How to use this knowledge organiser:

- Click on the name of the topic/page number/practical method you want to revise
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PHYSICS

Energy 1 - The Basics

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Paper 1:KS4

Energy stores and systems	Work done	Energy transfers	Conservation of energy	Calculating power	Measuring power	Efficiency	Reducing wasted energy	Thermal insulation practical (2 lessons)

Key Words

Key Word	definition
Energy	Measured in Joules (J)
Power	Rate of energy transfer. Measured in Watts (W)
Work done	Amount of energy transferred, measured in joules (J)
Energy changes	Discuss whether the size of the store is ***increasing***, ***decreasing*** or ***staying the same***.
Efficiency	How much output is useful compared to the input. Can be energy or power.
System	An object or group of objects involved in an energy transfer
Dissipated	Spread out into the surroundings
Lubrication	Used to reduce thermal energy due to friction between moving parts
Conductivity	Measures the rate of thermal energy transfer by conduction through a material

Misconceptions

Energy does not get 'used up'

It transfers to a different store

Energy and power are not the same thing

Energy is stored (joules), power measures how quickly energy is transferred (watts)

Work done is not different to energy transferred

Work done is another way to say energy is being transferred

Insulation does not only helps to reduce energy transfer from hot objects

Insulation reduces the rate of thermal energy transfer from whatever is hotter to whatever is colder

Key questions

What are the eight ways energy is stored?

What is meant by the law of conservation of energy?

What is meant by power? State the units of power.

Explain how lubrication/ insulation work to improve efficiency.

State the equations for calculating work done and power.

Physics Energy 1- The Basics

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Paper 1:KS4

Energy Stores

Energy Store	Description
Kinetic energy	Energy due to motion.
Gravitational Potential energy	Energy stored due to object's height in a gravitational field
Chemical Potential energy	Energy stored in chemical bonds.
Elastic Potential energy	Energy stored in stretched or compressed objects.
Magnetic energy	Energy stored by separated magnets
Electrostatic energy	Energy stored by charged objects
Nuclear Potential energy	Energy stored within the nucleus of an atom
Thermal/internal energy	Energy stored in an object that effects its temperature

Work done

Work is done to transfer energy from one store to another.

Work done equation

Work done (J) = Force (N) x Distance (m)

Power

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

Power equation

$$\text{Power (W)} = \frac{\text{Energy transferred (J)}}{\text{Time taken (s)}} \quad \text{or} \quad \text{Power (W)} = \frac{\text{Work done (J)}}{\text{Time taken (s)}}$$

Energy Transfers

Electrically – electrical current moves energy from a supply to a load
Heating – thermal energy transfers from hot to cold (conduction and convection - involves particles)
Radiation – waves transfer energy (light, sound, thermal energy transfer without particles)
Mechanically - forces transfer energy

Conservation of energy:

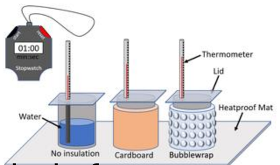
Energy can be transferred usefully, stored or dissipated, but cannot be created or destroyed.

Heating through Friction

- Car brakes - kinetic decreases, internal energy increases.
- The force that does work to cause this change is called FRICTION.

Thermal insulation practical (triple)

1. Use a kettle to boil water.
2. Start with a beaker with no insulation.
3. Put 80 cm^3 of this hot water into a beaker.
4. Use a piece of cardboard as a lid with a hole for a thermometer
5. Record the temperature of the water and start using the stopwatch.
6. Record the temperature of the water every 2 minutes for 20 minutes.
7. Repeat steps 1–5 using different materials wrapped around the beaker.



Ensure volume and starting temperature are always the same

Generating Electricity

Mains electricity Plugs	National grid	Energy resources Non renewables	Energy resources Renewables	Comparing energy resources	Calculating Ep	Biofuels	Plugging in to the National Grid

Key Words

Key Word	Definition
Alternating Potential Difference	Changing polarity (constantly switching between + and -) and size (constantly changes direction)
Direct Potential Difference	Constant polarity and size (flows in same direction).
Fossil fuels	Coal, oil and gas.
Mains Electricity	An a.c supply, in the UK it has a frequency of 50Hz a value of 230V.
Renewable Energy Resource	An energy resource that can be replenished as it is used.
Step-Down Transformers	Devices found between the transmission cables and the consumer that lower the potential difference of the power to make it safe.
Step-Up Transformers	Devices that increase the potential difference generated by a power station.
The National Grid	The network of transformers and cables that connect consumers to power stations.

Misconceptions

Power lines (overhead) are not usually insulated – it is very dangerous to fly kites/build tents near them

Birds are not resistant to electric shocks – they can sit on power lines because there is no connection to earth

Renewable resources are not better than non-renewables: they all have different advantages and disadvantages

All renewable resources are not good for the environment – some cause loss of habitats

Key questions

What is the structure and function of a three-pin plug?

What is the national grid and why is it needed?

What are the energy resources available on earth?

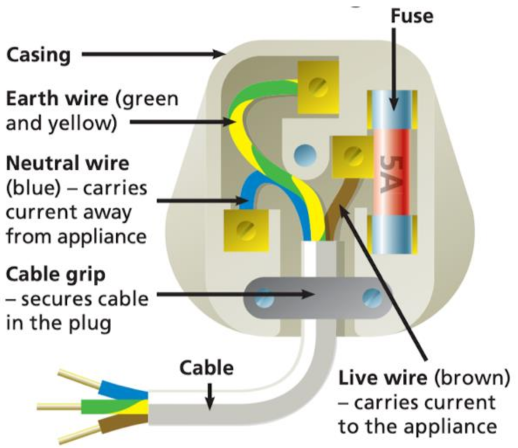
How can the gravitational potential energy stored by an object be calculated?

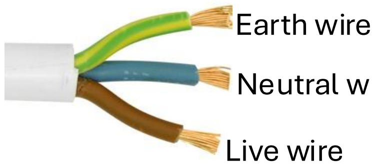
What are the advantages and disadvantages of using energy resources?

Three pin plugs

Earth Wire	The green and yellow striped safety wire that prevents an appliance from becoming live. Kept at 0V.
Insulation	The coating around power cables that prevents electrocution and is colour coded to allow for easy identification.
Live Wire	The brown coloured wire that carries the alternating potential difference of 230V from the supply in a mains power supply.
Neutral Wire	The blue coloured wire that completes the circuit in a mains power supply. Kept at 0V.

Electrical appliances are connected to the mains with a three-core cable, the three pins on a plug are the ends or terminals of the three wires.

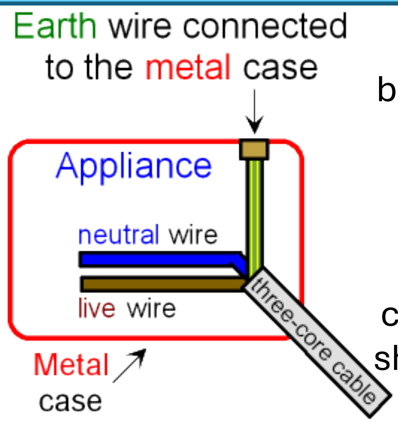




Some appliances use a two-core cable (don't need an earth wire) because they are made of plastic (an insulator)

Earth wires

- Safety wire connected to metal case of an appliance, kept at 0V
- Only carries a current if there is a fault and case becomes live (provides safe path for current to prevent electric shocks)
- Has low resistance
- Causes fuse to melt/blow to disconnect circuit and prevent electric shocks

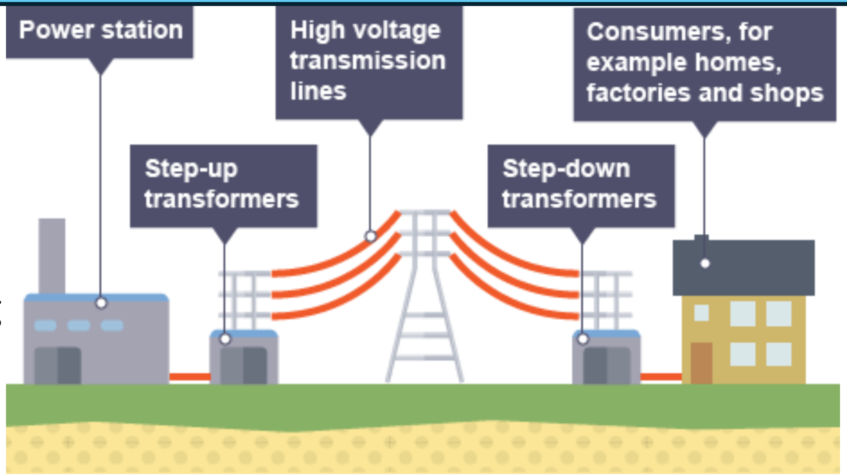


Any connection between the live and earth wire is very dangerous due to large potential difference which could cause electric shock or overheating (fires)

Even if the switch is off the live wire is still dangerous, if touched it can complete the path to earth (through you standing on the ground) and give you an electric shock

National grid

- Step-up transformers: increase the potential difference from power station to transmission cables (which decreases the current)
- Step-down transformers: decrease, to a much lower value, the pd for domestic use.
- Reason: for a given power (P=IV), increasing potential difference reduces current, which reduces energy losses due to heating in the transmission cables (increases efficiency).



Gravitational potential energy equation

Gravitational potential energy (J) = mass (kg) x gravitational field strength (N/kg) x height (m)

$E_p = m \times g \times h$

Main energy resources available on Earth

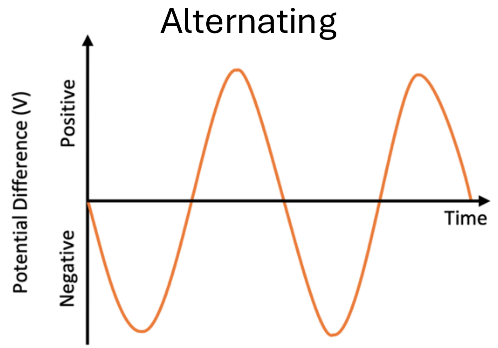
- fossil fuels - burn (coal, oil, gas) N ✔
- nuclear fuel - nuclear fission reaction in nuclear power stations N ✔
- bio-fuel - burn products from plants/animals R ✔
- wind - wind turbines R X
- hydroelectricity- water falling through turbines from behind dams R ✔
- geothermal - heat from radioactive rocks underground R ✔
- the tides - tidal water moving through turbines (in a barrage) R ✔
- the Sun - solar panels or solar cells R X
- water waves - waves rocking floats/moving air through a turbine R X

Key:
- renewable: being replenished as it is used (marked R)
- non-renewable: cannot easily be replenished so will run out (marked N)
- reliable resources marked ✔ (can be depended on)
- unreliable resources marked X (e.g. wind doesn't always blow, Sun sometimes behind clouds, these are unpredictable)
- uses of energy resources include: transport, electricity generation, heating

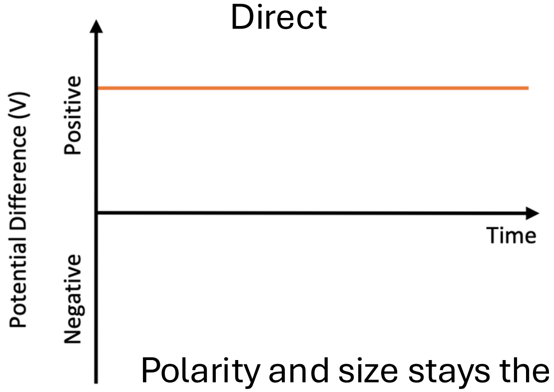
Political, Social, Economic, Ethical, Environmental Issues

- fossil fuels - → CO_2 causing global warming
- nuclear fuel - danger of explosion / leakage & waste very toxic (radioactive) for many years
- bio-fuel - → CO_2 but it came from the atmosphere originally, so no overall increase, growing bio-fuels instead of food can lead to shortages/price increases
- wind - wind turbines are an eyesore
- hydroelectricity - valleys must be flooded, displacing wildlife and farmers
- geothermal - only some places are suitable (e.g. Iceland due to volcanic activity)
- the tides - barrage destroys environments for wildlife
- the Sun - good for remote areas but solar cells are expensive
- water waves - viable large scale machines not yet built

Direct and alternating potential difference



Polarity and size constantly changing (from mains from power stations)



Polarity and size stays the same (from batteries and cells)

PHYSICS

CIRCUITS 1

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Paper 1:KS4

Circuit symbols	Current and charge	V=IR	Current in series and parallel	Potential difference in series and parallel	Circuit problem solving	Resistance of a wire	Resistors in series and parallel	Alternating and direct potential difference

Key Words

Key Word	Definition
Amperes (Amps)	The unit of current.
Coulomb	The unit of charge.
Electrical Current	The rate of flow of electrical charge
Electrical Work	When charge flows in a circuit, electrical work is said to be done.
Ohms	The unit of resistance.
Potential Difference	The energy transferred to or by each unit of charge, measured in volts.
Power	The rate of energy transfer. In electrical components, the power is found by multiplying p.d. by current.
Resistance	A measure of the opposition to current flow.
Volt	The unit of potential difference.
Work	Transfer of energy.

Misconceptions

Current is not used up as it flows around a circuit

Cells and batteries do not store current. Cells and batteries store chemical energy.

Potential difference does not flow through components, it measures the difference in energy across the component.

A cell or battery does not produce a fixed current, the current depends on the potential difference of the cell and resistance of the circuit

Key questions

What is the difference between series and parallel circuits?

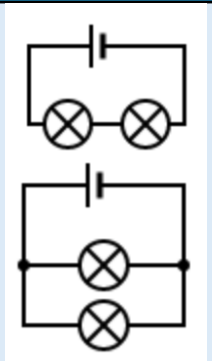
What is current and what does it do in series and parallel circuits?

What is potential difference and what happens to it in series and parallel circuits?

How are length of wire and resistance related?

How does connecting resistors in series and parallel effect total resistance?

Series and parallel circuits

	Series circuits have one loop/path Parallel circuits have two or more loops/paths/branches
Current	Series: is the same everywhere. Parallel: splits/rejoins at branches
Potential difference	Series: pd of power supply is shared between components. Parallel: is same as power supply across each loop/branch
Resistance	Series: total R = sum of resistances of all components Parallel: total R is reduced as current can follow more paths

Charge and current

Charge – electrons with negative charge, measured in coulombs (C)

Current – rate of flow of charge, measured in amps (A)

Q = I x t

Charge (C) = current (A) x time (s)

Current, resistance and potential difference

Potential difference or voltage – energy transferred to or by each coulomb of charge, needed for a current, measured in volts (V)

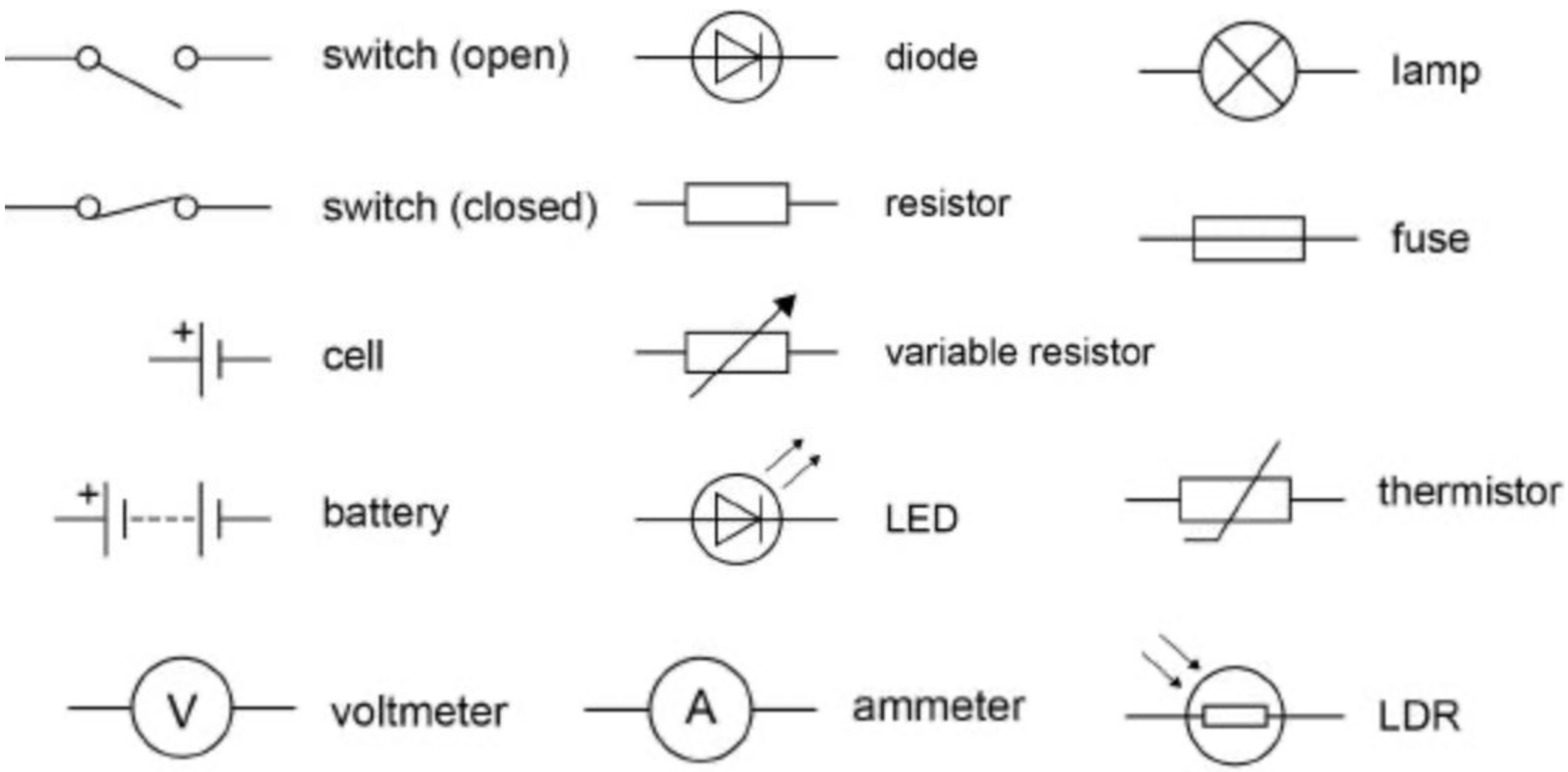
Resistance – how difficult it is for current to flow, measured in ohms (Ω)

Higher resistance means lower current for a give potential difference

V = I x R

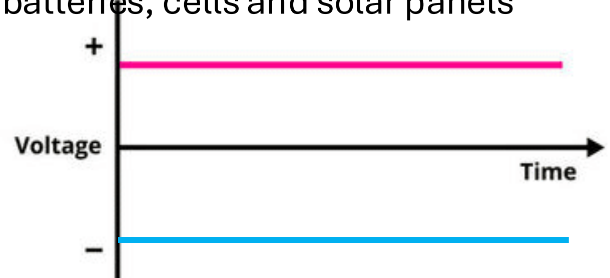
Potential difference (V) = current (A) x resistance (Ω)

Circuit components



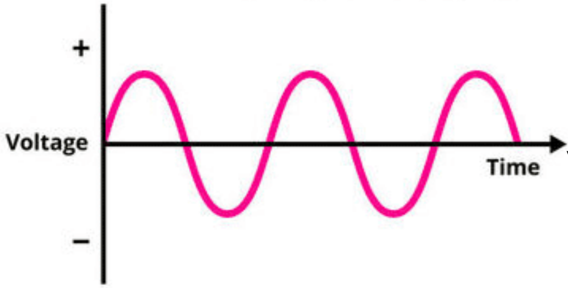
Types of potential difference

Direct potential difference flows in the same direction, it has a constant magnitude (size) and a constant polarity. Produced by batteries, cells and solar panels



Switching the poles of the supply will swap the direction of flow (blue line)

Alternating potential difference constantly changes polarity (between positive and negative) which reverses the direction of the current frequently. The rate at which the potential difference switches from positive to negative is called the frequency of the supply (50 Hz in the UK). Produced by power stations.



Has changing magnitude. +ve and –ve values indicate the direction of current flow.

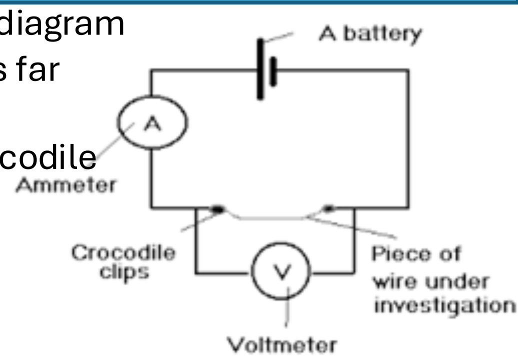
Resistance

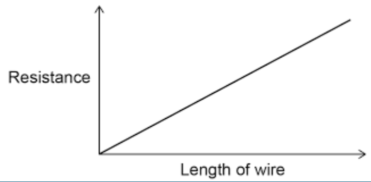
Resistance is affected by:

- The length of the wire or component - In a longer wire **electrons** must pass more **ions**. Passing more **ions** means more collisions between the **electrons** and the **ions** = greater resistance
- The thickness of the wire or component - In a thin wire there are fewer **electrons** to carry the current = greater resistance
- The temperature of the wire or component – at higher temperatures **ions** vibrate faster and further. **Electrons** are more likely to collide with **ions** if the **ions** are vibrating more = greater resistance
- The material the wire or components is made of - Some materials have more densely packed **ions** = greater resistance

Resistance of a wire practical

1. Set up the equipment as shown in the diagram
2. Place the crocodile clips on the wire as far apart as possible.
3. Measure the distance between the crocodile clips in m using a ruler.
4. Turn on the power supply and immediately record the voltmeter and ammeter readings.
5. Turn off the power supply.
6. Calculate the resistance of the wire using R = V / I
7. Repeat steps 2-6 reducing the distance between the crocodile clips each time.

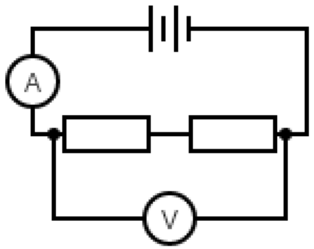


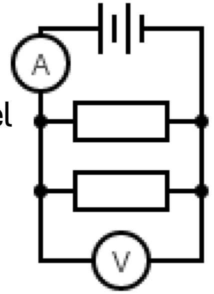


Length of wire is directly proportional to resistance (at constant temperature)

Resistors in series and parallel

1. Connect the resistors in series as shown in the diagram (below left)
2. Record the values for current and potential difference
3. Calculate the resistance using R = V / I
4. Now connect the resistors in parallel as shown in the diagram (right)
5. Repeat steps 2 and 3 for resistors in parallel





Total resistance in series = sum of individual resistors (adding resistors increases resistance)

Total resistance in parallel = less than resistance of one resistor (adding resistors decreases resistance as current increases due to more paths)

Key Words

Key Word	Definition
Model	Models are used all the time in science. A model represents the real world and can explain many things about the universe. However, models are never perfect and there are limits to what they can explain. That doesn't stop them being extremely useful though!
Particle model	The model that represents molecules or atoms as small, hard spheres. The important things to think about when using the particle model are the arrangement of the particles in each state of matter and the kinetic energy of the particles.
State of matter	The physical arrangement of particles determines the state of a particular substance: solid, liquid or gas. Changing from one state of matter to another is a physical process, NOT a chemical process. No new substance is produced, and if you reverse the state change, you have a substance with exactly the same properties as the stuff you started with.
Density	The quantity that defines how much material (i.e. mass) is in a certain volume. See equation.

Misconceptions

Heating does not cause particles to get bigger. They move around faster and take up more space.

Particles in a liquid are not halfway between solid and gas. They are closer to solids as particles are closely packed.

Models do not represent reality. They are not a perfect representation but help to understand a concept.

Evaporation is not the same as boiling. Boiling happens at a fix temperature for a pure substance, evaporation can happen at any temperature if particles posses enough energy to escape the surface of the liquid.

Key questions

How has the model of the atom changed?

Describe the arrangement and energy of the states of matter.

How can density of a liquid, regular and irregular solid be measured?

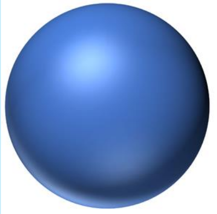
What is internal energy and how does change of state effect it?

What is gas pressure?

Physics — Particle Model (combined)

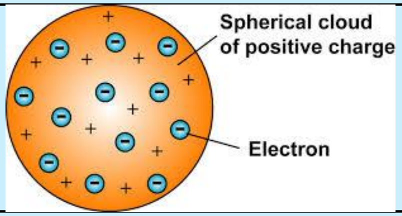
Development of the model of the atom

Dalton (1803)



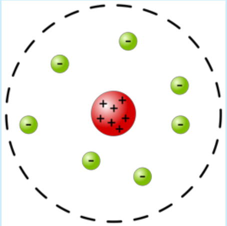
Suggested atoms are indivisible solid spheres based only on observations

JJ Thomson – plum pudding model (1897)



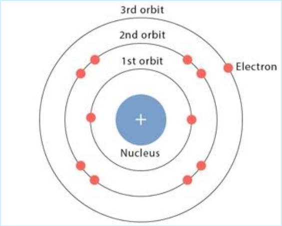
Discovered electrons in atoms and suggested the 'plum pudding' model for an atom - made up of electrons scattered throughout a spherical cloud of positive charge.

Rutherford – nuclear model (1911)



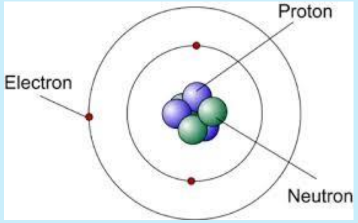
Rutherford fired positively charged alpha particles at a thin sheet of gold foil. Most passed through with little deflection, but some deflected at large angles. This was only possible if the atom was mostly empty space, with the positive charge (and mass) concentrated in the centre: the nucleus. Led to the discovery of positively charged nucleus with electrons orbiting this nucleus.

Bohr (1913)



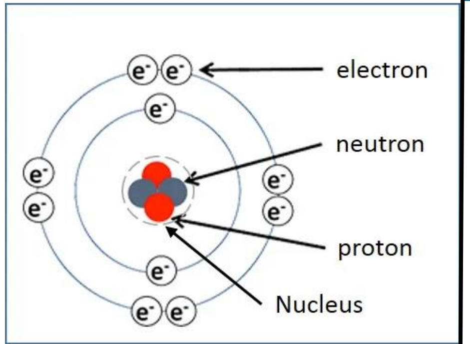
Bohr modified Rutherford's model of the atom by stating that electrons moved around the nucleus in orbits of fixed sizes and energies. (Electron shells)

Chadwick (1932)



Discovered neutrons in the nucleus.
Positively charged particle called proton.

Structure of atom



Size of atoms

Atoms have a radius of 0.1nm (1×10^{-10}m)

The radius of the nucleus is 1/10 000 of that of an atom (1×10^{-14}m)

Subatomic particles

Subatomic particle	Mass	Charge
Proton	1	+1
Electron	1/2000 or very small	-1
Neutron	1	0

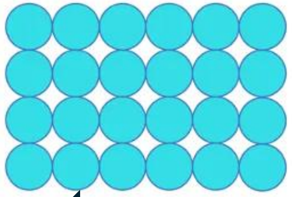
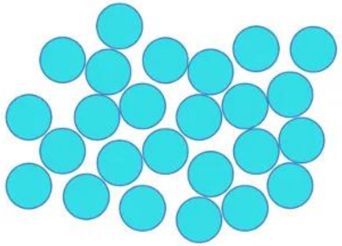
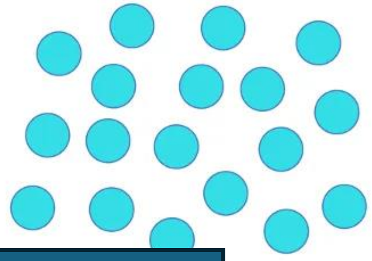
Isotopes

Atoms of the same element with the same number of protons and electrons but different numbers of neutrons

Charge of atoms

The number of protons (+) and electrons (-) are always equal in an atom – so atoms have no overall charge

States of matter

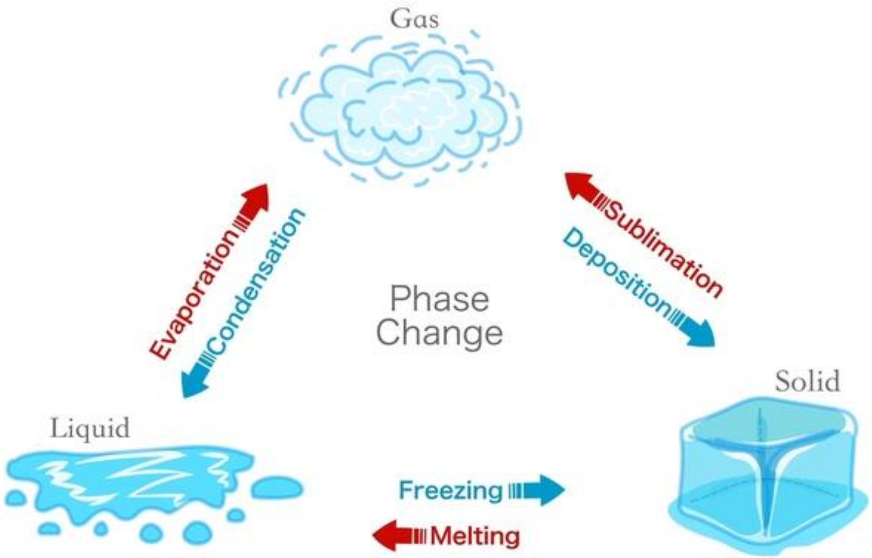
	Solid	Liquid	Gas
Arrangement of Particles	regular pattern close together	irregular pattern close together	irregular pattern far apart
Movement of Particles	vibrate around their fixed positions	move past each other in random directions	random directions at a range of speeds
Diagram			

← Increasing density

Increasing internal energy →

Changes of state

- Melt: solid → liquid
- Freeze: liquid → solid
- Boil: Liquid → gas (at boiling point)
- Evaporate: liquid → gas
- Condense: gas → liquid
- Sublimate: solid → (straight to) gas
- Mass conserved for all these changes
- Changes of state = physical changes - material recovers original properties if change reversed (chemical changes don't)



Internal energy

Internal energy: energy stored by particles (atoms & molecules)

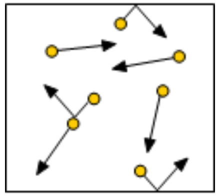
Internal energy =
kinetic energy + potential energy of particles

Heating → increases energy of particles by:

- raising temperature = increase in kinetic energy
- producing change of state → as distance between particles increases, potential energy increases

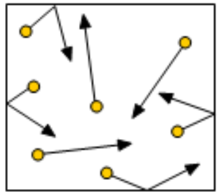
Particle motion in gases

Particles in a gas are constantly moving – so store kinetic energy. They collide with the walls of the container, and exert a force when they do. The total force exerted on a certain area of the wall is the gas pressure.



cold
Lower pressure

The average kinetic energy of the particles is related to the temperature of the gas. The higher the temperature, the more kinetic energy they have. This means they move faster. Therefore, there are more collisions with the container walls and they exert a greater force when they collide with the walls. Thus, increasing the temperature of a gas (keeping the volume the same) increases the pressure of the gas.



hot
Higher pressure

The pressure from gas molecules may increase if there are more molecules colliding each second or if the molecules are moving faster.

Density

Density describes how closely packed the particles are in a solid, liquid or gas. Scientists can measure how tightly packed the particles are by measuring **the mass of a certain volume** of the material. Usually measured in kilograms per metre cubed (kg/m^3) or grams per centimetre cubed (g/cm^3).

Density can be calculated using the equation:

$$density = \frac{mass}{volume}$$

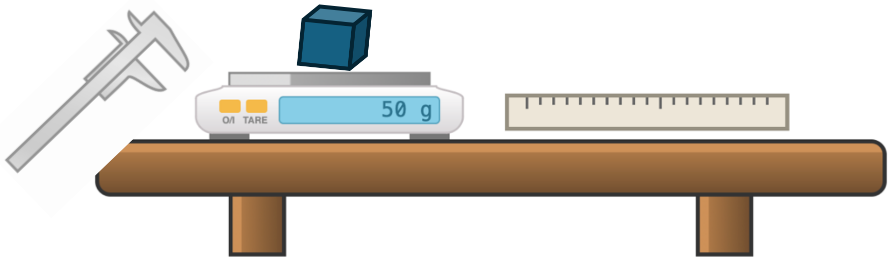
$$p = \frac{m}{V}$$

This is when:

- density (*p*) is measured in kilograms per metre cubed (kg/m^3)
- mass (*m*) is measured in kilograms (kg)
- volume (*V*) is measured in metres cubed (m^3)

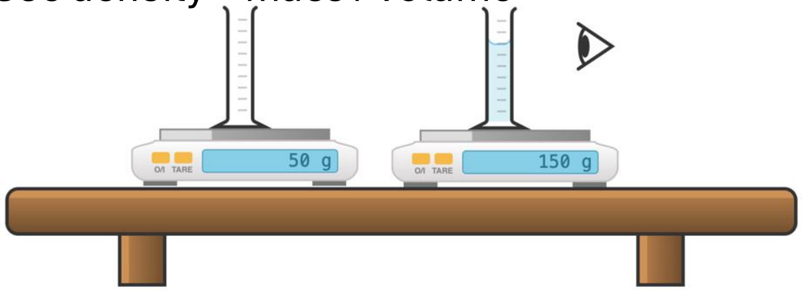
Density of regular solid

- Measure mass using balance
- Measure length, width, height with ruler or vernier calipers and calculate volume l x w x h
- Use density = mass / volume



Density of liquid

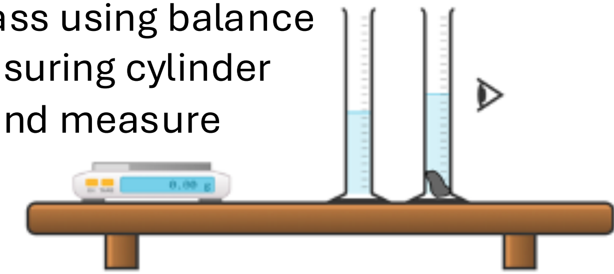
- Measure mass of empty measuring cylinder using balance
- Fill measuring cylinder with liquid and measure mass
- Find difference between full and empty
- Measure volume
- Use density = mass / volume



Density of irregular solid

Displacement method – small item

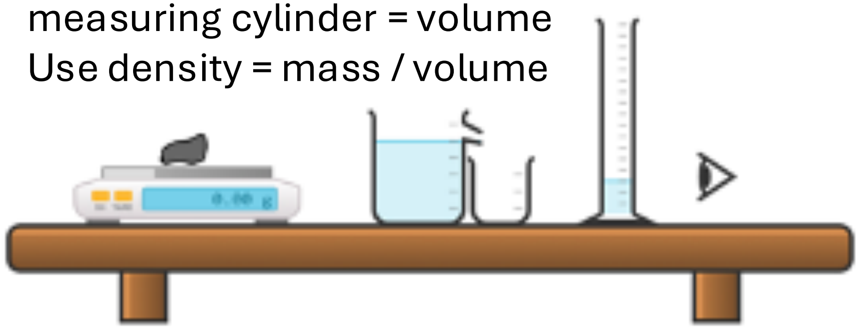
- Measure mass using balance
- Half fill measuring cylinder with water and measure volume



- Add object carefully and measure new volume
- Difference in volume = volume of object
- Use density = mass / volume

Displacement method – large item

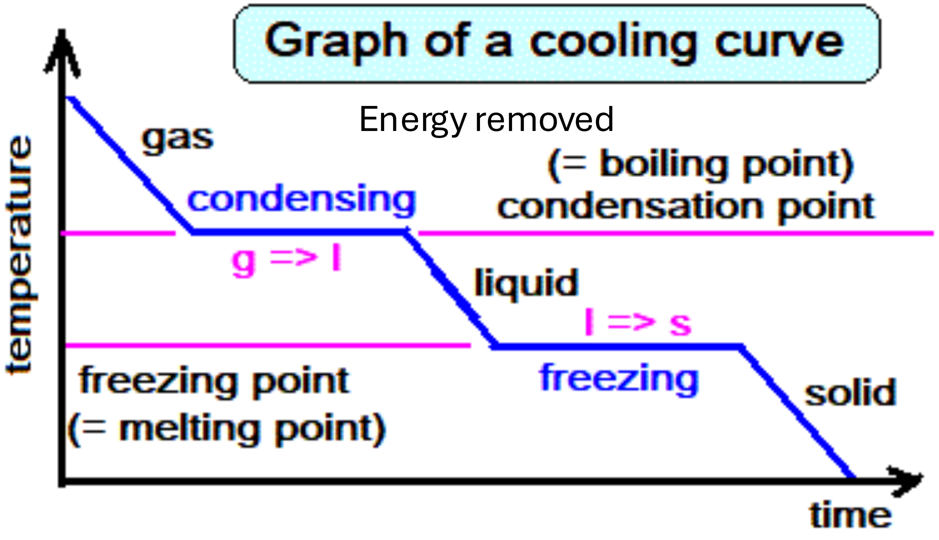
- Measure mass using balance
- Fill displacement can with water up to spout
- Add object carefully and collect displaced water
- Measure volume of displaced water with measuring cylinder = volume
- Use density = mass / volume

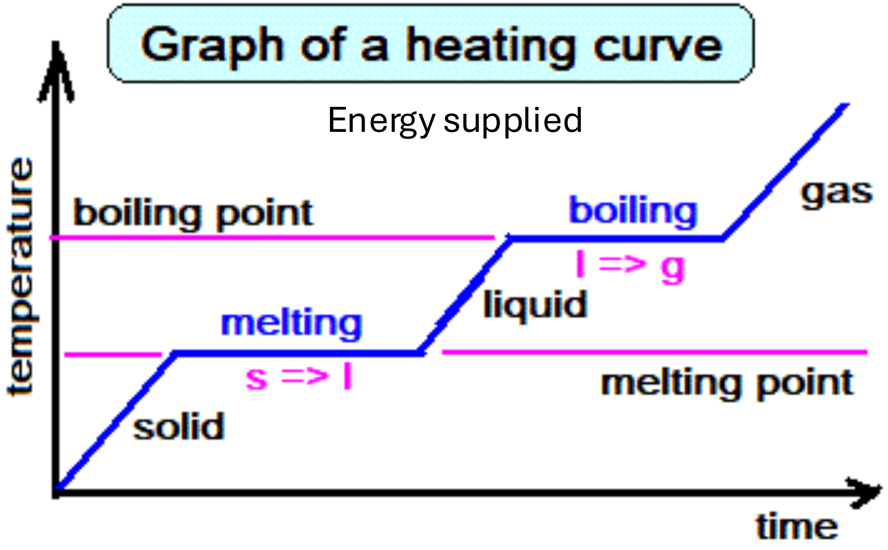


Specific latent heat

Specific latent heat	The energy needed to change the state of one kilogram of a substance with no change in temperature
Specific latent heat of fusion	The energy needed to change the state of one kilogram of a substance **from a solid to a liquid** with no change in temperature
Specific latent heat of vaporisation	The energy needed to change the state of one kilogram of a substance **from a liquid to a gas/vapour** with no change in temperature

The graph is horizontal at two places. These are where energy is being used to break the bonds between the particles to change the state, rather than increase the speed (and so temperature) of the particles.
The longer the horizontal line, the more energy has been used to cause the change of state. The amount of energy represented by these horizontal lines is equal to the latent heat.





E = m x L

Energy required to change the state of the substance depends on the mass and its specific latent heat

Energy = mass x specific latent heat

(E = m x L)

Energy (J)
Mass (kg)
Specific latent heat (J/kg)

Key words

Kinetic energy	The energy associated with movement. The kinetic energy of particles in any state of matter is related to the temperature of the matter.
Temperature	A measure of the average kinetic energy of particles in a substance. As temperature increases, the average kinetic energy increases. Note: temperature does not measure the potential energy of particles, just their kinetic energy.
Heating	Heating is one way to transfer energy from one store to another.

Energy Calculations

Back to contents

Energy transfers	Calculating efficiency	Kinetic energy calculations	Ee calculations	Linking equations	Specific heat capacity	Specific heat capacity practical

Key Words

Key Word	Definition
Efficiency	The ratio of useful output energy transfer to total energy input.
Elastic Potential Energy	The store of energy that stretched or compressed objects experience.
Kinetic Energy	The store of energy that all moving matter has.
Specific Heat Capacity	The amount of energy required to raise the temperature of 1kg of a substance by 1°C.
Spring Constant	A measure of a spring's stiffness.

Misconceptions

Doubling the speed of a moving object does not double the kinetic energy

Speed is squared

The only type of potential energy is not gravitational

Potential is any that is stored up ready to be release (elastic, chemical, nuclear…)

Elastic potential energy is not only stored in stretched objects

It is also stored in compressed elastic objects

Heat and temperature are not the same thing

Heat (joules), temperature (°C) how hot/cold object is, change in heat depends on change in temperature, mass, specific heat capacity

Key questions

What factors affect the amount of kinetic energy stored?

What factors affect the amount of Ee stored?

How is extension calculated?

What happens during energy transfers between Ep and Ek?

What is meant by 'specific heat capacity'?

How can the specific heat capacity of a material by determined by experiment?

Equations to learn

Efficiency

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

Kinetic energy

Kinetic energy (J) = 0.5 x mass (kg) x velocity^2 (m/s)

Gravitational potential energy

Ep (J) = m (kg) x g (N/kg) x h (m)

Equations provided

Elastic potential energy

Ee (J) = 0.5 x spring constant (N/kg) x extension^2 (m)

Specific heat capacity

Energy (J) = mass (kg) x c (J/kg^{o}C) x temperature change (^{o}C)

Efficiency

- Useful energy – Any energy that is transferred into a store that is used for the intended purpose.
- Wasted energy – Any energy that is ***dissipated***. Calculated efficiency will be a decimal.

Storing elastic potential energy

Two forces must be applied to elastic object to store Ee
Compression or extension will increase store of Ee

Ee stored depends on EXTENSION
Ee stored depends on spring constant

Changes in energy

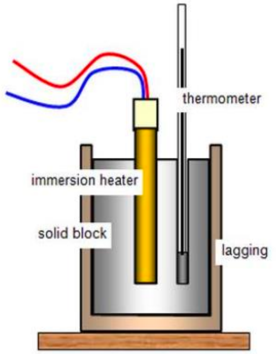
As one store decreases one or more stores increase (conservation of energy). For a child on a trampoline:
100 J of Ep at top of bounce will transfer to 100 J of Ek at bottom and 100 J of Ee on trampoline, some energy will be dissipated to thermal in surroundings, but total will equal 100 J

Specific heat capacity

Energy required to raise the temperature of 1kg of a material by 1^{o}C (J/kg ^{o}C)

Specific heat capacity practical

1. $c = \frac{\Delta E}{m \, \Delta\theta}$
2. Measure mass of block using balance
3. Connect immersion heater to powerpack and joulemeter, put in block with thermometer
4. Measure start temperature of block
5. Measure electrical energy transferred to block using joulemeter
6. Measure end temperature and find change
7. Use equation to calculate the SHC



Calculated value likely to be higher, improve accuracy by insulating block

CFIFA – setting out calculations

Set out calculations using CFIFA to maximise marks:

Convert Have standard units been used? Clearly show how you convert them e.g. x100, ÷1000
Formula Write the formula (equation) as you've learnt it/as it is on the equation sheet e.g. W = F x s
Insert Insert the values from the question replacing the parts of the formula above e.g. 10 = F x 5
Fine tune Show any rearranging needed (write what every you put into your calculator) e.g. $\frac{10}{5} = F$
Answer Give your answer, check if you need to give unit or to certain number of significant figures etc.

PHYSICS CIRCUITS 2 combined

Circuits recap	LDRs	Thermistors	IV characteristics	IV characteristics	Diodes	Potential dividers	EVQ and energy transfers	Electrical power equations

Key Words

Key Word	Definition
Amperes (Amps)	The unit of current.
Coulomb	The unit of charge.
Electrical Current	The rate of flow of electrical charge
Electrical Work	When charge flows in a circuit, electrical work is said to be done.
Ohms	The unit of resistance.
Potential Difference	The energy transferred to or by each unit of charge, measured in volts.
Power	The rate of energy transfer. In electrical components, the power is found by multiplying p.d. by current.
Resistance	A measure of the opposition to current flow.
Volt	The unit of potential difference.
Work	Transfer of energy.

Misconceptions

- Current is not used up as it flows around a circuit
- Cells and batteries do not store current. Cells and batteries store chemical energy.
- Potential difference does not flow through components, it measures the difference in energy across the component.
- A cell or battery does not produce a fixed current, the current depends on the potential difference of the cell and resistance of the circuit

Key questions

- What is an LDR/thermistor and how does its resistance change?
- How can the IV characteristic of a resistor/ filament bulb/ diode be identified?
- What effect do diodes have on circuits?
- What is an ohmic conductor?
- What is electrical power and how can it be calculated?

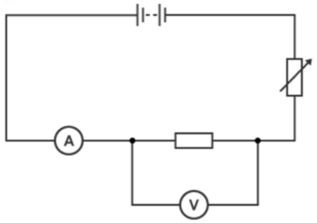
Physics — Circuits 2

Components

Component	Description
Diode	A component that only allows current to flow through in the forward direction. They have very large resistances in the reverse direction.
Filament Lamp	A light emitting component consisting of an enclosed metal filament. Its resistance increases as the filament's temperature increases.
Light Dependent Resistor (LDR)	A light sensitive component whose resistance increases as its temperature decreases. (Light Up Resistance Down, LURD)
Ohmic Conductor	A conductor whose current flow is directly proportional to the potential difference across it, when held at a constant temperature.
Thermistor	A temperature dependent component, whose resistance increases as its temperature decreases. (Temperature Up Resistance Down, TURD)

Required practical – IV characteristics

Safety:
Disconnect circuit when not taking readings to prevent overheating
Wires/components may get hot, allow to cool before handling



Equations

Energy Transferred – this depends on how long the appliance is on for and its power.
- Energy transferred (J) = power (W) × time (s) — $E = Pt$

Energy is transferred around a circuit when the charge moves.
- Energy transferred (J) = charge flow (C) × potential difference (V) — $E = QV$
- Power (W) = potential difference (V) × current (A) — $P = VI$
- Power (W) = current^2 (A) × resistance (Ω) — $P = I^2R$

From circuits 1:
$Q = It$
$V = IR$

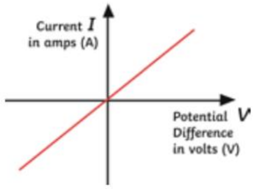
Common conversions:
1 kW = 1000 W
1 mA = 0.001A

IV practical method

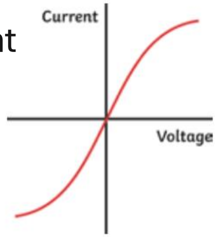
1. Set up the equipment as shown in the diagram.
2. Record the current from the ammeter and potential difference from the voltmeter.
3. Adjust the variable resistor.
4. Record the new current and potential difference.
5. Repeat this until you have 4-6 pairs of readings.
6. Swap the connections to reverse the polarity of the battery.
7. Repeat steps 3-4 until you have 4-6 negative pairs or readings.
8. Plot a graph of current against potential difference for each component.
9. Repeat the experiment replacing the fixed resistor with a filament lamp and diode.

Graphs of I-V Characteristics for Components in a Circuit

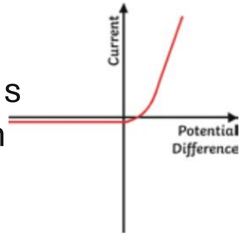
1. Ohmic conductor (fixed resistor): the current is directly proportional to the potential difference - it is a straight line (at a constant temperature).



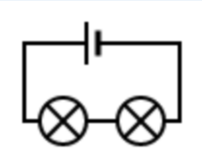
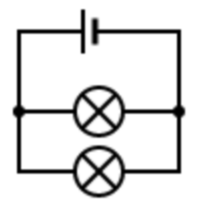
2. Filament lamp: as the current increases, so does the temperature. This makes it harder for the current to flow. The graph becomes less steep.



3. Diode: current only flows in one direction. The resistance is very high in the other direction which means no current can flow.



Series and parallel circuits

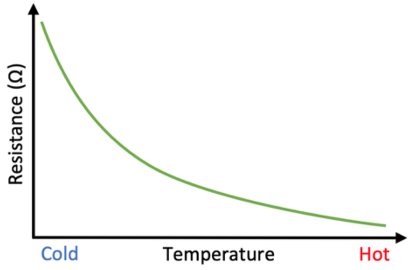
	Series circuits have one loop.
	Parallel circuits have two or more loops.
Current	Series: is the same everywhere. Parallel: is split between loops
Potential difference	Series: pd of power supply is shared between components. Parallel: is same across each loop
Resistance	Series: total R = sum of resistances of all components Parallel: total R is reduced as current can follow more paths

Energy transfers

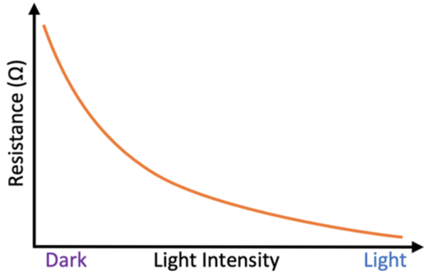
All electrical appliances transfer energy from one store to another. The amount of energy transferred depends on the power of the appliance and how long it is on for (E=Pt). Energy is transferred around a circuit when a charge flows (E=QV).

Resistance graphs

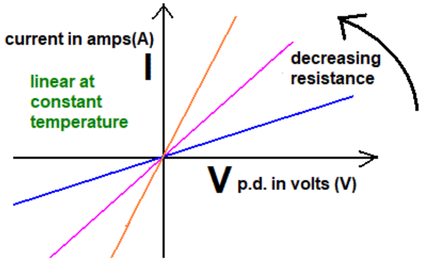
Thermistors – resistance decreases as temperature increases. Uses: thermostats, ovens, digital thermometers, car engines



Light dependent resistors – resistance decreases as light intensity increases. Uses: streetlights, automatic security lighting, photographic light meters

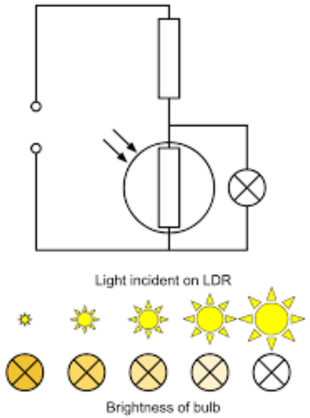


Fixed resistor (at constant temperature) – steeper gradient = lower resistance

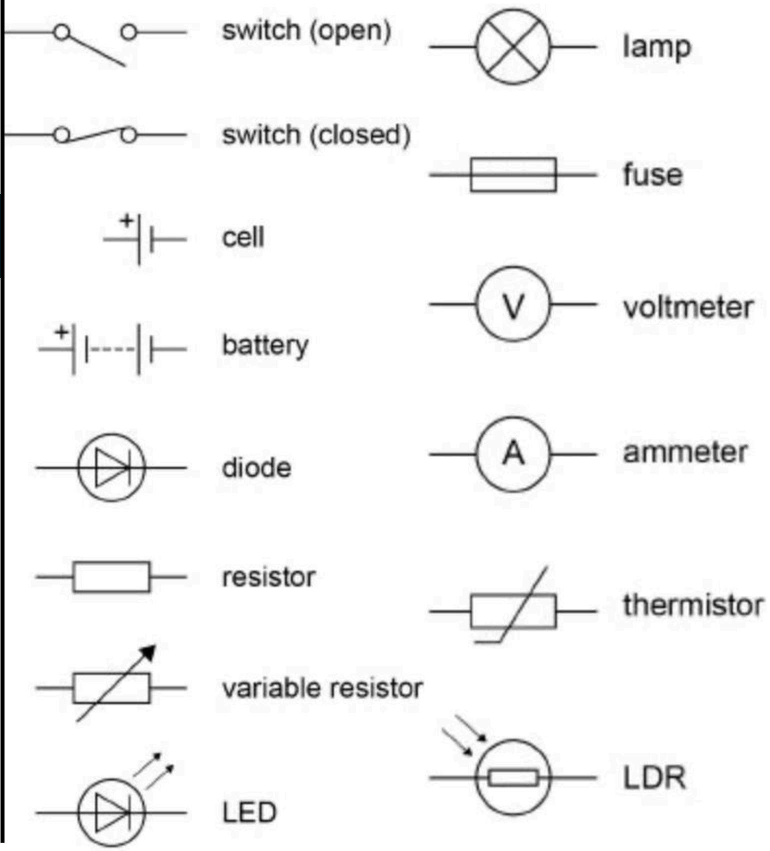


Potential dividers

A potential divider **splits the potential difference of a power source between two components.** The potential difference across each resistor depends upon its resistance: The resistor with the largest resistance will have a greater potential difference than the other one. Used with LDR/thermistor to turn on light/heater.



Circuit components



Types of radiation	Nuclear decay equations	Half life and activity	Hazards of radiation	Uses of radiation

Key Words

Key Word	Definition
Activity	The rate at which an unstable nucleus decays.
Atomic Number	The number of protons found in an atom of a specific element. Each element has a different atomic number.
Becquerel	The unit of radioactive activity. 1 Bq = 1 decay per second = 1 count per second
Count-Rate	The number of decays that a detector measures per second.
Geiger-Muller Tube	A detector that measures the count-rate of a radioactive sample.
Ions	Atoms with a charge due to the loss or gain of electrons.
Isotopes	Atoms with the same number of protons but different numbers of neutrons. The atomic number is the same, but the mass number is different.
Mass Number	The number of protons and neutrons in an atom.
Radioactive Decay	The random process involving unstable nuclei emitting radiation to become more stable.

Misconceptions

- Being irradiated does not make you radioactive
- Exposure to radiation does not cause immediate symptoms
- Radiation cannot be neutralised
- All radiation does not have the same danger level

Key questions

- What are the types of radiation and their properties?
- How is nuclear decay represented as an equation?
- What is half-life and how does it effect activity?
- What are the hazards of radiation and how can they be minimised?
- What are the uses of radiation linked to their properties?

Key words

Key Word	Definition
Alpha Particle	A positively charged particle consisting of two protons and two neutrons.
Beta Particle	A high speed electron that a nucleus emits when a neutron converts into a proton.
Gamma Ray	Electromagnetic radiation emitted from a nucleus.
Half-Life	The time it takes for the number of unstable nuclei of an isotope in a sample to halve, or the time it takes for the initial count rate of a sample of the isotope to halve.

Radiation and hazard level

Alpha = more dangerous inside body due to high ionising power and at very short distances. Less dangerous outside body as it cannot penetrate skin and as distance to source increases.

Beta = less dangerous inside body as some radiation can escape and at large distances. More dangerous outside body as it can penetrate skin and at moderate distances.

Gamma = less dangerous inside body as most will pass out and is least ionising. More dangerous at long distances as it has greatest range in air and can penetrate skin.

Radiation Properties

	Symbol	Penetrating power	Ionising power	Range in air
Alpha	α	Skin/paper	High	< 5 centimetre (cm)
Beta	β	3 mm aluminium foil	Moderate	≈ 1 metre (m)
Gamma	γ	Lead/concrete	Low	> 1 kilometre (km)
Neutron	n	An uncharged particle		

Nuclear decay equations

- Nuclear equations: represent radioactive decay.
- Alpha particle: $^{4}_{2}\text{He}$
- Beta particle: $^{0}_{-1}\text{e}$
- Emission of different types of nuclear radiation may cause change in mass and /or charge (atomic number) of nucleus. Eg:

$$^{219}_{86}\text{radon} \longrightarrow \, ^{215}_{84}\text{polonium} + \, ^{4}_{2}\text{He}$$

- Alpha decay decreases both mass & charge of nucleus (mass -4, atomic number -2)

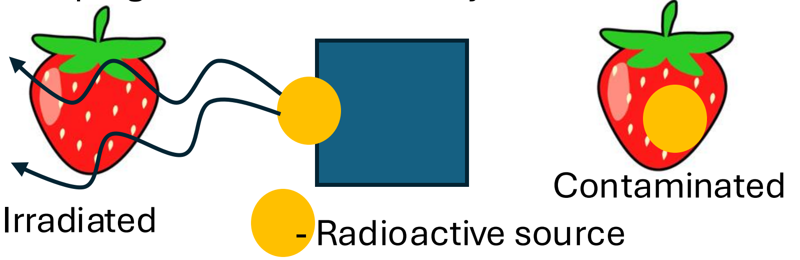
$$^{14}_{6}\text{carbon} \longrightarrow \, ^{14}_{7}\text{nitrogen} + \, ^{0}_{-1}\text{e}$$

- Beta decay → no change in mass of nucleus but charge increases (atomic number +1)
- Gamma emission → no change in mass or charge

Radioactive hazards

Radioactive contamination: unwanted presence of materials containing radioactive atoms on/in other materials.
Hazard is due to: The decay of the contaminating atoms. Type of radiation emitted affects level of hazard.

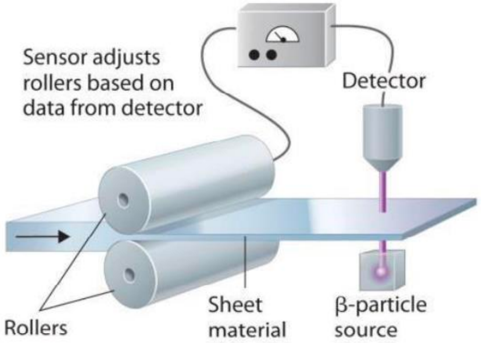
Irradiation: exposing object to nuclear radiation but object doesn't become radioactive.
Must take suitable precautions against any hazard presented by radioactive sources. E.g. concrete shielding, lead shielding (aprons), keeping a safe distance away and limiting time..



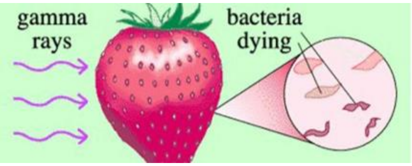
Key words

Key Word	Definition
Emission	Releasing or giving out. Nuclear radiation is emitted from the nucleus during radioactive decay.
Ionisation	The process of making an ion by 'knocking off' electrons. Ionising radiation causes this and is dangerous in living organisms as it can cause mutations of DNA increasing risk of cancer
Penetration	Passing through a material. Different types of nuclear radiation can penetrate different materials and are absorbed by certain materials.
Peer review	where other scientists check the methods and analysis performed, on the findings of studies into the effects of radiation on humans

Uses of radiation

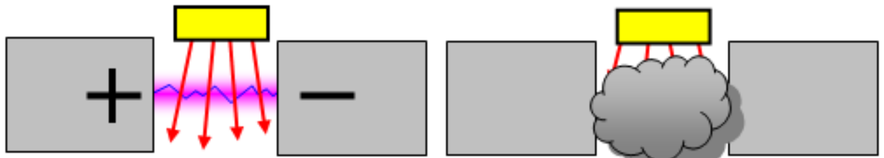


Monitoring paper thickness - beta



Sterilising food/ equipment - gamma

Smoke detectors - alpha



Cancer treatment – gamma

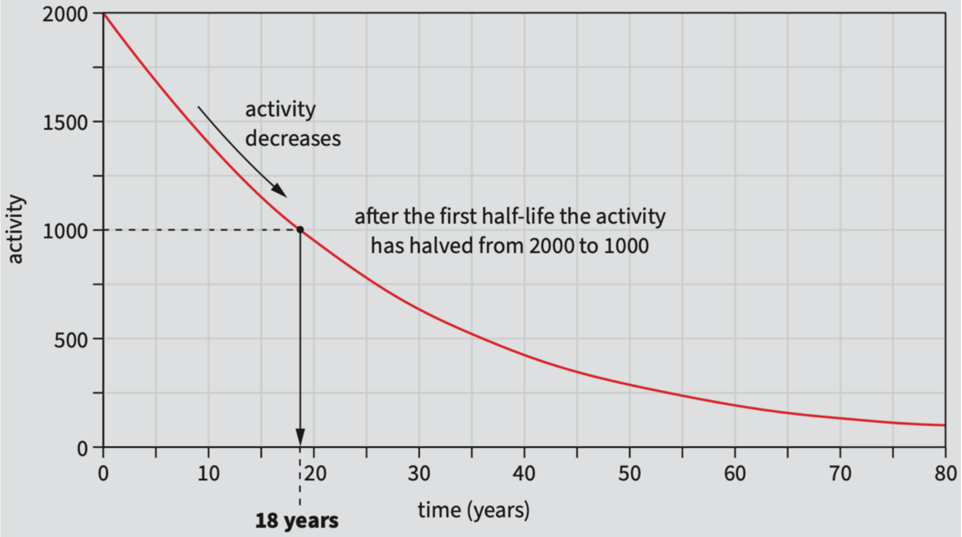
Detecting cracks in underground pipes - gamma

Half life

The half-life of a radioactive source is:

- the time it takes for the number of nuclei of the isotope in a sample to halve
- the time it takes for the count rate (or activity) from a sample containing the isotope to fall to half its initial level.

Radioactivity is a random process – cannot be predicted when any one nucleus will decay but half-life is a constant so allows activity of many nuclei to be predicted during the decay



The time taken for the activity to halve is 18 years. This is the half-life of this substance.

Half-life and stability:
Less stable → shorter half-life
More stable → longer half-life

Half-life and radioactivity:
Shorter half-life → more active
Longer half-life → less active

To find half life from a graph:

1. Find where decay curve starts on y axis (2000 above)
2. Halve the start number (1000 on above) and read from y axis across to decay curve
3. From decay curve read down to time on x axis (18 years on above) = half life

(HT only) Net decline can be given as a ratio: net decline = $\frac{\text{initial number} - \text{number after X half−lives}}{\text{initial number}}$

Example: There were initially 80 nuclei of an element with a half-life of 15 minutes. What was the net decline after 3 half-lives?

1st $\frac{80}{2}=40$ 2nd $\frac{40}{2}=20$ 3rd $\frac{20}{2}=10$ $\frac{80-10}{80}=\frac{7}{8}$

Working scientifically term	Definition	Example/how to improve
Accurate / accuracy	Result that is close to the true value	Improve method, reduce random errors, use higher resolution equipment Use vernier calipers when measuring lengths to calculate volume. Add insulation when finding specific heat capacity Use jockey clips for length of wire
Valid result	Test only the effect of the independent variable on dependent variable	Use control variables - keep everything else the same between what you are testing
Random error	Results vary in unpredictable ways	Reduced by making more measurements, ignoring anomalies (results that don't fit pattern) and calculating a mean
Systematic error	Results differing from the true value by a consistent amount each time	Reading above/below eye line on measuring cylinder the same each time
Zero error (specific type of systematic error)	Equipment that should read 0 but doesn't	Ammeter / voltmeter / balance zero before using or read error value and add to finial measure if it is a negative and subtract if it is a positive
Precise	Results that cluster closely	Small amount of variation between repeats, uncertainty value will be small
Uncertainty	How far above (+) or below (-) mean the results are	Difference (between highest and lowest result) ÷ 2 Given as ±, add uncertainty value to mean to find highest result, subtract for lowest
Resolution	Smallest measurement that equipment can make	12.1°C = resolution of 0.1°C Higher resolution equipment will give more accurate result
Repeatable	Repeats under same condition by same investigator give similar pattern	Repeat investigation
Reproducible	Similar results are obtained by different investigators with different equipment	Ask someone else to repeat investigation