Whitley Academy

Physics Paper 1 (F) Knowledge Recall Booklet

Paper Physics 1F 8464/P/1F

For this paper, the following list shows the major focus of the content of the exam:

- 6.1.1 Energy changes in a system, and the ways energy is stored before and after such changes
- 6.1.3 National and global energy resources
- 6.2.1 Current, potential difference and resistance
- 6.3.1 Changes of state and the particle model
- 6.4.2 Atoms and nuclear radiation

Required practical activities that **will be assessed**:

- Required practical activity 14: an investigation to determine the specific heat capacity of one or more materials. The investigation will involve linking the decrease of one energy store (or work done) to the increase in temperature and subsequent increase in thermal energy stored.
- Required practical activity 16: 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.

Your teacher will tell you specific topic areas to focus on …

Topic	RAG			Revision technique					Date completed	Teacher Signed
	R	A	G	Flashcards	Mindmap	Notes	Video Watched (With notes)	Frog resource		

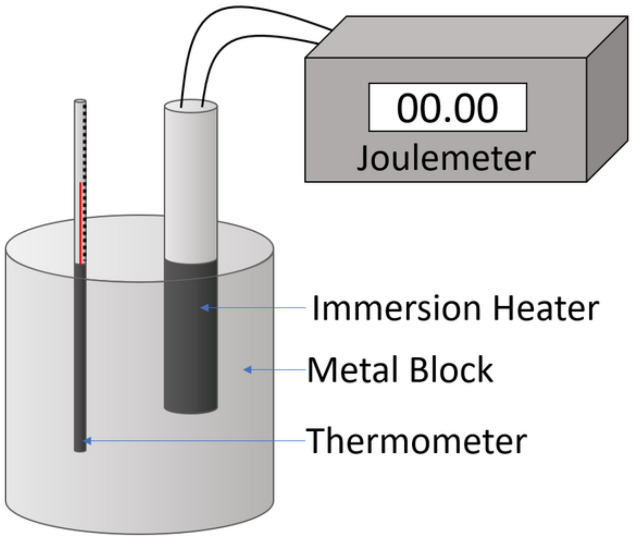
Required Practical – How to find the Specific Heat Capacity

Recall it …

Use the information in the following page(s) to answer these questions …

1. What equipment is needed for the practical?
2. Outline all the steps / method for this investigation in sufficient detail.
3. What is the formula to find the specific heat capacity?

Required Practical - Specific Heat Capacity



- Use a balance to find the mass of your metal block.
- Wrap the metal block in insulating material.
- Place an immersion heater into the metal block. Connect this to a joulemeter.
- Use a thermometer to find the start temperature of the metal block.
- Use the immersion heater to heat the metal block for at least 20 minutes. Use the thermometer to read the new temperature.
- Use the joulemeter to see how much energy was transferred into the metal block.
- Use the temperature change and energy to determine the specific heat capacity of the metal.
- Repeat the experiment using a different type of metal block.

Specific Heat Capacity

The specific heat capacity of a substance is the amount of energy required to raise the temperature of 1 kg of the substance by 1°C.

$$c = \frac{\Delta E}{m\Delta\theta}$$

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

m = mass (kg)
c = specific heat capacity (J/kg°C)
ΔE = change in thermal energy (J)
$\Delta\theta$ = change in temperature (°C)

Find the specific heat capacity of the metal block by re-arranging

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

into:

$$c = \frac{\Delta E}{m\Delta\theta}$$

Required Practical – Finding the I/V characteristics of different electrical components

Recall it ...

Use the information in the following page(s) to answer these questions ...

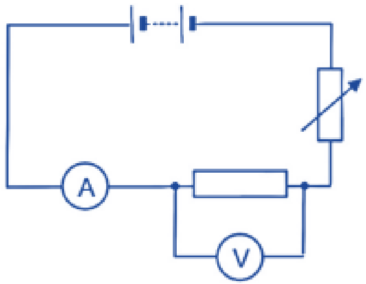
1. Name the three components that we are trying the find the I/V characteristics to?
2. Sketch the three circuits that need to be made?
3. Describe the method for the investigation?
4. Sketch the graphs for the results that you would find for resistor at constant temperature, filament lamp and diode?

Required Practical – Investigating the I/V characteristics of a filament lamp, diode and resistor at constant temperature

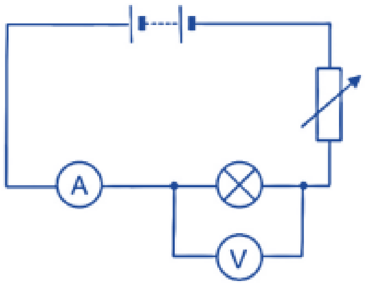
What happens to the current through a component when the potential difference across it changes?

① Draw a circuit diagram to investigate the behaviour of a resistor, a lamp and a diode. In each one you are going to measure electric current in the component as you change the potential difference across it.

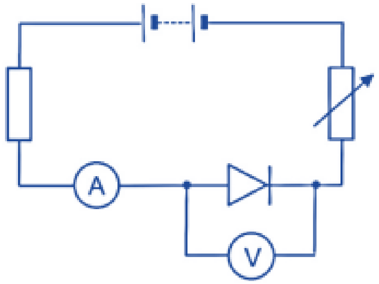
Resistor



Lamp

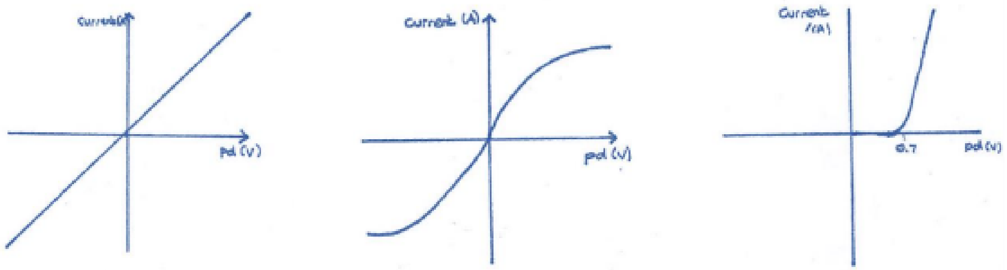


Diode



② Describe how you could use the circuits you drew to investigate the I-V characteristics of a filament lamp, a diode and a resistor at constant temperature.

- record the readings on the ammeter and voltmeter
- adjust the variable resistor and record the new ammeter and voltmeter readings
- repeat this to obtain several pairs of readings
- repeat for negative values
- plot a graph of current in *A* against potential difference in *V*
- expected graphs for resistor, lamp and diode:



Recall it ...

Energy

Use the information in the following page(s) to answer these questions ...

1. What is an energy system?
2. What is the law of conservation of energy?
3. Describe the energy transformation in a motor?
4. Name 8 energy stores?
5. Describe the energy change when a ball in thrown upwards?
6. Describe the energy change when a ball is hitting an object?
7. Describe the energy change when a vehicle is slowing down?
8. Describe the energy change when bringing water to boil on a camping stove?
9. What is mechanical work? Give a worked example of how the formula for force or work can be used?
10. What is electrical work? Give a worked example of how electrical work is calculated?

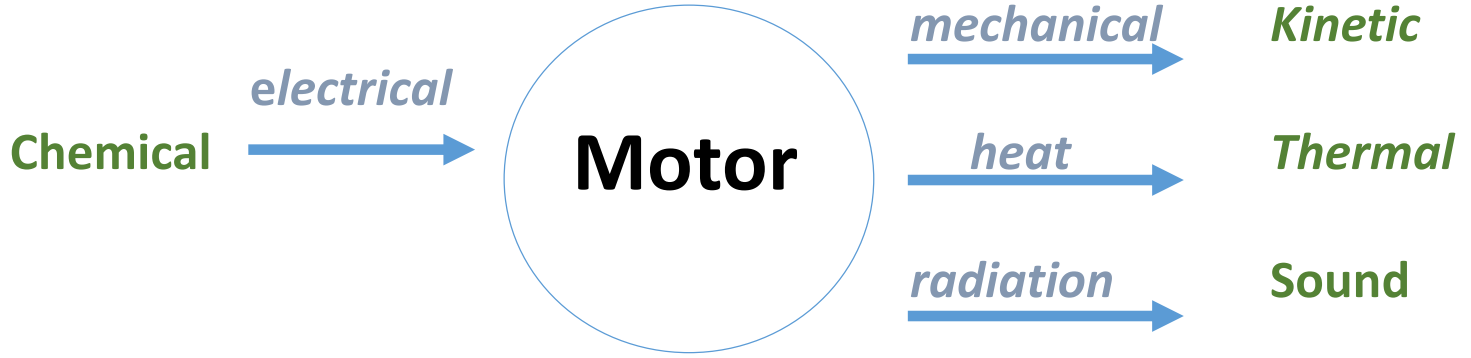
Energy stores and systems

An energy system is a group of objects that have the ability to do work.

Remember: energy can not be created or destroyed so when work is done, energy from one store is carried along a pathway to another energy store.

Consider the energy flow diagram for an electric shaver.

The battery has a store of chemical energy.
The current flows through an electrical pathway to the motor.
Energy from the motor follows a mechanical pathway to a kinetic store of the moving blades, a heat pathway to a thermal store and a radiation pathway to a sound store.



Energy stores and systems

Energy stores	Examples
Chemical	In food, fuel and electric batteries
Kinetic	In moving objects
Gravitational potential	In objects raised above a planets surface
Elastic potential	In a stretched, compressed or twisted object
Internal (thermal)	In any heated object
Magnetic	In any object with a magnetic field
Electrostatic	In electrostatic forces between charges
Nuclear	The forces acting between atomic nuclei
Force pathways include: Mechanically – when a force acts and an object moves Electrically – when an electric current flows Heating – a temperature difference between objects Radiation – electromagnetic waves or sound	

Energy stores and systems

Examples of energy changes in a system:

An object thrown (projected) upwards e.g. You throw a tennis ball upwards.

- As the **ball leaves** your **hand** it has a **store** of **kinetic energy**.
- At its **highest point** it has a **store** of **gravitational potential energy (G.P.E)**.
- As you are about to catch it just **before it hits your hand** it has a **store** of **kinetic energy.**

A moving object hitting an obstacle e.g. A bowling ball hitting a pin

- As you move the muscles of your arm to throw the ball the **chemical energy store** in your muscles **decreases** and the **kinetic energy store** of the bowling ball **increases**.
- At the ball hits a pin some of the **kinetic energy** has been transferred to a **store** of **internal (thermal) energy** this causes the ball and its surroundings to warm up a little.
- You will hear a **sound** when the ball hits the pin, the **energy of the sound** is also transferred to the **internal energy store** of the **surroundings**.

Energy stores and systems

Examples of energy changes in a system:

A vehicle slowing down e.g. When you apply the brakes in a lorry

- The **moving** lorry has a **store** of **kinetic energy**.
- At the **brakes** are applied the **kinetic energy store decreases** the energy is transferred to the **internal (thermal) energy store** in the brakes and the brakes get hot.
- You will hear a **sound** when the brakes of the lorry are applied, the **energy of the sound** is also transferred to the **internal energy store** of the **surroundings**.
- When the lorry **stops** its **kinetic energy store** is **zero**.

Bringing water to a boil on a camping stove.

- As the fuel burns the **chemical energy store** in the fuel **decreases** and the **internal (thermal) energy store** of the water **increases.**
- The temperature of the water increases and as bubbles form the **kinetic energy store** of the water increases.

Energy is measured in Joules (J)

1 kilojoule (kJ) = 1000 J (10^3J)

1 megajoule = 1000 000 J (10^6J)

Energy stores and systems

Energy change – mechanical work is the amount of energy transferred by a force

When a pushback truck is used to move an aircraft, it does work.

Work (J) = Force (N) x Distance (along the line of the force) (m).

$$W = F s$$

If the aircraft has a mass of 30 000kg and it is moved a distance of 20m, calculate the work done by the pushback truck.

Force (weight) = mass x gravitational field strength

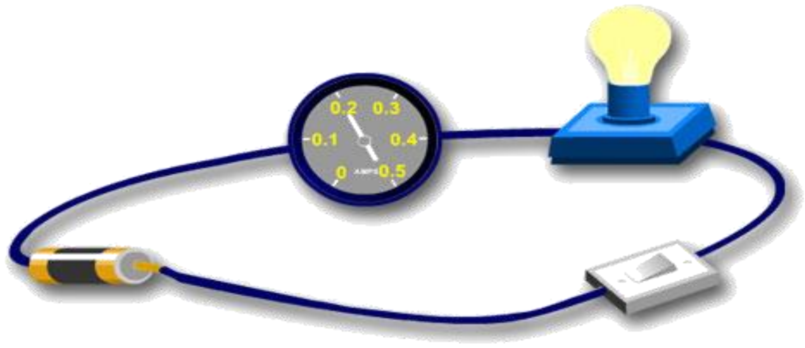
Force = 30 000 x 10 = 300 000 N

$$W = F\ s$$

Work = 300 000 x 20 = 6 000 000 J (6 MJ)

Energy stores and systems

Energy change – Electrical work is done when charge flows in a circuit is the amount of energy transferred.



When a current flows through a circuit, work is done (energy is transferred) and the energy store changes.

Energy transferred (Work) (J) = Charge flow (Q) x Potential difference (V)

$$E = Q\,V$$

In one minute, 30 Coulombs of charge flows through the bulb when a potential difference of 3 V is placed across it. Calculate the work done (energy transferred).

$$E = Q\,V$$

$$\mathrm{E} = 3 \times 30$$

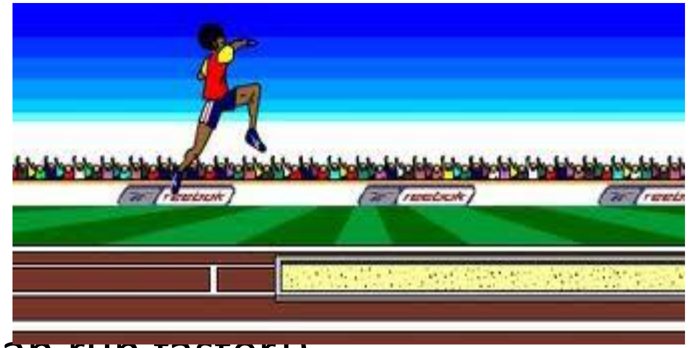
Energy transferred (Work) = 90 J

Recall it … Energy Calculations

Use the information in the following page(s) to answer these questions …

1. Give a worked example of how kinetic energy is calculated?
2. What is elastic energy? Give a worked example of how elastic energy is calculated?
3. What is gravitational potential energy? Give a worked example of how gravitational potential energy is calculated?
4. How does the energy store of a metal change when it is heated?
5. What is specific heat capacity?
6. What is the specific heat capacity equation? Give a worked example of how this equation can be re-arranged to make specific heat capacity the subject?
7. What is meant by power?
8. Give an example of how power can be calculated?

Changes in Energy - Kinetic Energy



Moving objects have kinetic energy.

The long-jumper is using her **kinetic energy** to carry her body as far as possible. The more kinetic energy she has, the longer her jump will be. Her kinetic energy depends on her mass (which she can not change) and her velocity (she can run faster!).

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

Kinetic energy (J) = 0.5 × Mass (kg)× Speed^2 (m/s)

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

If her mass is 46 kg and she is travelling at 8 m/s, her kinetic energy during her jump will be:

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

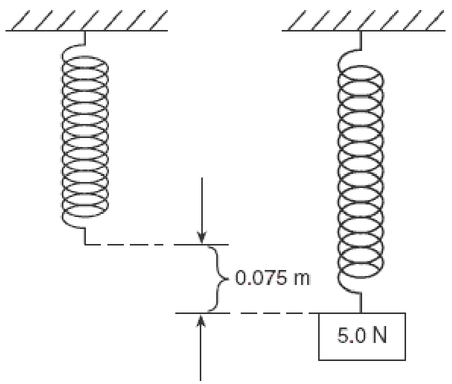
$$E_k = \frac{1}{2} \times 46 \times 8^2$$

The energy transferred in the jump is: E_k = **1472 J**

Changes in Energy - Elastic Energy

Stretched or bent objects have **elastic energy (E_e)** if they have the ability to **recover** to their original shape and dimensions.

When a weight (force) is added to a spring it extends (gets longer).
The spring now has a store of elastic potential energy which will be released if the weight is removed.



The amount of stored elastic energy (E_e) can be calculated using the following equation:

Elastic potential energy (J) = 0.5 × Spring constant (N/m) × Extension² (m)

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

In the above example the spring has a spring constant of 670 N/m. The elastic potential energy of the spring when a 50 N load is hung from it is:

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

$$E_e = 0.5 \times 670 \times 0.075^2$$

The elastic energy stored in the spring is: E_e = 1.88 J

Changes in Energy – Gravitational potential energy

When an object is raised above ground level it gains **gravitational potential energy** (GPE). This **stored energy** can be released if the object is allowed to **fall**.

A pile driver is a machine that lifts a heavy weight then drops it on a post to drive it into the ground.

The amount of gravitational potential energy (G.P.E) gained by an object raised above ground level can be calculated using the equation:

G.P.E (J) = Mass (kg) × Gravitational field strength (N/kg) × Height (m)

$$E_p = m\,g\,h$$

The pile driver hammer has a mass of 120 kg and it is raised to a height of 4 m above the ground. How much G.P.E will it have?

$$E_p = m\,g\,h$$

$$E_p = 120 \times 10 \times 4$$

The G.P.E gained is: $E_p = 4800\ \text{J}$

The **thermal (internal) energy store** in a system changes if its **temperature changes**.

When metal is heated in a furnace the **thermal energy store** increases. The amount of energy gained depends on the **mass** of the metal, how much the **temperature increases** and the **specific heat capacity** of the metal.

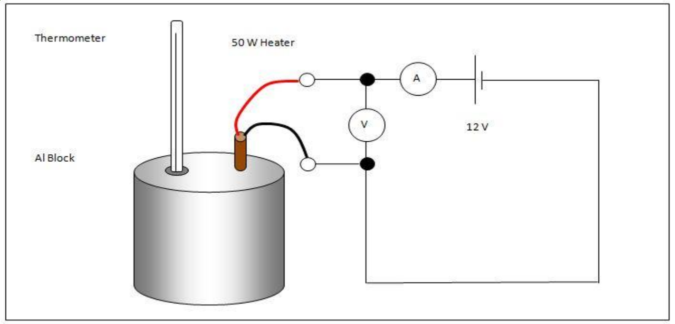
Specific Heat Capacity (*c*) – the amount of energy required to raise the temperature of 1 kg of a substance by one degree Celsius.

Steel has a specific heat capacity of 450 J/kg ^{o}C

Therefore a 1 kg block of steel needs 450 J of thermal energy adding to it to raise the temperature from 20 ^{o}C to 21 ^{o}C (1 ^{o}C rise).

Specific heat capacity

The apparatus shown can be used to determine the specific heat capacity of aluminium.



Example: When the heater was left on for 5 mins, the heater supplied 10 800 J of thermal energy to the aluminium block.

The temperature of the 2 kg block of aluminium rose by 6 ºC.

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 (J) = Mass (kg) x Specific Heat Capacity J/kgºC x Temperature Change (ºC)

$\Delta E = m \times c \times \Delta\theta$ rearrange to give $c = \Delta E / m \times \Delta\theta$

$c = 10\,800 / 2 \times 6$ Specific heat capacity of aluminium = 900 J/kg ºC

Power

Power - the rate at which energy is transferred

the rate at which work is done (rate means "how quickly")

Power is measured in Joules / second 1 J/s = 1 Watt

An object which transfers energy does so at a certain rate.
The metal filament in this light bulb transfers the electrical energy store into heat and light.
This bulb transfers 2400 joules of energy in 60 seconds.

Power can be calculated using the following equation:

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

$$P = \frac{E}{t}$$

P= 2400 / 60 = 40 J/s

So this is a **40 Watt** light bulb.

Power

Power - the rate at which energy is transferred

the rate at which work is done (rate means "how quickly")

Mechanical power

Power = work done / time

The crane lifts the 2000 kg container through a height of 5.4m in 30s.
The power of the crane is:

Power = Work / time

But: Work = force x distance

= 20 000 N x 5.4 m = 108 000 J

Power = 108 000 J / 30 s

The Power of the crane is 3600 J/s or 3600 Watts

Recall it …

Energy Resources

Use the information in the following page(s) to answer these questions …

1. Name and describe renewable and non-renewable energy resources?
2. What is a non-renewable and renewable energy resource?
3. How are energy resources used?
4. Give the advantages and disadvantages of coal, oil, gas, nuclear, solar, wind tidal, geothermal, hydroelectric, biomass and wave?
5. Explain the issues related to having a mix of energy supplies?
6. Explain the world energy trends, solution/actions that are taken?

National and global energy resources

ENERGY RESOURCES	
Non-renewable	
Coal	Fossil fuels They are becoming more difficult to find and extract
Oil	
Gas	
Nuclear	Plentiful but difficult to extract / purify
Renewable	
Bio-fuel	Plant matter usually used as a fuel
Wind	Turbines spin a generator to produce electricity
Hydro-electric	Falling water spins a turbine to produce electricity
Geothermal	Hot rocks underground produce steam
Tides	Rise and fall of the tide can be used to turn a turbine
Sun	To directly heat things or produce electricity
Waves	Up and down movement can turn turbines

National and global energy resources

Non-renewable energy sources are those which will **eventually run out** – there is a finite supply. New supplies are more difficult to find and extract.

Renewable energy sources are those which can **replenish themselves in the short term,** and so will never run out.

Nuclear energy resources are technically non-renewable but they can be produced on an almost indefinite basis.

How energy resources are used.

Transport – cars, trains, buses, planes etc.

Electricity generation – industry, homes, commerce, lighting etc.

Heating – homes, industrial processes, schools and hospitals etc.

Energy use is usually divided between the four economic sectors - **residential, commercial, transportation**, and **industrial.**

Energy resources – Non-renewable

Coal	**Coal is mined then burnt to provide heat or used to generate electricity.**	**Large reserves of coal which are relatively inexpensive to mine. All major coal mines have now closed in the UK.**	**Coal mining is dangerous and burning coal contributes to global warming.**
Oil	**Frequently burnt to produce electricity. Large quantities of oil are refined to provide fuels for transport.**	**Large reserves becoming more difficult to find and extract. Transport and refinement are relatively easy.**	**Oil reserves becoming more difficult to find and extract. The need for oil in developed countries means supplies are politically sensitive. Releases greenhouse gases when burnt.**

Energy resources – Non-renewable

Gas	Extracted from underground gas fields sometimes alongside oil extraction. Mainly used for electricity production, domestic heating and industrial processes that require heat.	Cleaner than burning oil or coal. Relatively easy to transport and store.	UK has good gas reserves but extraction is expensive (often under the sea) and becoming more difficult to reach.
Nuclear	Nuclear supplies (Uranium) are mined and purified. The nuclear fission releases heat which is used to produce steam. This spins a turbine and generator to make electricity	Potentially in-exhaustable energy supply even though it is extracted form resources in the ground.Very efficient process which produces lots of electricity from little nuclear fuel.	Danger of nuclear accidents releasing radioactive materials into the air or water. Security of nuclear sites can be a problem.Start-up costs and decommissioning are very expensive and no real solution to managing radioactive waste has been found.

Energy resources – Renewable

Solar	Energy from sunlight is captured in photovoltaic cells and converted into electricity. Hot water from solar panels	Renewable energy resource. Individual houses can have their own electricity/hot water supply.	Manufacture and installation of solar panels/cells can be costly.
Wind	Wind turbines turn wind energy into electricity by turning a generator.	Renewable energy resource and can be used as individual units.	Manufacture and installation of wind farms can be costly. Some consider an eyesore.
Tidal	The movement of tides drives turbines. A tidal barrage is built across estuaries to trap water.	Ideal for an island such as the UK to potentially generate a lot of energy. Tidal barrage can help prevent flooding.	Construction of barrage is very costly and can impact on wildlife. Only a few estuaries are suitable.

Energy resources – Renewable

Geothermal	In volcanic regions, cold water is pumped underground and comes out as steam. Steam can be used for heating or to power turbines creating electricity.	Renewable energy resource. Used successfully in some countries, such as New Zealand and Iceland.	Can be expensive to set up and only works in areas of volcanic activity.
Hydroelectric Power (HEP)	Energy harnessed from the movement of water through rivers, lakes and dams. Used to turn turbines for electricity production.	Creates water reserves as well as energy supplies.	Costly to build. Can cause the flooding of surrounding communities and landscapes.

Energy resources – Renewable

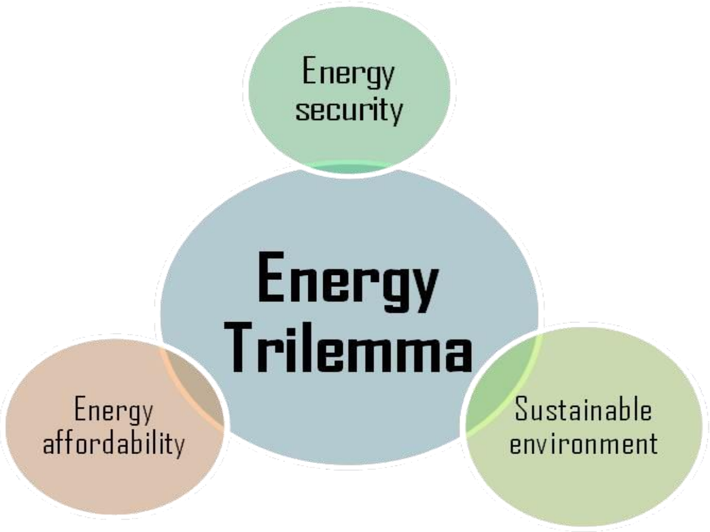
Biomass	**An organic material, which can be burned to provide energy, eg heat or electricity. After treatment with chemicals it can be used as a fuel in vehicle engines.**	**It is a cheap and readily available source of energy. If replaced, biomass can be a long-term, sustainable energy source.**	**When burned, it gives off greenhouse gases. Growing takes up large amounts of arable land..**
Wave	**The movement of water in and out of a cavity on the shore compresses trapped air, driving a turbine.**	**More likely to be small local operations, rather than done on a national scale.**	**Construction can be costly. Only produces small amounts of electricity.**

National and global energy resources

Security and reliability of energy supplies

In the UK a **mix** of energy supplies are used so should one supply become **unavailable**, others can be used without **disruption** to supplies.

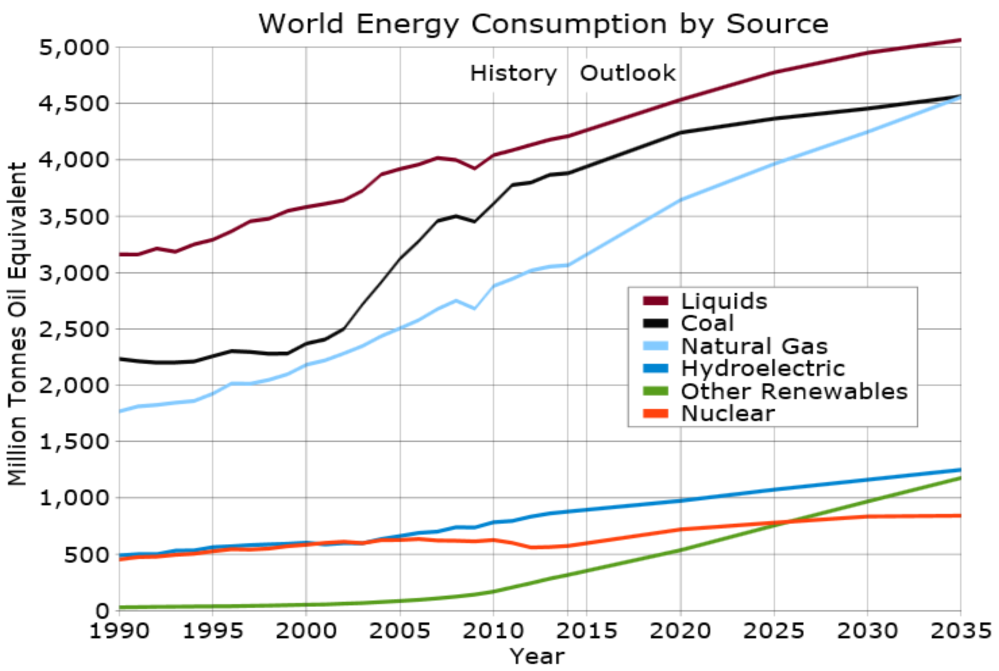
Some energy sources are more **reliable** than others. Coal, oil, gas and nuclear are reliable sources as they can supply a **continuous** flow of electricity.



Electricity from wind turbines relies on the wind blowing, solar power does not work at night and hydro-electric requires a continuous supply of water. These are considered **unreliable** sources.

National and Global energy resources – Trends in energy use

World energy use trends and predictions



The total amount of energy used in the world is increasing as the population increases and each person is using more energy.

Renewable energies only make up around 20% of total energy consumption and this trend is unlikely to change until after 2035.

- **Future world agreements on emissions are likely to determine the trend of using fossil fuels.**
- **As reserves of coal, oil and gas dwindle, an increase in the use of renewable energies is likely.**

Circuit Symbols and terminology

Recall it ...

Use the information in the following page(s) to answer these questions …

1. Draw a label 14 circuit symbols?
2. What is meant by…

a) Current
b) Potential difference
c) Charge
d) Resistance

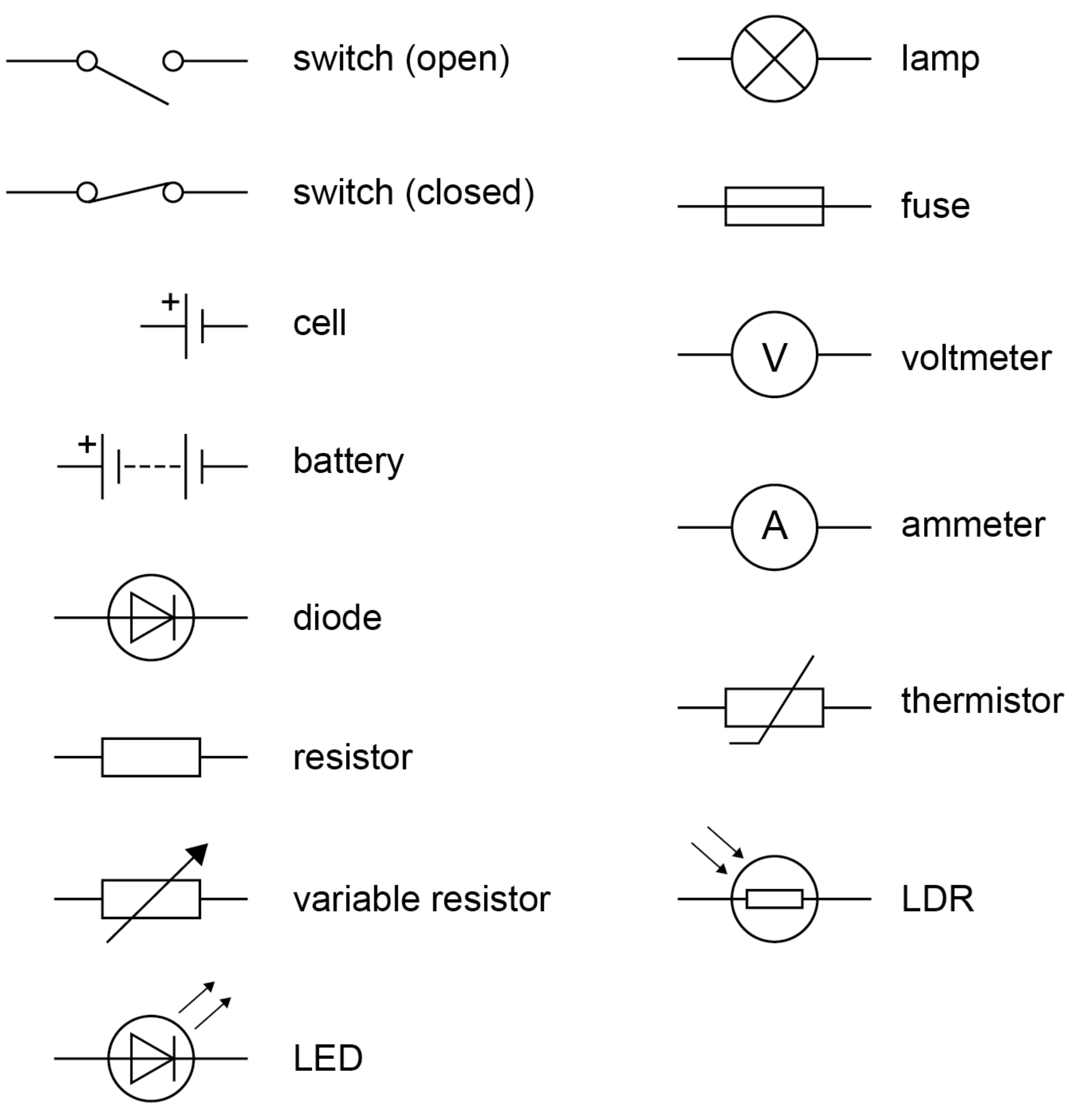
3. What is the difference between a series and parallel circuit?
4. What is the formula for charge flow? Give an example of how it is calculated?
5. What is the link between current, potential difference and resistance?
6. Give a worked example of how the V=IR formula is used?

Circuit Symbols

Circuit symbols are used to clearly show components in a circuit and how they are connected.

These circuit symbols must be learnt so that you can draw them and interpret circuit diagrams that use them.

Standard Circuit Diagram Symbols



Terminology

Term	Definition
Current	The rate of flow of charge in a circuit.
Potential Difference	Also called voltage. The difference in potential between two points of a circuit. Causes a current to flow.
Charge	Charge is the amount of electricity travelling through a circuit.
Resistance	Anything that slows the flow of charge around a circuit. Resistance is usually caused by electrons colliding with ions in a material.
Series Circuit	A circuit with a single loop of wire.
Parallel Circuit	A circuit with two or more loops (branches) of wire.

Electrical charge and current

For electrical charge to flow through a closed circuit, the circuit must include a source of potential difference.

An electric current is the flow of electrical charge, usually electrons, around a circuit. The size of the electric current is the rate of flow of electrical charge. In a series circuit (one with a single loop of wire) the current is the same at any point of the loop.

Intensité de courant

'I' symbol used by

André-Marie **Ampère**

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

Charge flow (C) = Current (A) × Time (s)

$$Q = I\,t$$

Name	Equation symbol	Unit	Unit Symbol
Charge flow	Q	Coulombs	C
Current	I	Amp	A
Time	t	Seconds	s

Example

A current of 1.2 A flows through a wire for 5 minutes.

Work out the charge that has moved in the wire in the 5 minutes.

Solution

Convert time into standard units: 5 minutes = 300 seconds

State equation: $Q = I\,t$

Substitution: Q = 1.2 x 300

Answer: Q = 360 C

Current, Resistance and Potential Difference

- **The current (*I*) through a component depends on both 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 *(V)* across the component.**

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

Potential Difference *(V)* = Current *(A)* x Resistance *(Ω)*

$$V = I\,R$$

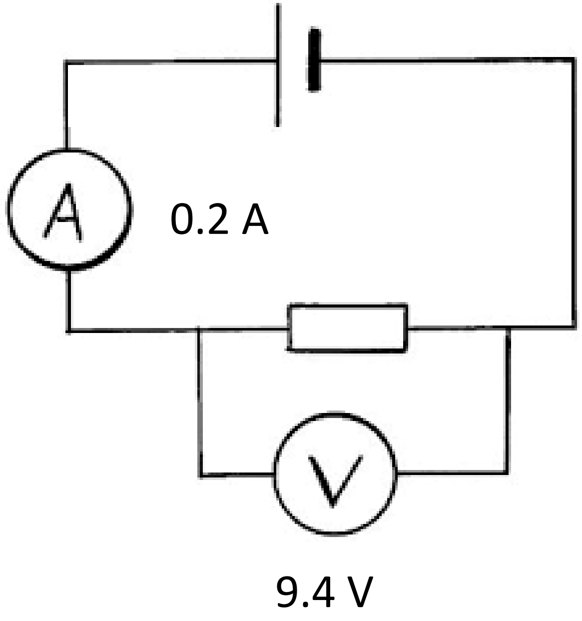
The resistance in a circuit will depend on the components used in the circuit as well as the length of wire used in the circuit. The longer the wire, the greater the resistance.

Name	Equation symbol	Unit	Unit Symbol
Potential difference	V	Volts	V
Current	I	Amp	A
Resisitance	R	Ohms	Ω

Example

A resistor is placed into the circuit shown. The meter readings are shown next to each meter.

Work out the resistance.



Solution

State the equation: $V = I \times R$

Rearrange: $R = V / I$

Substitution: $R = 9.4 / 0.2$

Answer: $R = 47\ \Omega$

Circuit Components

Recall it ...

Use the information in the following page(s) to answer these questions …

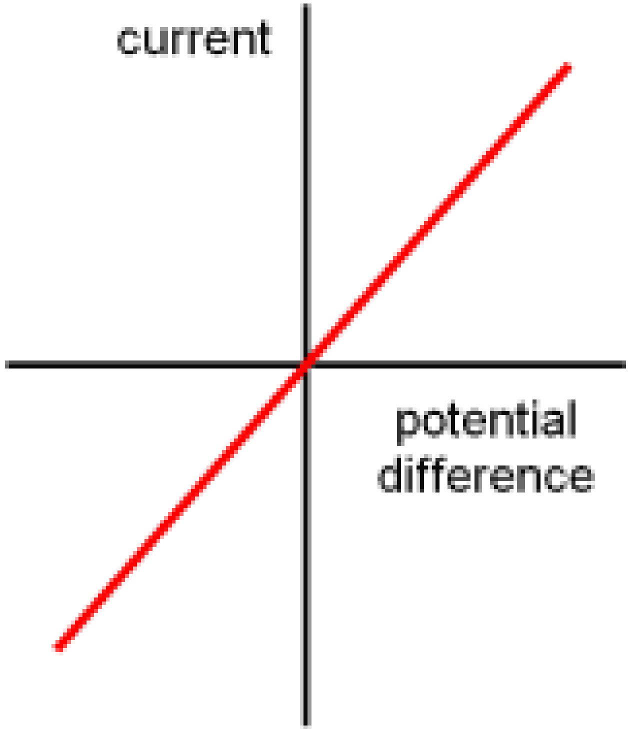
1. What is an ohmic conductor? Sketch and describe the voltage – current graph for an ohmic conductor?
2. What is an non-ohmic conductor? Sketch and describe the voltage – current graph for filament lamp and resistor?
3. What is a thermistor? What happens to the resistors through a thermistor as the temperature increases? How are thermistors used? Draw the circuit symbol for an LDR?
4. What is a LDR? What happens to the resistance through a LDR as light levels increase? How are LDRs used? Draw the circuit symbol for an LDR?
5. Describe an experiment of how to measure resistance? What circuit would be made? What would be measured? What formula would be used?

Ohmic Conductors

Some resistors have a fixed value that does not depend on the current flowing through the circuit. These are ohmic conductors.

Ohm's Law states "the current through an ohmic conductor (at a constant temperature) is directly proportional to the potential difference across the resistor".

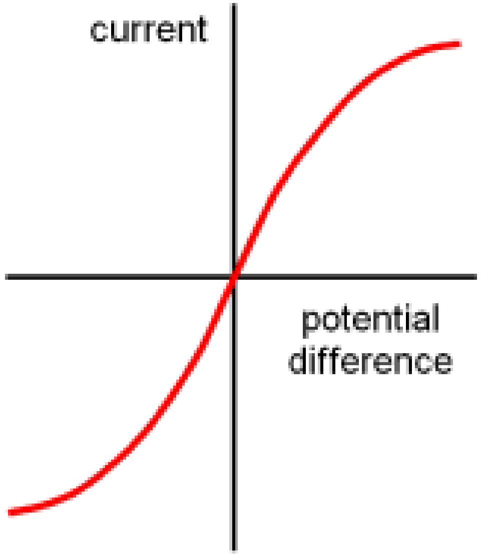
Ohmic conductors will produce a straight line I – V graph that goes through the origin.



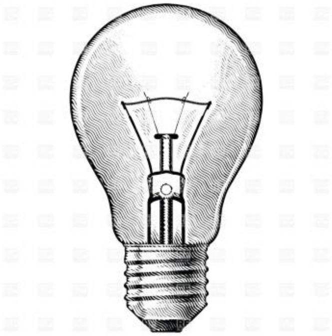
Non-Ohmic Conductors: Filament Lamp

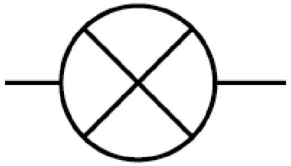
The resistance of components such as lamps, diodes, thermistors and LDRs is not constant. It changes with the current through the component.

A filament lamp is often called a lamp or a lightbulb.



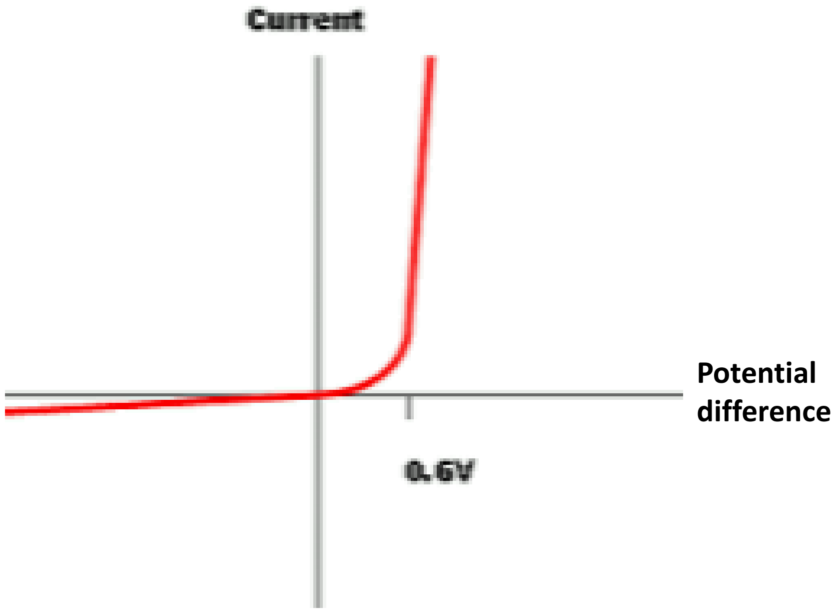
As the current increases, the temperature of filament increases therefore the resistance of the filament lamp increases.

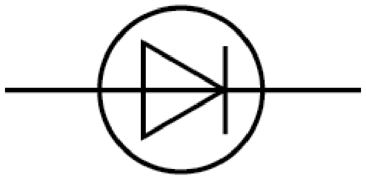




Non-Ohmic Conductors: Diodes

Diodes are electrical components that only allow a current to flow in one direction only.

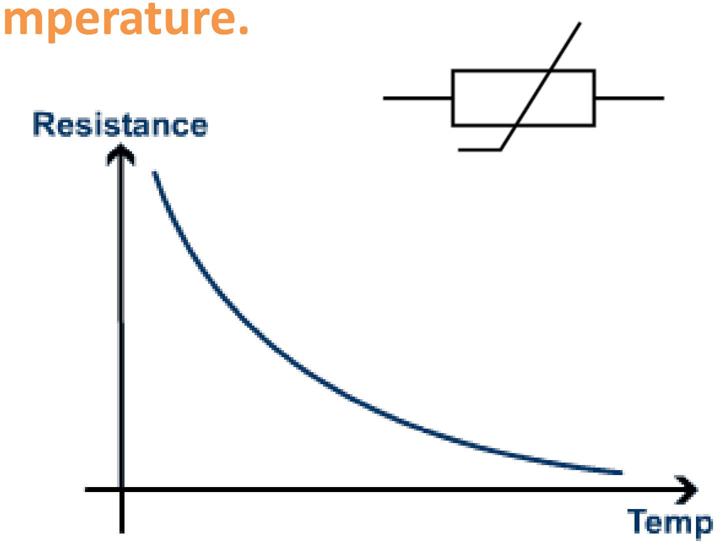




Diodes have a low resistance in the forward direction but a high resistance in the reverse direction.

Thermistors and LDRs

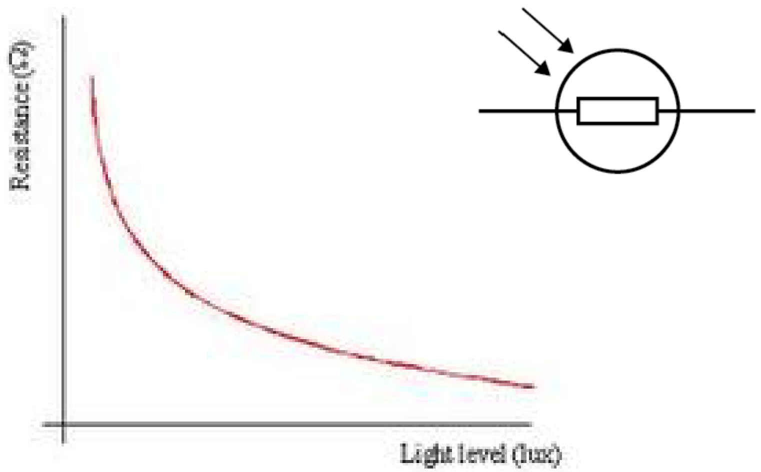
Thermistors are types of resistors where the resistance varies with temperature.



The resistance of a thermistor decreases as temperature increases.

Thermistors are used in thermostats to control temperature in the home.

Light Dependent Resistors - LDRs are types of resistors where the resistance varies with light intensity.



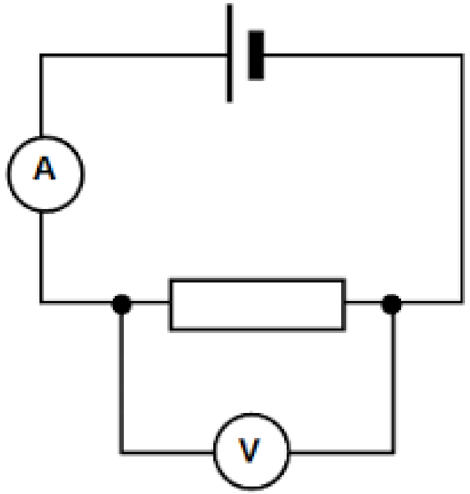
The resistance of a LDR decreases as light intensity increases.

LDRs are used as switches to turn on street lights when it gets dark.

Resistors

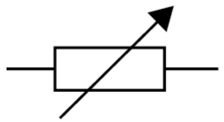
Measuring Resisitance:

To measure the resistance of an electrical component the following circuit needs to be set up…



By measuring the current, using the ammeter, and the potential difference, using a voltmeter, the resistance can be found from…

$$R = \frac{V}{I}$$



The electrical component tested can be changed from the resistor shown to any other electrical component.

To get a range of potential differences and currents a variable resistor can be added into the circuit or the input potential difference changed.

Name	Equation symbol	Unit	Unit Symbol
Potential difference	V	Volts	V
Current	I	Amp	A
Resisitance	R	Ohms	Ω

Particles

Recall it ...

Use the information in the following page(s) to answer these questions …

1. What is density? How is it calculated? Give an example calculation for density?
2. Describe particles in solids, liquids and gases? Describe how density changes in solids, liquids and gases? What is the exception to this?
3. Describe how to find the density of an irregular object?
4. Describe 6 changes of state? How can we bring about a change in state?
5. What happens to mass during changes of state?
6. What is the difference between a physical change and a chemical change?

Density is the mass of a given volume of a substance

The density of a substance is determined by the mass of the atoms it is made from and how closely these atoms are packed together.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

mass in kg

volume in m^3

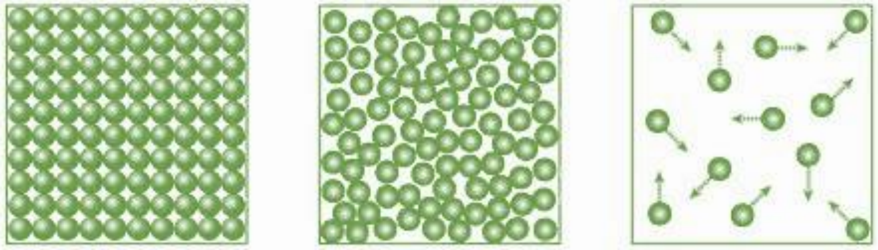
What is the density of a bar of gold if its volume is 350 cm^3 (0.00035 m^3) and its mass is 6.76 kg?

$$\text{Density } \rho = \frac{\text{mass (kg)}}{\text{volume } (m^3)} = \frac{6.76}{0.00035}$$

Density of gold = 19 314 kg/m^3

Substance	Density (kg/m^3)
Water (l)	1 000
Glass (s)	3 140
Iron (s)	7 700
Aluminium (s)	2 800
Hydrogen (g)	0.085

Density also depends on the **state** of a substance.



In **solids** the particles are packed close together.

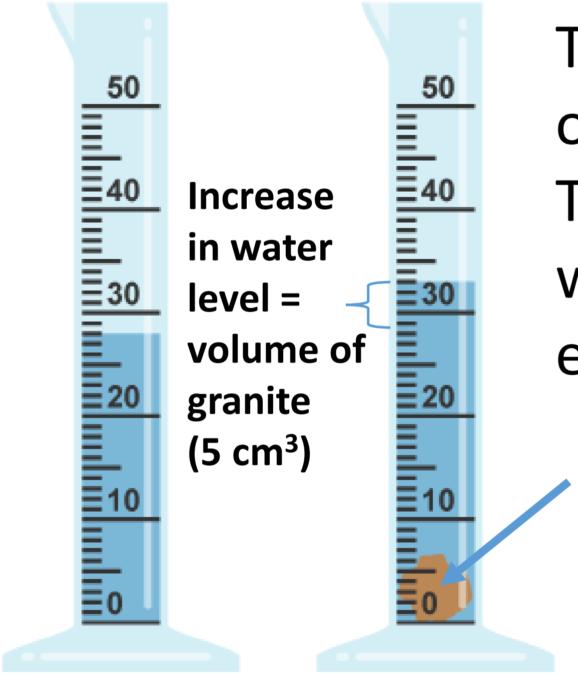
In **liquids** the particles are free to move so the same mass takes up more space.

In **gases** the particles take up a much greater volume than in liquids and solids.

For any particular substance, a solid is usually denser than its liquid and the liquid is usually denser than the gas.

However, there are exceptions to this. Solid water (ice) is less dense than liquid water. This is why ice floats on water.

Finding the density of an irregular object



To find the density of an **irregular** shaped object, you need to determine its volume. To do this, it is placed in a known volume of water and the amount of water **displaced** equals the volume of the object.

Piece of **granite** stone with a mass of 13.5 g (0.0135 kg)

Volume = 0.000005 m^3

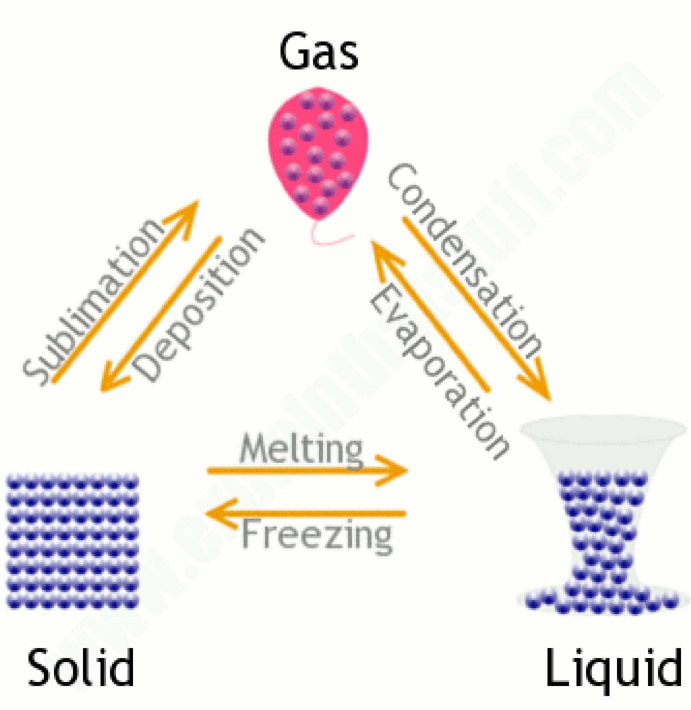
$$\text{Density of granite} = \frac{0.0135\ \text{kg}}{0.000005\ \text{m}^3} = 2\,690\ \text{kg/m}^3$$

Changes of state and the particle model – Changes of state

A change of state can be brought about by changing the **temperature** or **pressure** of a material.

If the solid shown has a mass of 1kg, then the liquid and gas will both have a mass of 1 kg.

Mass is conserved when a substance changes state, only the volume changes.



The arrows show the direction in change of state.

Changes of state are **physical changes not** chemical changes. The change can be **reversed** in a physical change so the material recovers its **original properties**. This does not happen with a chemical change.

Nuclear Radiation

Recall it ...

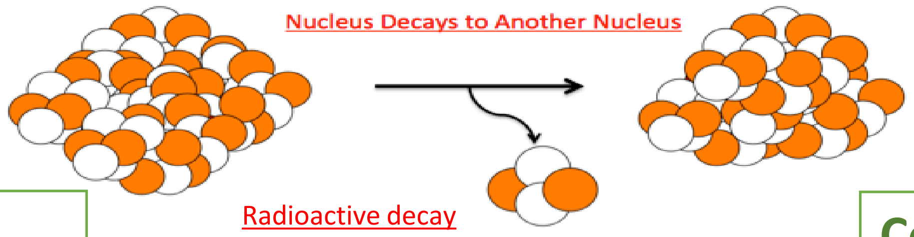
Use the information in the following page(s) to answer these questions …

1. What happens when an atom decays?
2. How is radioactivity measured? Do all radioactive isotopes decay at the same rate?
3. What is alpha, beta and gamma radiation? What are the symbols for them?
4. What does alpha, beta and gamma radiation penetrate through? What blocks alpha, beta and gamma radiation?
5. What is ionisation? Describe the properties of alpha, beta and gamma radiation e.g. range in air, ionisation, speed?
6. Is radioactive decay random or fixed? What is meant by half life? How can you find out half life on a graph?
7. Describe what is irradiation?
8. Describe what is contamination?

Radioactive decay and nuclear radiation

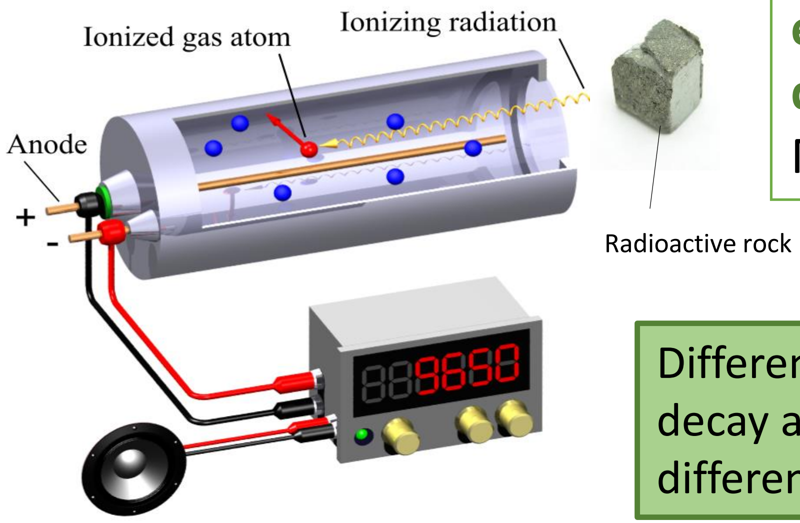
The nuclei of some atoms are unstable.
To become more stable these nuclei give out radiation.
This process is called radioactive decay.

Unstable atom



Stable atom

Activity = **rate at which a source of unstable nuclei decays**, measured in **becquerels (Bq).**

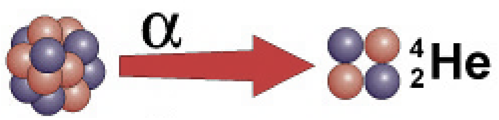


Count-rate = **number of decays recorded each second by a detector** (e.g. Geiger-Muller tube)

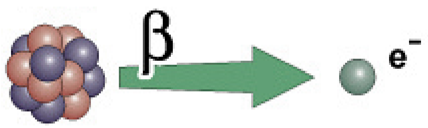
Different radioactive isotopes decay at different rates and emit different types of radiation.

Radioactive decay and nuclear radiation

There are three types of radioactive decay, **alpha, beta and gamma**. All come from the **nucleus of the atom**. In the examples below, only the nucleus is shown.



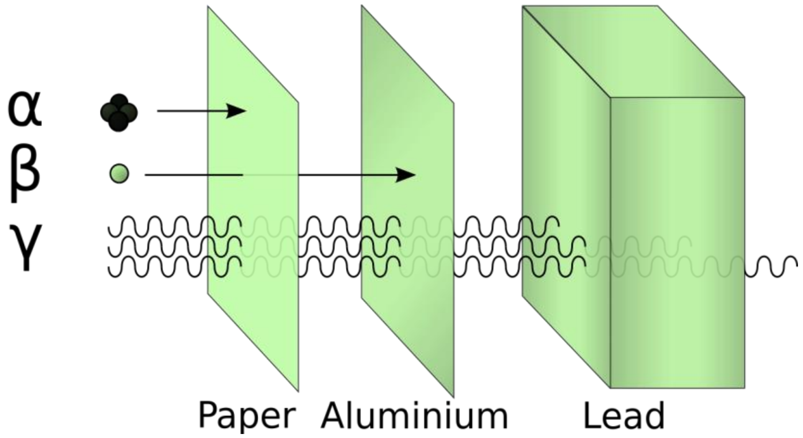
Alpha (symbol α or ^4_2He) consist of **2 protons and 2 neutrons** emitted from the nucleus. They have a **positive** charge as they contain 2 (+) protons.



Beta (symbol β or $^{0}_{-1}e$) consist of an **electron** emitted from the nucleus. This results from a neutron splitting into a proton and an electron. Beta particles are **negatively** charged.

Gamma rays (symbol γ) are **electromagnetic radiation** emitted from the nucleus. Gamma radiation has **no mass** and **no electrical charge.**

Properties of alpha, beta and gamma radiation.



Alpha, beta and gamma radiation can penetrate different materials due to their differing nature.

Alpha – easily stopped by **a few sheets of paper**.

Beta – penetrates paper but stopped by a thin **sheet of aluminium**.

Gamma – only stopped by **thick lead** or several metres of **concrete**.

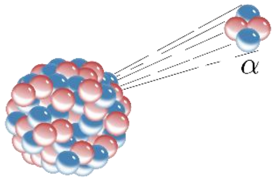
All three types of radiation cause **ionisation** of other atoms. If these atoms are in **living cells** it can cause damage which could lead to **cancer.**

Name	Symbol	Speed	Range in air	Ionising power
Alpha	α	Slowest	6 - 8 cm	High
Beta	β	Medium	1 – 2 m	Medium
Gamma	γ	Fastest	300 - 500 m	Low

Nuclear equations

Nuclear equations show the changes to an atom when it emits radiation.

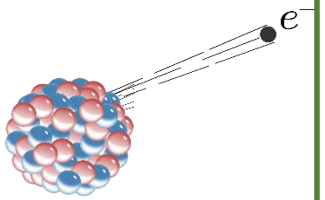
Alpha emission



Nucleus **loses 2 protons** and **2 neutrons**.
Atomic number will reduce by 2 and atomic mass by 4.

$$^{238}_{92}\mathrm{U} \longrightarrow {}^{234}_{90}\mathrm{Th} + {}^{4}_{2}\mathrm{He}$$

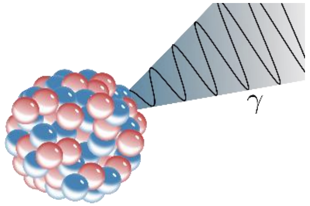
Beta emission



Nucleus **loses an electron** which is produced when a neutron turns into a proton. So **mass stays the same** but **atomic number of the product increases by one**.

$$^{14}_{6}\mathrm{C} \longrightarrow {}^{14}_{7}\mathrm{N} + {}^{0}_{-1}\mathrm{e}$$

Gamma emission



No particles are emitted so there is **no change to the nucleus**. Atomic mass and atomic number stay the same.

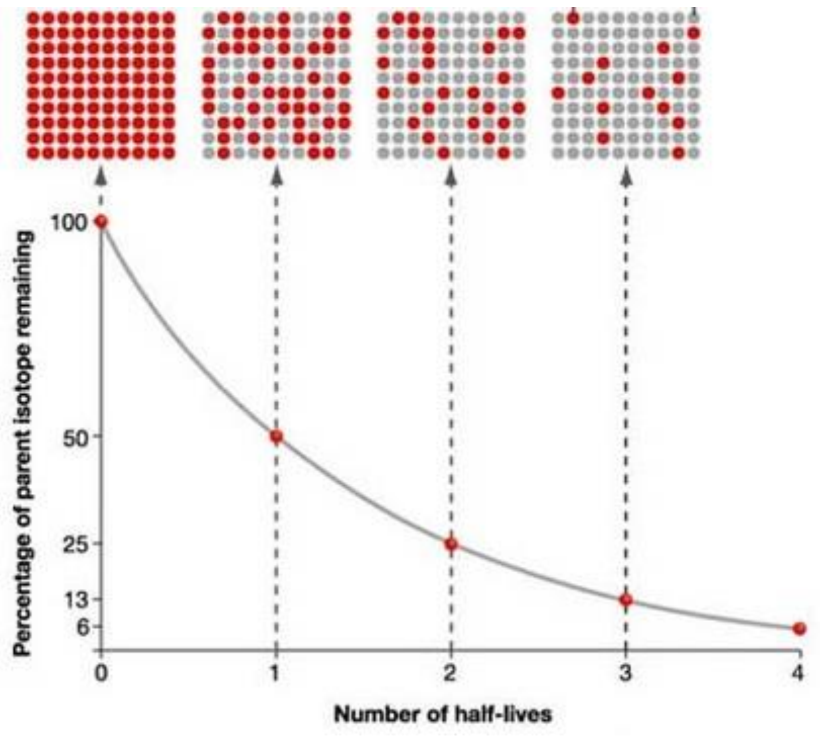
$$^{99}_{43}\mathrm{Tc} \longrightarrow {}^{99}_{43}\mathrm{Tc} + \gamma$$

Half life and the random nature of radioactive decay

Radioactive decay is a random process so the likelihood of a decay taking place is a probability problem. For this reason, the **half-life** of an isotope is given rather than saying how long it will take to fully decay.

The **half-life** of a radioactive isotope is the time it takes for the **number of nuclei** of the isotope in the sample to halve, or the time it takes for the **count rate** from a sample containing the isotope to fall to half its initial level.

The net decline of the isotope is the fraction remaining after a number of half lives.
E.g. 100 → 50 → 25
After 2 half lives net decline is 75/100 = **3/4**



Half life and the random nature of radioactive decay

Calculating the half life of a radioactive isotope.

If you know the start and finish count rate and the time taken, you can calculate the half life.

Example:

The count rate of an isotope is 1008 Bq. This falls to a count rate of 126 over a period of 21 days.

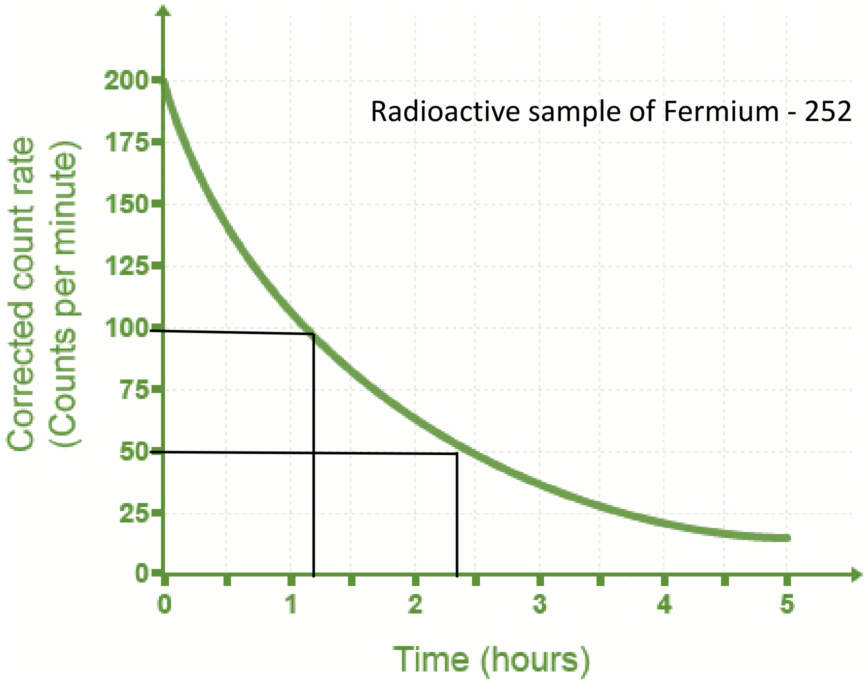
1008 → 504 → 252 → 126

1 2 3

3 half lives for count rate to fall to 126.

These 3 half lives took 21 days so each half life took 7 days.

Half life if this isotope = 7 days



200 counts / min at the beginning.

100 counts/min occurred after 1.2 hours.

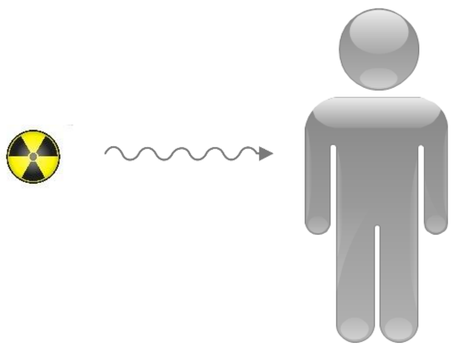
50 counts/min occurred after 2.4 hours.

It always takes 1.2 hours for the count rate to halve.

Half life of Fermium - 252 = 1.2 hours.

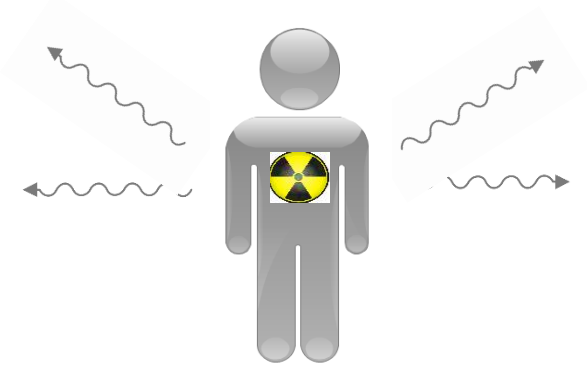
Radioactive substances can be hazardous by contamination or irradiation.

Irradiation is when an object or person is **exposed** to radiation. Protection from irradiation means stopping the radiation from reaching you.



Medical dressings are often irradiated but present no danger to the user.

Contamination is when a radioactive source is in **contact** with an object or person. The radioactive substance rather than the emissions are present.



The object remains radioactive until the contamination is removed or decays naturally.