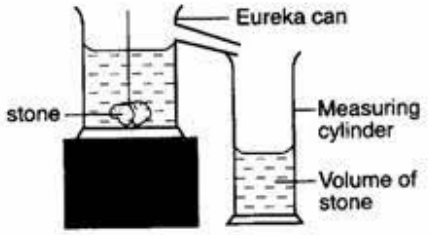
Volume measured by **displacement of water**

This means putting the object into water and measuring the volume of water 'pushed out'

Measure the volume of small objects by putting them into a measuring cylinder with 100cm^3 water in

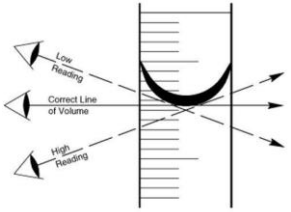


Measure the volume of larger objects by putting them into a full eureka can and catching and measuring the water that is displaced



Zero error

Read the meniscus!



Required practical continued : Density of liquids

1. Find the mass of an empty measuring cylinder using a top pan balance.
2. Pour a known volume (100ml) of liquid into the measuring cylinder.
3. Use the meniscus to measure the volume of the liquid accurately. This is the volume.
4. Now measure the mass of the measuring cylinder + the liquid combined.
5. Subtract the mass of the empty measuring cylinder and this is the mass of the liquid.

Density = mass ÷ volume.

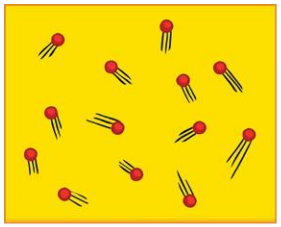
Internal energy

The temperature of any substance is related to the average speed of its particles.

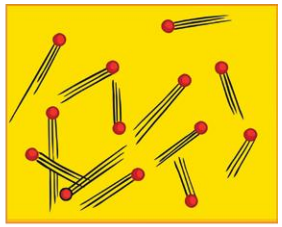
The internal energy of a system is the total kinetic energy and the potential energy of the particles

The particles in a system **vibrate** or **move around** because they have energy in their **kinetic energy stores**

The faster a particle moves, the greater its **kinetic energy store**



Low Temperature



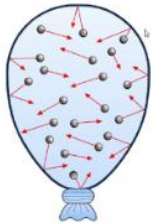
High Temperature

The particles also have energy in their **potential energy stores** due to their position.

As particles **move further apart**, their potential energy stores **increase**

Gas pressure

The particles in a gas are in constant random motion
They collide with the walls of their container
This exerts a force **on the container.**



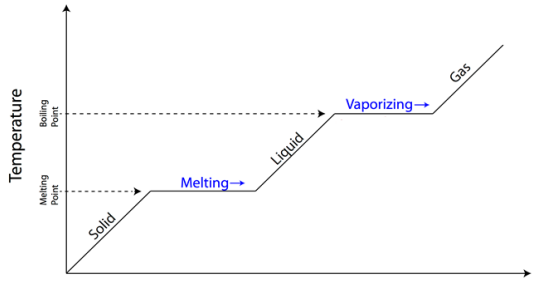
The more energy the particles have, the higher the temperature.
An increase in temperature of a gas causes the particles to move further apart.
If this is not possible, because of the container, then there is an increase in pressure.

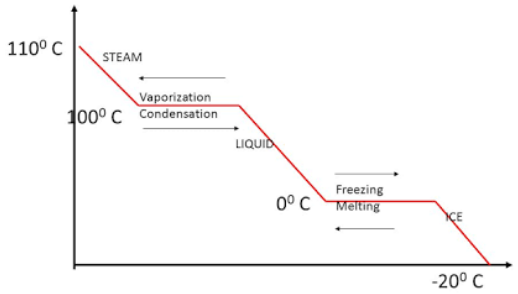
Heating and cooling

When the internal energy of a substance changes, then either :

- **The temperature** of the substance changes
- **The state** of the substance changes

This can be seen by plotting the temperature change during **heating** or **cooling.**
Heating a solid would give us a graph that looks like this:





- The **temperature stays the same**.
- This is when a change of state is happening – for example melting.
- The energy transferred is not increasing the mean particle speed – it is increasing the potential energy of the particles.

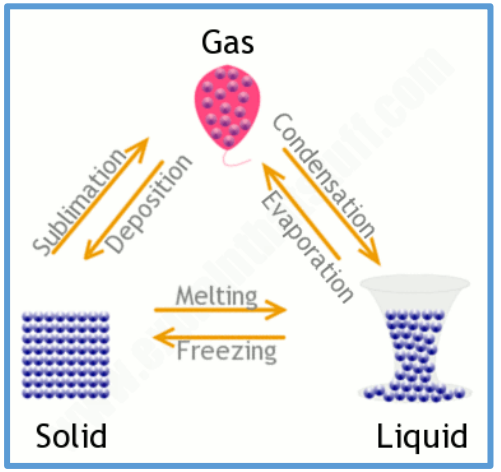
When the line is increasing (heating) or decreasing (cooling)

- The temperature is increasing / decreasing
- The kinetic energy store is increasing /decreasing
- Average particle speed is increasing /decreasing

Specific latent heat

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

- Energy needed to change 1kg of Solid → liquid - **specific latent heat of fusion**
- Energy needed to change 1kg of Liquid → gas - **specific latent heat of vaporisation**



The amount of energy needed to change 1Kg of a material is found by the equation:

Energy = mass (kg) x specific latent heat (L)

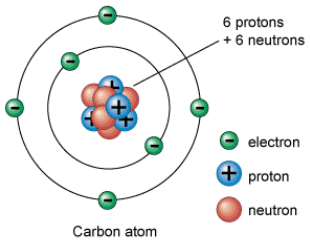
$E = m L$

Specific heat capacity

This is the among of energy needed to change the temperature of 1Kg of a substance by 1ºC
It is calculated by:
E = specific heat capacity x mass x temp change
$E = SHC \times m \times \theta$

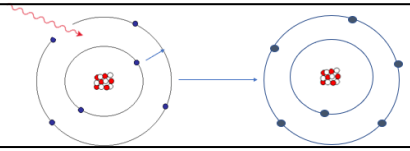
P4 – Atomic Structure

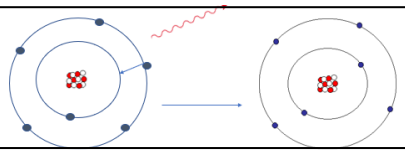
Atoms



- Atoms are tiny – around 10^{-10}m
- There is a positive nucleus made of protons and neutrons
- Electrons orbit in shells or energy levels
- The nucleus is 10,000 x smaller than the atom (4 orders of magnitude) so around 10^{-14} m

Electrons can move further away or closer to the nucleus





If EM waves (eg UV /light) are **absorbed** electrons can move up energy levels

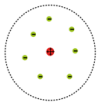
If EM waves are **emitted** by the atom, then electrons move closer to the nucleus

How the atomic model developed:

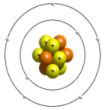
The atomic model has developed over time, when new evidence was discovered.

Atoms were first thought to be tiny spheres that could not be divided

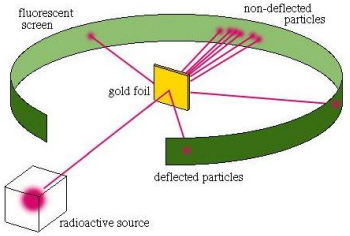
JJ Thomson then discovered the electron
Led to the plum pudding model
Atoms a cloud of positive charge with electrons randomly scattered



Rutherford discovered the positive charge is very small and in the nucleus
This discovery was from the Gold leaf experiment



Chadwick discovered neutrons
Bohr discovered the electrons orbit in shells



Rutherford's experiment:
Alpha particles fired at gold leaf
Most went straight through
Some deflected to the side
Some came straight back
This told him that most of the atom was empty space and that the positive charge was in a tiny nucleus

- Atoms of the same element have the same number of protons.
- This is the atomic (proton number)
- In an atom, the number of electrons is equal to the number of protons.
- The total number of protons and neutrons is called the mass number

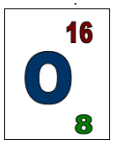
(Mass number) 23
(Atomic number) 11
Na

Sodium has :
11 protons
11 electrons
12 neutrons (23-11)

Isotopes

Isotopes are atoms with same number of **protons**, but different numbers of **neutrons** (different mass number)

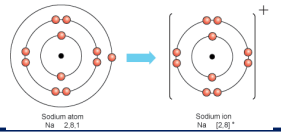
E.g.



These two isotopes both have 8 protons
One has 8 neutrons (16-8)
One has 10 neutrons (18 – 8)

Ions

If atoms lose one or more outer electrons, they turn into positive ions



P4 – Atomic Structure

Nuclear radiation

If an isotope is **unstable**, then **particles** and **energy** are emitted from the nucleus.
There are 3 main types :

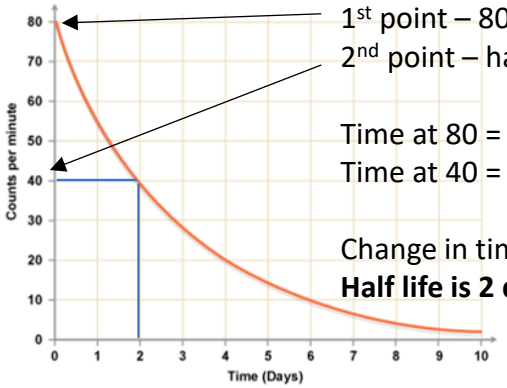
Radiation	What is it?	How far does it travel?	Ionising power	Penetrating power
Alpha α	2 protons and 2 neutrons	A few cm	Strong	Stopped by paper
Beta β	A fast moving electron	Metres	Medium	Stopped by aluminium
Gamma γ	An electromagnetic wave	kilometres	Weak	Takes thick concrete or lead to stop it

Neutrons can also be emitted from the nucleus**.**

Half life

Radioactive decay is random.
The half life of an isotope is the time it takes for half of the atoms in the sample to decay OR for the count rate to fall by half

Half life is calculated from a graph by reading two points off the y axis – one value being half the other.
Read the corresponding change in time**.**



1st point – 80
2nd point – half of that, so 40

Time at 80 = 0
Time at 40 = 2 days

Change in time = 2 days
Half life is 2 days

Isotopes are selected for use depending on their properties and half life – e.g. a medical tracer needs to have a short half life so it isn't in the body for very long

Alpha decay:

An unstable nucleus gives out 2 protons and 2 neutrons
An alpha particle is written as : $^{4}_{2}\alpha$

So when a particle gives out alpha radiation, it loses 2 from the proton number and 4 from the mass number
E.g

$$^{226}_{88}Ra \rightarrow {}^{222}_{86}Rn + {}^{4}_{2}\alpha$$

Beta decay:

In an unstable nucleus, a neutron changes into a proton and an electron.
The electron is fired out as the beta particle
Beta particles are written as $^{0}_{-1}\beta$ or $^{0}_{-1}e$

The proton number increases
The mass number stays the same
E.g. $^{14}_{6}\text{carbon} \longrightarrow {}^{14}_{7}\text{nitrogen} + {}^{0}_{-1}e$

The emission of a gamma ray **does not change the nucleus**

Irradiation is the exposure to alpha, beta or gamma radiation

Contamination is the presence of radioactive atoms on materials.