



Edexcel GCSE
Combined
Science
Physics Paper 2
Revision Book



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Topic 8: Energy and Forces- Revision

There are 8 different stores of energy

Thermal, kinetic, chemical, elastic potential, magnetic, gravitational potential, electrostatic and nuclear. (Today Kids Can Easily Memorise GCSE Energy Names)

Energy can be transferred between these stores mechanically, electrically, by heating and by radiation.

Energy in systems

When **energy is transferred**, it **changes the system**. A **system** is just the scientific name for an **object**, or a **group of objects**. When a **system changes** some **energy is always dissipated** into less useful forms, usually by heating.

Energy transfer by heating



Think about a pan of water being heated by the hob at home. If we consider the pan of water then energy is transferred into the system by heating, the thermal energy store within the pan of water increases.

If the system consists of the pan of water and the stove, then energy is transferred within the system. The chemical energy stores in the fuel are transferred to thermal energy stored in the pan of water.

Electrical energy transfer

Think about your TV, energy is transferred into the system, electrically, from the mains supply and then light and sound transfer energy away from the system by radiation.

Mechanical energy transfer

Forces can be used to transfer energy. Think about lifting a box onto a shelf, chemical energy (from the food you have eaten) is transferred into the box and stored as kinetic and eventually gravitational potential energy stores. As the box is lifted you must do work against gravity, if you dropped the box then gravity would do work on the box to make it fall. Think about the falling box, no energy is transferred into the system, but the gravitational potential stores are transferred to kinetic energy stores, some energy would be dissipated by heating to the surroundings.



When a **force moves** an object through a distance, and **does work**, some energy is often **dissipated** to the **thermal energy stores** of the **surroundings**. **Lubrication** can **reduce friction** and, therefore, **reduce** the amount of **energy wasted** improving the **efficiency**.

Work done

Whenever a force acts to move an object through a distance work is done on the object as energy is transferred. When **1 newton of force** moves an object through **a distance of 1 metre** (1 Nm) we say that **1 joule (1 J) of work** has been done. **1 joule (J) = 1 newton meter (Nm)**.

$$\text{Work done (J)} = \text{force (N)} \times \text{distance moved in direction of force (m)}$$
$$E = F \times d$$

Power

Power is the **rate of energy transfer**; it tells us how much **work is done every second**. The unit of power is the **watt (W)** which is the same as **1 joule per second (J/s)**.

$$\text{Power (W)} = \text{work done (J)} \div \text{time taken (s)}$$
$$P = E \div t$$

Equations from paper 1

You also need to be able to recall and apply these equations from your paper 1 knowledge.

$$\text{GPE (J)} = \text{mass (kg)} \times \text{gravitational field strength (N/kg)} \times \text{change in vertical height (m)}$$
$$\text{GPE} = m \times g \times \Delta h$$

$$\text{KE (J)} = \frac{1}{2} \text{ mass (kg)} \times \text{velocity}^2 \text{ (m/s)}$$
$$\text{KE} = \frac{1}{2} m \times v^2$$

$$\text{Efficiency} = \frac{\text{useful energy transferred by device}}{\text{total energy supplied to device}}$$

Topic 9: Forces and their Effects- Revision

Forces are caused by interactions

An object is pushed or pulled because it is interacting with something else. Some forces occur when objects are touching, **contact forces**. Some forces occur when objects are not touching each other, **non-contact forces**. Forces are vector values as they have magnitude (size) and direction, unlike scalar values (such as mass) which only have magnitude.

Contact Forces

If the interacting objects are touching, then there will be a contact force. The '**normal contact force**' acts on ALL objects that touch, and **friction** is another example of a contact force. When you sit on the chair, there is an upward force from the chair that stops you falling, this is a 'normal contact force'. N.B. In this context, the term 'normal' refers to the force acting at right angles to the surface. **Upthrust**, such as **buoyancy** or **lift**, is also a contact force.



Non-contact forces

If the interacting objects are not touching then there will be non-contact forces.

A **force field** is the area around an object where it can affect other objects. For example, the Earth orbits the Sun because the Sun's **gravitational field** provides a centripetal force. The area around a magnet that can attract or repel another magnet is called the **magnetic field** and an object charged with static electricity has an **electrostatic field** around it.

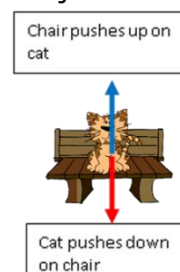
Gravitational fields can only attract, they are round and affect all objects.

Magnetic fields have different shapes, can attract or repel and only affect magnetic objects

Electrostatic fields are circular, affect all objects and can attract or repel.

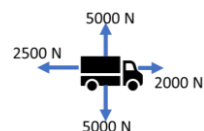
Action-reaction pairs

Or Newton's 3rd law pairs, is the name given to the pair of forces in every interaction. Every action force has an equal and opposite reaction, the pair of forces are the same size but act in opposite directions. Action-reaction pairs are always the same size, act in opposite directions and act on different objects. They are also the same type of force.



Free-body diagram & Resultant force

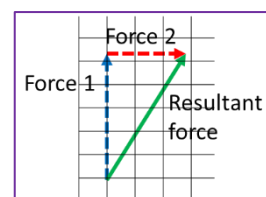
Shows all the forces acting on an object, or system, in isolation. It only shows the forces acting on that object. It is very rare that only one force acts on an object, the sum of all the separate forces can be replaced by 1 single force- the resultant force. When forces are parallel, they are simply added or subtracted to find the resultant force.



Vector Diagrams

You can draw scale diagrams to measure the size and direction of resultant, missing or component forces.

To find the resultant force acting on an object we **draw all the forces from the first to last (tip-to-tail)**. Then **connect the start to the end**- the resultant force. We select a sensible scale to represent the size of the force (e.g. 1 cm = 1 N) and use a protractor to measure angles to find the direction of the force.



If an object is in equilibrium, we know that the forces acting on it must be balanced, or the resultant force equals zero. If we drew a scale diagram to represent a situation in equilibrium, then the tip of the last arrow would meet the tail of the first.

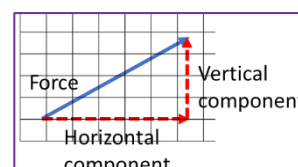


If you are given several forces and told the object is in equilibrium but there is a force missing then all you need to do **is draw the forces you are given**, and **connect the tip of the last force to the tail of the first**- this line is the missing force. Measure it and use the scale to find the size, use a protractor to find the direction.

A force acting **at an angle** can be **broken down** into the **horizontal and vertical components**. These can be easier to work with.

We can split the force into horizontal and vertical components using a simple scale drawing. With a sensible scale use a **ruler and a protractor to draw your force**. Then **add your components to complete a**

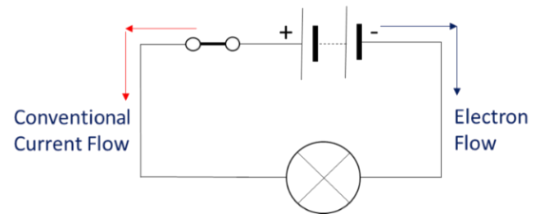
'triangle', measure the length and use your scale to find the size of the component forces.



Topic 10a: Electric circuits- Revision

Electrons and current

Metals have '**free electrons**' these are electrons that are able to move from atom to atom, when connected in a circuit the voltage 'pushes' these free electrons around the circuit. Electrons are **negative** so they move towards the positive terminal in the circuit. Electricians use an idea of **conventional current** in which current flows from the positive terminal to the negative one.



Series and Parallel Circuits

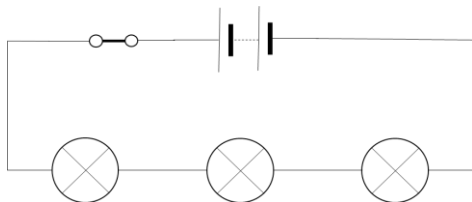
We use common **circuit symbols** when drawing circuit diagrams.

Circuit Symbol	Component	Circuit Symbol	Component
	Cell		Switch (closed)
			Switch (open)
	Battery		Voltmeter
	Lamp		Ammeter

Components can be added into circuits in different ways, they can be connected in **series** or in **parallel**.

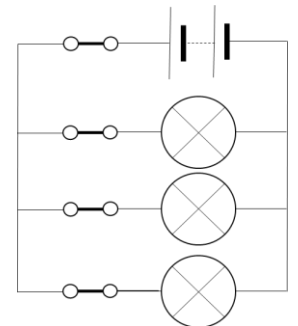
In a **series circuit**, there is only **one route** for the current to take and the components cannot be turned off separately.

In a **parallel circuit**, there are **junctions** so the current may take different routes and each component can be turned off separately.



A series circuit- no junctions. If one lamp breaks, they all go off.

Parallel circuit- junctions. If one lamp breaks, the others will stay on.

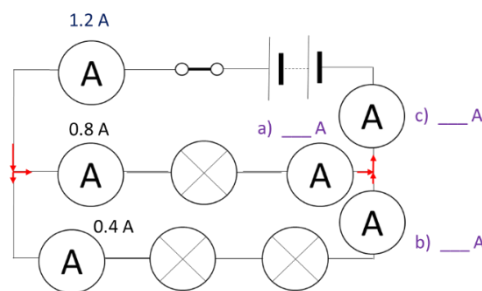


Measuring current

Current is measured in **amperes**

(A) using an **ammeter**. Ammeters are placed in **series** and measure the current that passes through them. The current leaving and entering the power source are always the same, we say it is conserved.

Current will split at a junction but the **sum of currents entering a junction always equals the sum of currents leaving** the junction.



A current is a flow of charge; in a circuit the charge is carried, around a complete circuit, by **electrons**. All the electrons in the circuit move at the same time.

This diagram shows three identical lamps in a circuit. You can see that the **1.2 A splits** at the junction into **0.8 A** and **0.4 A** (the sum of these currents is equal to the current that entered the junction (1.2 A).

Within a series branch the current is the same so the reading at 'a' would be **0.8 A**. The reading at 'b' would be **0.4 A**. These currents recombine at the second junction

and the reading at 'c' would be **1.2 A** (as $0.8 + 0.4 = 1.2$).

Measuring Potential Difference

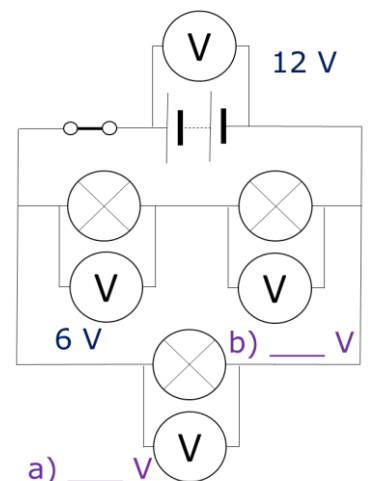
Electrons will only flow around a circuit if there is a **potential difference** (p.d.) across the circuit to '**push**' the electrons round.

Potential difference is measured in **volts (V)**, using a **voltmeter**. Voltmeters are placed in **parallel** and measure the potential difference across a component or circuit.

In a parallel circuit, the p.d. is the **same across each branch**. So the p.d. at voltmeter 'a' is **12 V**, the same as the p.d. across the battery.

The total potential difference in the series branch is also 12 V.

However, within a **series branch** of a circuit the **p.d. across each of the component in that branch is equal to the total voltage** (in this case 12V). Voltmeter 'b' will give a reading of **6 V** (as $6 + 6 = 12$).



Topic 10b: Resistance- Revision

Electric Charge

An **electric current** is simply the **flow of electric charge**. **Current is the rate of flow of charge**, so an ammeter tells us how much charge passes through it every second. **Electric charge** is measured in **coulombs (C)** and **1 coulomb of charge** has flowed through a circuit when there has been a **current of 1 amp flowing for 1 second**.

In metal wires the **charge** is carried **by electrons**, each electron carries a tiny charge of **1.6×10^{-19} C**. You can calculate the total charge moved if you know the current and the time.

$$\text{charge (C)} = \text{current (A)} \times \text{time (s)}$$
$$Q = I \times t$$

Energy in Circuits

In a circuit, the **cell** or a **power supply** supplies **energy**. The energy is **transferred** around the circuit by the **charge** before being transferred to the components.

Potential difference is a measure of how **much energy** is transferred to each **coulomb of charge** flowing around a circuit. **1 volt is equal to 1 joule per coulomb** (**$1 \text{ V} = 1 \text{ J/C}$**).

$$\text{Energy transferred (J)} = \text{charge moved (C)} \times \text{potential difference (V)}$$
$$E = Q \times V$$

Electrical resistance

Some wires have more **resistance** than others- this means it is **more difficult** for **current to flow**. Wires with larger resistances need a larger potential difference to produce the same current flow. **Resistance** is measured in **ohms (Ω)** and a wire has **one ohm** of resistance when a current of **one amp** is produced by a **potential difference of one volt**.

$$\text{Potential difference (V)} = \text{current (A)} \times \text{resistance (Ω)}$$
$$V = I \times R$$

Resistors in a Series Circuit

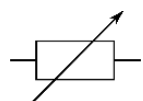
In a **series circuit**, the potential difference is **divided between the components** so if **more components** are added then the **resistance increases**, and **current reduces**. The **total resistance** in a series circuit is the **sum of the separate resistances**.

Resistors in a Parallel Circuit

In a **parallel circuit**, **each branch** experiences the **same potential difference**. When **resistors** are added in **parallel the total resistance decreases** because the current flows through either resistor.

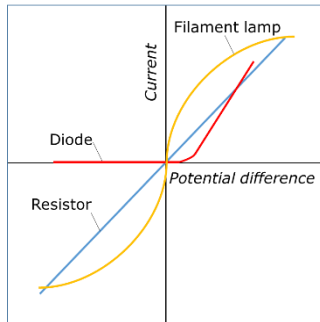
<u>Resistors in a Series Circuit</u>	<u>Resistors in a Parallel Circuit</u>
If a 5Ω and a 10Ω resistor are placed in series, then the total resistance will be 15Ω .	If a 5Ω and a 10Ω resistor are placed in parallel, then the total resistance will be less than 5Ω .
$R_{\text{Total}} = 5 + 10 = 15 \Omega$	If you know the total current and potential difference you can use the equation $R = V \div I$ to calculate total resistance.

A **resistor** that we can **control** is called a **variable resistor**, if we **increase** the **resistance** then the **current** will **go down**- lights might become dimmer, speakers might become quieter. If we **reduce** the **resistance** then **current** will **increase**- lights might become brighter, speakers might become louder.

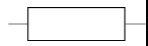


Current against Potential Difference Graphs

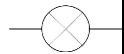
When we increase the potential difference across components, we see different changes in the current that flows, you can see typical relationships on the graph below. You will need to recognise and describe the shape of these graphs, identify the circuit symbols and explain why the graphs are this shape.



Fixed resistor: Resistance stays the same. Current and potential difference (p.d.) are directly proportional. If you double p.d. then the current will also double.



Filament lamp: The graph is curved because as a greater p.d. is applied across the lamp it gets hotter - this increased temperature causes resistance to increase, so we get smaller increases in current.

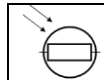


Diode: A diode only allows current to flow in one direction. In the positive direction, the resistance is low and allows current to flow. In the negative direction, resistance is very high and no current can flow.

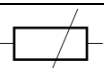


Responding to the Environment

Some **resistors change** their resistance as **a response to their surroundings**. **Light dependent resistors (LDRs)** have a **lower resistance** when placed in **bright light** whereas **thermistors** have a **lower resistance** when placed into **warmer temperatures**. As the **resistance reduces**, the amount of **current** flowing in a circuit **increases**, this means that components in the circuit can be turned on in response to environmental changes. For example, a fan that comes on when the temperature gets to 25°C.



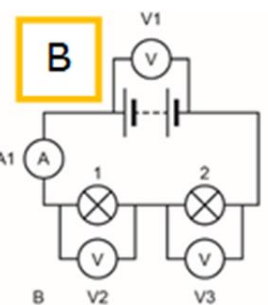
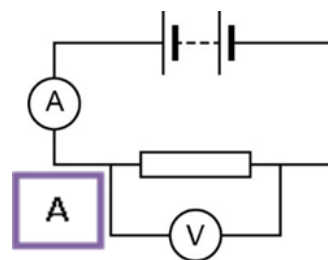
An LDR has high resistance when it is dark but as the light get brighter (intensity increases), the resistance gets smaller.
Smaller resistance means bigger current.



A thermistor has high resistance when it is cold but as the temperature increases, the resistance gets smaller.
Smaller resistance means bigger current.

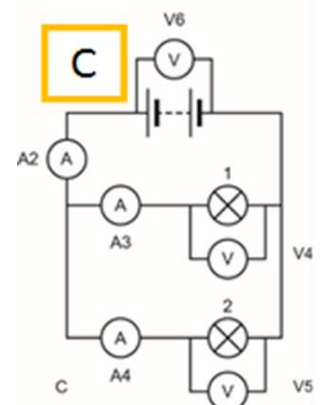
Investigating resistance

- Set up the circuit as shown in **circuit A**, use a power supply that allows you to change the voltage (potential difference).
- Set the power supply to 1 V and record the values from the **ammeter and voltmeter**.
- Repeat for five further power settings, up to a maximum of 6 V.
- Swap the resistor for a filament lamp and repeat the above steps.
- Use the equation $R = V \div I$ to calculate resistance.



Filament lamps in series and parallel

- Set up the circuit as shown in **circuit B**, use a power supply that allows you to change the voltage (potential difference).
- Set the power supply to 1 V and record the values from the **ammeter and voltmeter**.
- Repeat for five further power settings, up to a maximum of 6 V.
- Repeat the above steps for **circuit C**.
- Use the equation $R = V \div I$ to calculate resistance.



Topic 10c: Electrical energy- Revision

Work

When **current** passes through a circuit, **energy is transferred** because electrical work is done against the resistance in the circuit. Energy is **transferred by heating**, so the circuit **heats up**. The greater the resistance, the more energy is transferred and the hotter the circuit becomes- think about your phone or laptop charger heating up.

$$\text{Energy transferred (J)} = \text{current (A)} \times \text{Potential difference (V)} \times \text{time (s)}$$
$$E = I \times V \times t$$

The heating effect

The **heat** associated with **current flow** can be **useful** in appliances such as **kettles, toasters and electric heaters**. Other times it is **not useful**, such as **plugs, wires and computers**, it means that energy is being **dissipated** away from the circuit- making it **less efficient**. Heating can also **cause burns** and **increase the risk of fires**.

Thinking about resistance

As **electrons flow** through metal wire, they pass through a lattice of vibrating ions (atoms that have lost an electron). As they pass, they **collide with ions**, **increasing the resistance**. Each collision **transfers energy** from the electrons to the ions.

Reducing resistance

The **heating effect** of current flow can **be reduced** by **reducing the resistance** of a circuit. This can be achieved by changing the wires that are used.

- Some metals, such as **copper**, have a **lower resistance**
- **Thicker wires** have a **lower resistance**
- Metals can be **cooled**, so the ions in the lattice vibrate less, to **lower** their **resistance**

Energy Transfers

The **chemical energy** stored in **batteries** can be **transferred by electricity** through circuits.

- With the hand-held fan the **energy is transferred** to a **store of kinetic energy** in the spinning fan blades. Eventually all of the energy will be **dissipated by heating** to the surroundings.
- In the heated gloves the **chemical energy stored** in the batteries is **transferred by electricity** to wires where is **transferred to thermal stores** in the wires. The energy is then **transferred by heating** to the gloves, the wearer's hands and **dissipated to the surroundings**.

Power

The energy transferred in a circuit depends on how long it is used for, therefore we usually use power to compare household appliances. **Power** tells us how much **energy is transferred every second**. **Power** is measured in **watts (W)** and **1 watt** is the same as **1 joule per second (J/s)**.

There are three different equations you need to be familiar with.

$$\text{Power (W)} = \text{Energy transferred (J)} \div \text{time (s)}$$
$$P = E \div t$$

$$\text{Power (W)} = \text{Current (A)} \times \text{Potential difference (V)}$$
$$P = I \times V$$

$$\text{Power (W)} = \text{Current}^2 (\text{A}^2) \times \text{Resistance } (\Omega)$$
$$P = I^2 \times R$$

Power ratings

We give appliances power ratings, measured in watts (W), that inform us the rate at which the appliances transfer energy. A **1500 W** toaster transfers **1500 J** of energy, by electricity, **every second**.

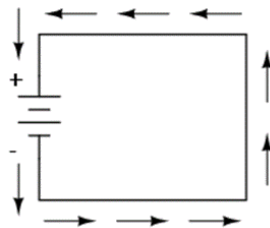
Mains electricity

Appliances that we plug in at home use **mains electricity**, delivered from power stations to our homes through the **national grid**.

In power stations the kinetic energy stored in a rotating turbine is transferred by electricity through the network of cables and wires that make up the national grid.

Mains electricity arrives at our homes at a **voltage of 230 V** and a **frequency of 50 Hz**.

Direct and alternating current

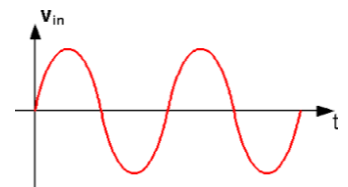


← **Direct current (d.c.)** consists of charges flowing in **one direction**. D.c. is **provided by cells, batteries and solar panels**. The negative electrons are repelled from the negative terminal and attracted to the positive terminal.

Alternating current (a.c.) consists of charges that flow in **changing directions**. A.c. is **produced by rotating generators**, this is what causes the current flow to

change direction.

Alternating current causes an **alternating voltage**, it increases up to a peak voltage and then decreases down to zero. The voltage then increases to a peak in the opposite direction before dropping back to zero. →



Safety features

When using household electricity there are several **safety features** which work to keep us safe. These include **switches, fuses, the earth wire and circuit breakers**.

Switches are connected to the live wire and **stop current flowing** to the appliance when we switch them off.

A faulty appliance can draw too much current, this can cause overheating in the appliance or in the household wiring- this can lead to fires. Fuses work to stop this happening.

Fuses contain a thin wire that is designed **to melt** if **too much current** passes through the wire. A 3A fuse will melt if more than 3A flows but a 13A fuse will only melt at a higher temperature (caused by more than 13A). When the **fuse wire melts** the **circuit is broken** stopping current flowing through the appliance. In faulty appliances the metal parts can be at a high voltage, and if touched could give the user an electric shock, as charge flowed

Earth wires connect the metal parts **to the ground** so that the **current flows through the low resistance wire and not through the user**.

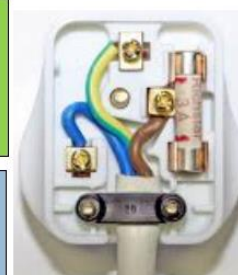
If a fault connects the live wire to the earth wire (by touching any metal part) then a very large current can flow through the low resistance wire, which could cause a fire. In this case, the fuse blows and breaks the circuit.

Circuit breakers are used as an **alternative to fuses**, they 'trip' when they detect a difference in current between the live and neutral wires.

They are **more expensive than fuses**, but they **work faster** (so can **save lives**) and can **be reset** which is much easier than having to replace the fuse each time.

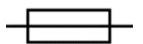
Earth wire (green & yellow): is for safety and protecting the wiring. Carries the current to the ground if there is a problem.
Voltage = 0 V

Neutral wire (blue): completes the circuit by providing the return path to the power station
Voltage = 0 V



Live wire (brown): carries the voltage from the power station to the appliance.
Voltage = 230 V

Fuse: is for safety and protecting the wiring. Designed to carry different sized currents. Often 3A, 5A or 13A.

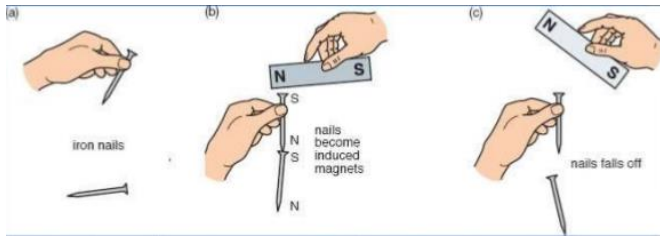


Topic 12: Magnetic fields - Revision

Magnets

A bar magnet is a **permanent magnet**- it is always magnetic. It will attract magnetic materials (iron, steel, nickel and cobalt) if they are placed inside the **magnetic field**. The north end of a magnet will attract the south end of another magnet or repel the north end.

When a piece of magnetic material is placed inside a magnetic field, it becomes a magnet. This is an **induced magnet** because it stops being magnetic when removed from the magnetic field.



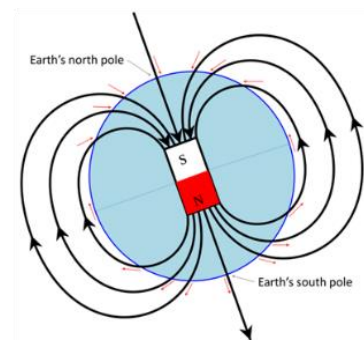
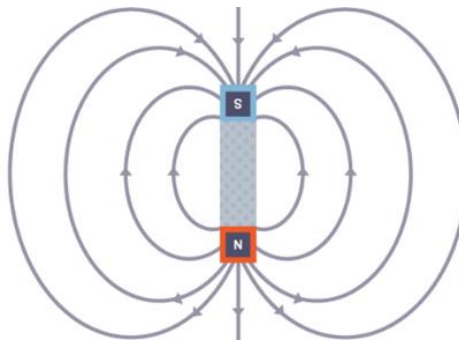
The diagram here shows that the iron nails do not attract (a) once placed inside the magnetic field, however, they act as magnets (b). When removed from the magnetic field, they no longer attract, and fall (c).

Magnetic fields

Magnets have many uses including speakers, electric motors, generators and compasses.

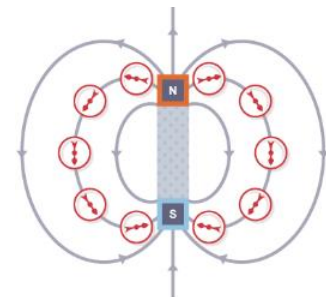
Compasses contain small magnets that are free to rotate and line up with any magnetic field they experience. The Earth's magnetic field is similar in shape to that of a bar magnet.

When drawing field lines you should ensure that, none of your lines overlap and the arrows point in the correct direction (from north to south). Notice that what we call the North Pole is actually a magnetic south pole- this is why the north pole of a compass magnet will point north.



You can also use **plotting compasses** to **investigate** the **magnetic field** surrounding a bar magnet. Remember that the needle of a plotting compass points to the south pole of the magnet.

1. Place the plotting compass near the magnet on a piece of paper.
2. Mark the direction that the compass needle points.
3. Move the plotting compass to many different positions in the magnetic field, marking the needle direction each time.
4. Join the points to show the field lines.

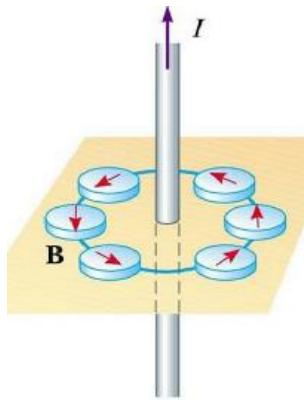


Uniform magnetic fields

Two flat magnets can produce a **uniform magnetic field** when placed close to each other. The field is the same strength and direction at every point.



Electromagnets



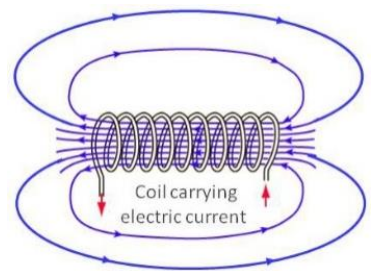
Whenever current flows through a length of wire- a magnetic field is created. This magnetic field can be investigated with plotting compasses, using a similar method as described above.

The **higher the current**- the **stronger the magnetic field**. The field gets weaker as you move away from the wire.

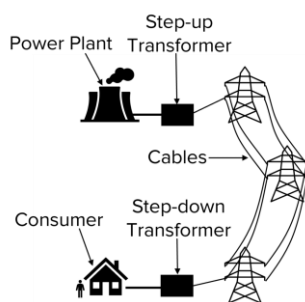
If the current changes direction then so does the magnetic field.

A **solenoid** is a coil of wire with current flowing through it- this is an electromagnet. The magnetic field is strongest inside the solenoid because

the fields add together whereas outside of the coil they tend to cancel each other out making the field weaker. An electromagnet is made stronger by placing an iron core through the centre- this acts as a temporary magnet as it is only magnetic whilst the field from the electromagnet is affecting it.



The national grid



Electricity is sent from the power station to homes, schools and factories through a network of wires, and cables called the **national grid**. As the current flows through the wires, they get warm and energy is wasted. Smaller currents mean less energy wasted by heating. Transformers are used to change the size of the potential difference (voltage). If the voltage increases then the current decreases. If the voltage decreases then the current increases.

Transformers

A transformer is made of an iron core with two separate coils of wire wrapped around.

A step-up transformer increases the voltage and decreases the current.

A step-down transformer decreases the voltage and increases the current.

A power station produces electricity at 25 kV, this is **increased**, by a **step-up** transformer, to 400 kV. This decreases the current and means **less energy is wasted** as heat- the efficiency has been improved.

High voltages, however, are dangerous so the **voltage** is then **decreased**, by a **step-down** transformer, before it is delivered, **safely**, to the consumer.

Larger factories use electricity at 33 kV, smaller factories use 11 kV and homes, schools, offices and shops use 230 V.

An alternating current is needed for transformers to work.

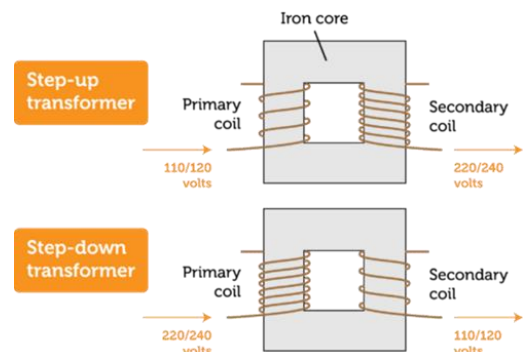
- The alternating current produces a changing magnetic field in the primary coil
- The magnetic field is strengthened by the iron core
- The magnetic field produces a changing voltage in the secondary coil
- The changing voltage produces an alternating current in the secondary coil.

Because energy cannot be made or destroyed then, if a transformer is 100 % efficient, then the power supplied by the primary coil must be equal to the power transferred by the secondary coil.

The current or voltage in either coil can be calculated using the following equation:

$$\text{primary voltage} \times \text{primary current} = \text{secondary voltage} \times \text{secondary current}$$

$$V_p \times I_p = V_s \times I_s$$



Topic 13: Electromagnetic induction (H) - Revision

Electromagnetic induction

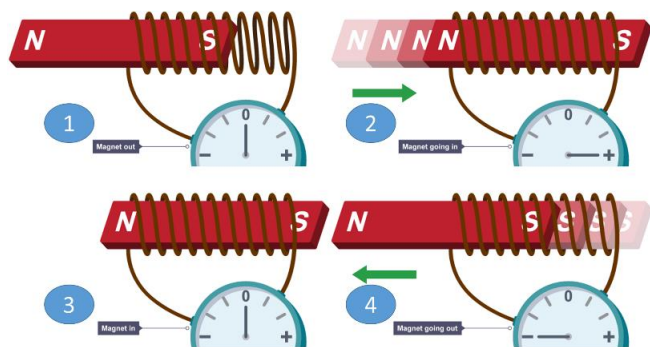
If a wire is placed inside of a changing magnetic field, then a potential difference (voltage) can be induced inside the wire. The induced voltage causes a current to flow. The same effect is seen if the wire moves inside of a magnetic field.

Diagram 1 shows the magnet stationary, outside of the coil, and no voltage induced.

Diagram 2 shows the magnet moving into the coil and a positive voltage induced.

Diagram 3 shows no voltage induced when the magnet is stationary inside the coil.

Diagram 4 shows the magnet moving out of the coil and a negative voltage induced.



Changing the induced voltage

The direction of the induced voltage changes if the direction of movement is changed or if the poles of the magnet were switched.

The size of the induced voltage increases if the number of turns of wire is increased, the magnetic field strength is increased or the speed of movement is increased.

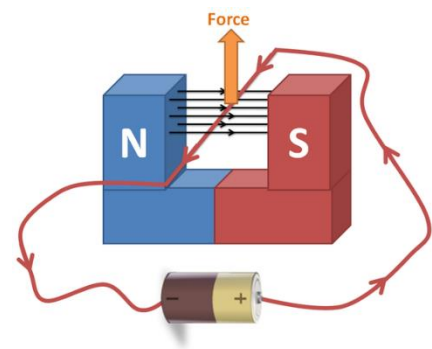
When an induced voltage causes a current to flow, the current induces a magnetic field around the coil. The induced magnetic field always acts against the motion that caused it to be created.

For example in diagram 2 the magnet is moving into the coil, the magnetic field would work against this movement- trying to push the magnet back out of the coil.

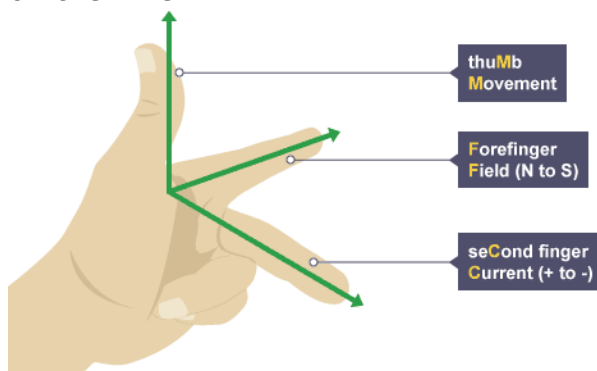
The motor effect

When a current carrying wire is placed inside a magnetic field, it feels a force acting on it- this is called the **motor effect**.

The motor effect is caused because the current flowing the wire creates a magnetic field, around the wire, and this interacts with the magnetic field between two magnets. The magnet also feels the same force, but in the opposite direction.



Fleming's left hand rule (FLHR) can be used to find the direction of the force acting on the wire.



Hold your thumb, forefinger and second finger at right angles to each other:

- the forefinger is lined up with magnetic field lines pointing from north to south
- the second finger is lined up with the current pointing from positive to negative
- the thumb shows the direction of the motor effect force on the conductor carrying the current

The size of the force acting on the wire depends on several factors: the strength of the magnetic field, the size of the current flowing through the wire and the length of wire that is inside the magnetic field.

$$\text{Force (N)} = \text{magnetic field strength (T)} \times \text{current (A)} \times \text{length (m)}$$
$$F = B \times I \times l$$

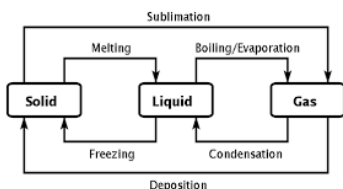
The strength of a magnetic field (also known as the flux density) is measured in units of **tesla (T)**. One tesla is equivalent to 1 newton per amp metre (1 N/Am).

Topic 14a: Particle model - Revision

Kinetic theory model

Everything is made of tiny particles, these particles are arranged differently in solids, liquids and gases. The way the particles are arranged explains the different properties of solids, liquids and gases.

Changes of state are physical changes- this



means that no new substances are formed, the particles are just arranged differently and the change can easily be reversed.

Kinetic model	Properties	Particle arrangement	Forces of attraction
Solid 	Cannot be compressed Have a fixed shape	Particles are tightly packed, can vibrate but cannot move around	Particles are held together by strong force of attraction
Liquid 	Cannot be compressed Take on the shape of their container	Particles are still tightly packed but can move past each other	Force of attraction is not strong enough to hold particles in a fixed position
Gas 	Easy to compress Expand to fill their container	Particles are far apart and moving around quickly	There is no force of attraction between the particles

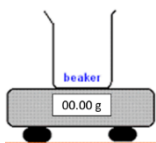
Density

Solids are denser than liquids, which are denser than gases. The density of a substance is the mass of a certain volume. Solids are denser than gases because the particles are more tightly packed- the same amount of particles have a smaller volume in a solid than in a liquid.

$$\text{Density (kg / m}^3\text{)} = \text{mass (kg)} \div \text{volume (m}^3\text{)}$$

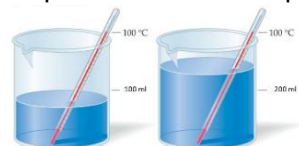
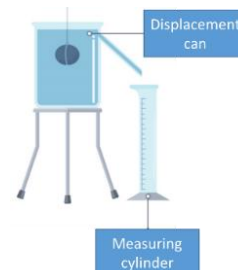
$$\rho = m \div V$$

Investigating density



To investigate the density of a liquid place beaker onto a balance, and set the reading to zero, use a measuring cylinder to measure out a set volume of liquid and pour into the beaker- record the mass and volume of the liquid. Use the equation $\rho = m \div V$ to find the density.

To investigate the density of a solid you use a balance to find the mass of the object. To find the volume you submerge the object into a displacement can and collect the water displaced, in a measuring cylinder- this is the volume as the object. Record the mass of the object and the volume of water displaced. Use the equation $\rho = m \div V$ to find the density.



Changing temperature

Temperature and thermal energy are linked but are not the same- 200 ml of boiling water stores twice as much energy as 100 ml of boiling water. When an object is heated, energy is stored in the moving particles- this is thermal energy. When a solid is heated and stores more thermal energy the vibrations of the particles increases. When a liquid or gas is heated the movement of the particles increases. During a change of state, the energy is being used to overcome the forces between the particles and is not stored in the moving particles- therefore the temperature of an object being heated does not increase during a change of state. When an object is cooled (loses energy) and changes state the movement of the particles does not decrease, as energy is released as the force of attraction, between particles, is strengthened so the temperature does not change.

Specific heat capacity

Different materials heat up at different rates, this is because they have different heat capacities.

Specific heat capacity is the energy required to increase the temperature of 1 kg of a substance by 1°C, represented by the following equation.

$$\text{Energy (J)} = \text{specific heat capacity (J / kg}^\circ\text{C)} \times \text{mass (kg)} \times \text{temperature change (}^\circ\text{C)}$$

$$Q = m \times c \times \theta$$

Specific latent heat

Different materials need different amounts of energy to change state, and boiling requires more energy than melting. **Specific latent heat** is the energy required to make 1 kg of a substance change state, represented by the following equation.

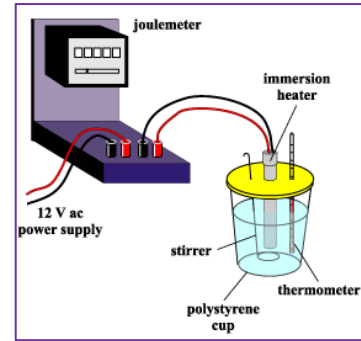
$$\text{Energy (J)} = \text{specific latent heat (J / kg)} \times \text{mass (kg)}$$

$$Q = L \times m$$

Topic 14b: Particle model - Revision

Investigating specific heat capacity

- Place a beaker on a balance and zero the balance, add some water and record the mass. Use a thermometer to measure and record the temperature of the water.
- Place an immersion heater into the beaker and connect to a joule meter.
- Turn on the heater and leave on for 5 minutes, gently stirring the water occasionally.
- Record the new temperature and the value on the joule meter. The reading on the joule meter tells you the energy change and the temperature change is the difference between the start and end temperature.
- Specific heat capacity = energy ÷ (mass x temperature change).**

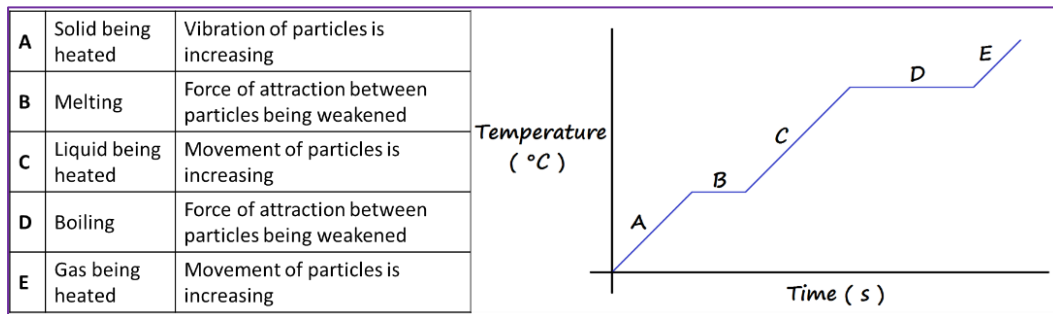


The results of this experiment are improved by using insulation such as lagging wrapped around the beaker, or a lid. This reduces the unwanted energy transfer to the surroundings- more of the energy supplied by the heater stays in the water.

Investigating melting ice

- Place a thermometer into a boiling tube of crushed ice and record the temperature.
- Place the boiling tube into a beaker of hot water and use Bunsen burner to keep the water hot.
- Record the temperature every minute, once the ice has all melted take the temperature for five minutes more.
- Make a note of the time when the ice started to melt and had all melted.

This graph shows how the temperature of a substance changes when heated from a solid state through to a gas. The table describes what is happening at each stage and describes how the energy is used.



Gas temperature and pressure

The particles in a gas are free to move, the more they are heated the faster they move- the more kinetic energy they have. Gas pressure is caused when the particles collide with the walls of a container, the faster the particles are moving the more often they collide and the more force they collide with- **as the temperature of a gas increases so does the pressure.** The units of pressure are **pascals (Pa)**, 1 Pa = 1 N/m².

Absolute zero

If we cool a gas the pressure reduces, in a linear manner (a straight line), eventually the gas will condense to become a liquid, however if we could continue reducing the temperature of any gas the **pressure would become zero at -273 °C**, this is known as **absolute zero** and the particles would have **no kinetic energy**

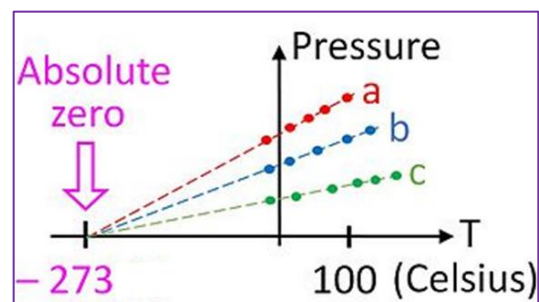
The Kelvin scale measures temperature from absolute zero, the average kinetic energy of the particles in a gas is directly proportional to its kelvin temperature. 1 K is equal to 1 °C.

To convert from kelvin to degrees Celsius: subtract 273.

$$293 \text{ K} = 293 - 273 = 20 \text{ °C}$$

To convert from degrees Celsius to kelvin: add 273.

$$100 \text{ °C} = 100 + 273 = 373 \text{ K}$$



Topic 15: Forces and matter - Revision

Changing shape

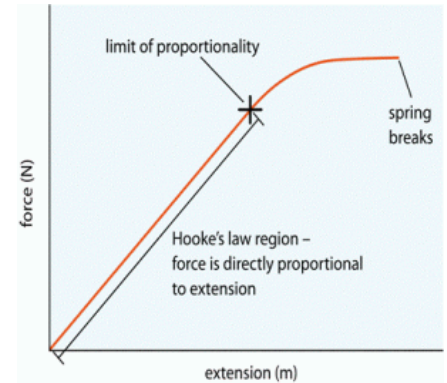
Forces can **change the shape** of an object- they can stretch, bend or compress an object. This requires **two forces**- with one force the object might change velocity but a change in shape always requires at least two forces.

Elastic objects return to their own shape when the forces are removed.

Inelastic objects keep their new shape when the force is removed.

A spring is elastic when smaller forces are applied as it returns to its own shape- however if larger forces are applied they behave inelastically and are permanently deformed (keep their new shape). There is a **linear** relationship between the length of a spring and the force applied- the graph is a **straight line**.

If a graph of force is plotted against extension the straight line passes through the origin- the extension is **directly proportional** to the force. If the extension doubles then so does the force. If you stretch the spring too far, it passes the elastic limit and the relationship becomes non-linear. Rubber bands have **non-linear** relationships between extension and force- the graph is **not a straight line**.



Calculations with springs

The stiffer a spring is, the more force you need to get the same extension as a less stiff spring. The **spring constant** is a value that tells us about the stiffness of a spring- it tells us how much force is needed to create an extension of 1 metre, it has the unit N/m.

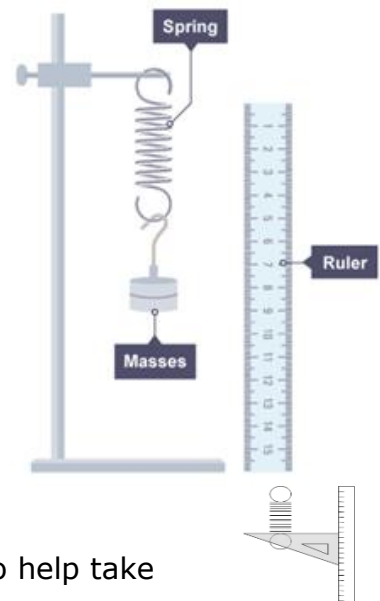
$$\text{Force (N)} = \text{spring constant (N/m)} \times \text{extension (m)}$$
$$F = k \times x$$

A stretched spring stores energy because work has to be done to stretch it (a force moves through a distance- remember: work done = force x distance moved by force). The amount of energy stored in a spring depends on the spring constant (stiffness) and the extension of the spring.

$$\text{Energy (J)} = \frac{1}{2} \times \text{spring constant (N/m)} \times \text{extension}^2 \text{ (m}^2\text{)}$$
$$E = \frac{1}{2} \times k \times x^2$$

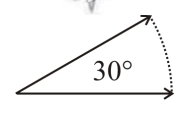
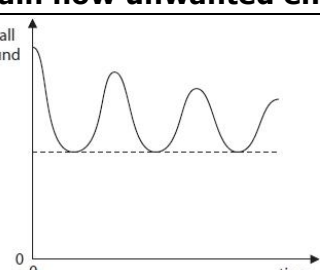
Investigating springs

- Measure the length of an unstretched spring- this is the original length.
- Add a known weight (e.g. 1 N) to the spring and record the new length.
- Subtract the original length from the new length- this is the extension, record the extension.
- Keep adding weights to the spring and repeating the measurements until you have added 10 N.
- Plot a graph of force against extension- the gradient of the slope is equal to the spring constant
- Use energy = $\frac{1}{2} \times \text{spring constant} \times \text{extension}^2$ to calculate the work done to stretch the spring.

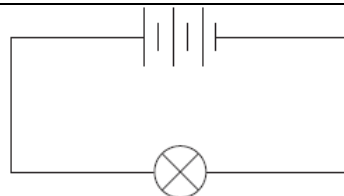


You can improve your investigation by using a set square to help take your measurements.

Topic 8 & 9: Energy and Forces - Exam Questions

1a	Which of these is NOT an energy store? (1) Tick the correct box:			
	A. Kinetic	B. Thermal	C. Renewable	D. Chemical
1b	Which of these is a non-contact force? (1) Tick the correct box:			
	A. Upthrust	B. Thermal	C. Friction	D. Magnetic
1c	Which of these is NOT a type of energy transfer? (1) Tick the correct box:			
	A. Chemically	B. Mechanically	C. Electrically	D. By heating
1d	50 J of thermal energy supplied by the electric heater  38 J of thermal energy raising the temperature of the water wasted energy The diagram to the left is a Sankey diagram and show the input energy and useful energy output for an energy transfer. State the amount of wasted energy. (1)			
1e	State the equation used to calculate the efficiency of an energy transfer. (1)			
1f	Calculate the efficiency of the above energy transfer. (2)			
2	A rock falls off the top of a cliff. The Earth exerts a force of 150 N on the rock. The work done by this force when the rock falls from the top to the bottom of the cliff is 2700 J.			
2a	Calculate the height, h, of the cliff. (2)			
2b	State the value of the kinetic energy of the rock just before it hits the ground. (1)			
2c	The mass of the rock is 15 kg. Calculate the velocity of the rock just before it reaches the bottom of the cliff. (3)			
3	A man pulls a suitcase for 80 m along a horizontal path. The mass of the man and the suitcase is 85 kg. The man does 1200 J of work on the suitcase as he pulls the suitcase along. He walks with an average velocity of 1.5 m/ s.			
3a	Calculate the kinetic energy of the man and the suitcase. (2)			
3b	Calculate the horizontal force that the man exerts on the suitcase. (2)			
3c	The man runs up a set of stairs carrying his suitcase. Explain whether he does more total work if he walks up the same stairs instead of running. (2)			
3d	The man lifts his 12 kg suitcase & increases its gravitational potential energy by 264 J. ($g = 10 \text{ N/kg}$). Calculate the vertical height the suitcase is raised. (3)			
4a	A large box is placed upon a table. Draw a free body diagram to show the forces acting on the box. (3)			
4b	The box pushes down on the table with a force of 250 N. Describe the action-reaction force that completes the Newton's third law pair. (2)			
4c	Compare the balanced forces acting on the box with forces acting as part of a Newton's third law pairs. (3)			
4d		HIGHER ONLY	This diagram shows two astronauts in space pushing a satellite. Force F_1 acts to the right and is 3.0 N. Force F_2 acts upwards and is 2.0 N. Draw a vector diagram to determine the magnitude of the resultant force. (4)	
4e			Later the satellite is pushed with a resultant force of 4.5 N at an angle of 30° . Draw a vector diagram to determine the horizontal and vertical components on this force. (4)	
5a	Describe what happens to some energy during all energy transfers. (2)			
5b	Explain how unwanted energy transfers are reduced in mechanical systems. (2)			
5c	height of ball above ground  0 time A wrecking ball is used to knock down a wall. After knocking down a wall it is left to swing freely. This graph shows how the height of the ball above the ground varies with time during these swings. Explain how the energy within the system changes during this time. (6)			

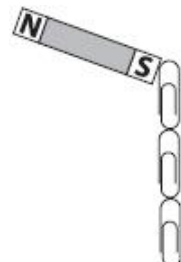
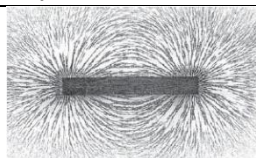
Topic 10: Electric circuits- Exam Questions

1a	A student is investigating electric circuits. Complete this sentence by selecting the correct word. (1) An electric current is the rate of flow of...			
	A. atoms	B. voltage	C. watts	D. charge
1b	Complete this sentence by selecting the correct word. (1) The charge that flows in a wire is made up of...			
	A. electrons	B. protons	C. negative ions	D. positive ions
1c	The student is designing a battery-powered torch. She wants the torch to have a brightness control that can be turned by hand. Which of these should she use? (1)			
	A. a thermistor	B. a light-dependent resistor	C. a variable resistor	D. a diode
2a	Ryan is investigating series and parallel circuits i. sketch a series circuit with a single cell and 2 lamps (2) ii. add an ammeter to the circuit (1) iii. add a voltmeter to the circuit (1) iv. sketch a parallel circuit with a single cell and 2 lamps (2)			
2b	Ryan takes some readings from his circuit, he measures the potential difference at 1.5 V and the current at 0.11 A. Calculate the resistance of the circuit, give answer to 2 significant figures. (3)			
2c	Ryan leaves the circuit on, with a current of 0.11 A for 6 minutes. Calculate how much charge has been moved. (3)			
2d	In a different experiment Ryan calculated that 0.8 kJ of energy had been transferred by the 1.5 V cell. Calculate how much charge had been moved. (4)			
3a	Sonia is investigating resistors. She has two resistors, each has a resistance of 150 Ω. i. what would the total resistance be if she placed them in series? (1) ii. would the total resistance be smaller or greater than 150 Ω if she placed them in parallel? (1)			
3b	Sonia has a different resistor and she want to carry out an investigation to find its resistance value. Explain how she could investigate the resistance. (6)			
4a	At the airport x-ray machines are used to scan luggage, the x-rays are produced in a vacuum tube. In order to produce X-rays which can penetrate the luggage, each electron must have at least an energy of 1.4×10^{-14} J. The charge on an electron is 1.6×10^{-19} C. Calculate the accelerating potential difference which will produce electrons of this energy. (3)			
4b	This diagram shows a circuit used to light a lamp. State two things you could do to the circuit to make the lamp dimmer. (2)			
4c	The potential difference across the lamp is 4.2 V. The current in the lamp is then 0.19 A. Calculate the resistance of the lamp. (3)			
4d	The lamp in 4c is left on and transfers 100 J of energy. Calculate how long the lamp left on for. Give your answer to the nearest whole minute. (5)			
5	Electric cars have to be charged at battery charger stations, an electric car has a rechargeable battery that drives the motor. The battery provides a potential difference of 330 V and can store up to 64 MJ of energy. It takes 8 hours to fully charge the battery. i. Calculate the total charge that flows whilst the battery is being charged (3) ii. Calculate the average charging current (3)			
6	Circuits can be built as series or parallel circuits. Compare current and potential difference in series and parallel circuits (6)			

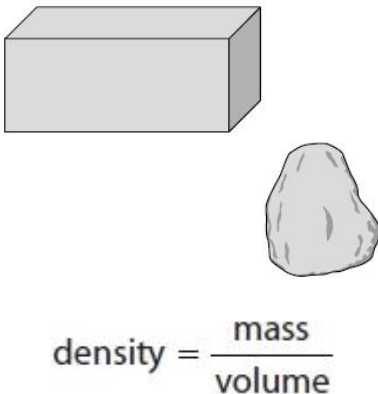
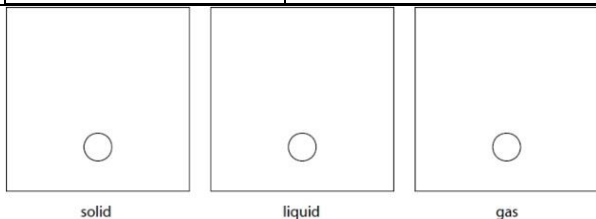
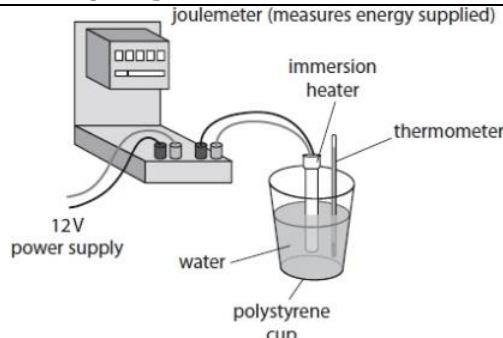
Topic 10: Electric circuits- Exam Questions

1a	A battery sends a current through a metal wire. Complete this sentence by selecting the correct word. (1) Direct current is the movement of charge...			
	A. in many directions	B. up and down	C. in one direction	D. backwards & forwards
1b	A resistor can be used to control the current flowing in a circuit. What happens to the temperature of a resistor when current flows through it? (1)			
1c	Different components have different relationships between current and potential difference. Copy and complete these current-potential difference graphs. (3)			
	Fixed resistor	Filament lamp	Diode	
1d	Draw the circuit symbols for each of the component above. (3)			
2a	An electric heater is connected to a 230 V supply and has a current of 7.5 A through it. Calculate the power of the heater; give your answer in kilowatts (kW). (3)			
2b	The heater in '2a' will need a fuse to ensure safety. Which of these fuses would be most appropriate? (1)			
	A. 3 A	B. 5 A	C. 10 A	D. 13 A
2c	A similar electric heater has a power rating of 7500 W and is switched on for 1 hour. Calculate how much energy the heater transfers during this time. (4)			
2d	Mains electricity is different to the electricity we get from a battery. Describe the frequency, voltage and type of current delivered by mains electricity. (3)			
3a	A kettle is designed to make good use of the heating effect of current. Explain why the temperature of a resistor increases when current passes through it. (2)			
3b	A particular kettle has a power rating of 3 kW and has a current of 2.5 A passing through it. Calculate the resistance of the kettle. (4)			
3c	The kettle in '3b' is connected to a 230 V supply and takes 2 minutes to boil. Calculate how much energy is transferred during this time (3)			
3d	The kettle boils water by transferring energy to it. Describe the energy transfers involved when using the kettle to boil water. (3)			
4a	An electric whisk has a power rating of 92 W is connected to a 230 V supply. Calculate the power of the whisk. (4)			
4b	Electrical engineers often want to reduce the amount of energy dissipated due to the heating effect of electric current. Explain one way that wires could be designed to reduce the amount of heat lost when large currents flow through them. (2)			
5	A plug contains 3 different wires and a fuse. Compare the role of the different wires and the fuse within a plug. (6)			
6	A resistor is a circuit component. Two other circuit components are a light dependent resistor (LDR) and a thermistor. Explain how LDRs and thermistors can be used to control the current in a circuit. (6)			

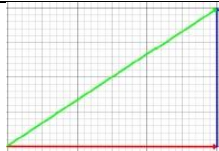
Topic 12 & 13: Magnetic forces - Exam Questions

1a	State the name of the device used to change the size of an alternating voltage. (1)			
1b	Which statement is true for transformers? (1)			
	A. Transformers can only step-up voltages.	B. Transformers can only step-down voltages	C. Transformers can work with direct current.	D. Transformers have primary and secondary coils.
1c	Which of these is a magnetic material? (1)			
	A. aluminium	B. carbon	C. cobalt	D. copper
1d	Which of these is NOT a way to increase the size of an induced current when a magnet is passed through a coil of wire (1)			
	A. move the magnet faster	B. use a stronger magnet	C. turn the magnet around	D. have more turns of wire
1e	Describe one way that you can change the direction of an induced current when a magnet is passed through a coil of wire. (1)			
2a	This diagram shows a magnet holding some paper clips. Describe how a student could show that the paper clips are induced magnets. (2)			
2b	Describe how you could show that the Earth has a magnetic field. (2)			
2c	The same student uses a solenoid to make an electromagnet. Describe what a solenoid is. (2)			
2d	Explain where the magnetic field produced by a solenoid is strongest (2)			
3a		A student uses iron filings to show the pattern of a magnetic field around a bar magnet. This diagram shows the pattern the student produced. Describe how you can tell where the magnetic field is strongest. (2)		
3b	The bar magnet is placed on a sheet of paper. Describe how the student could plot the shape and show the direction of the magnetic field around the magnet. (3)			
3c	A student has a power pack, a long piece of wire, a stiff card and some iron filings. Describe how the student could use this equipment to show the shape of the magnetic field produced by a current in the wire. You may draw a diagram to help. (4)			
3d	This diagram shows two magnetic poles facing each other. The magnetic field between the poles is uniform. Make a sketch of the diagram, draw the magnetic field lines between the two poles, and show the direction of this magnetic field. (3)			south pole north pole
4a	Complete the following sentences using the phrases from the right.		Efficiency is reduced The national grid A power station Heat loss is reduced A transformer	
i	Electrical power is generated at... (1)			
ii	Electricity is transmitted over long distances by transmission lines that are part of... (1)			
iii	Electricity is transmitted at high voltages so that... (1)			
4b	In a small transformer - the primary voltage is 230 V - the primary current is 0.020 A - the secondary voltage is 5.0 V Calculate the secondary current. (2)		Use the equation $I_s = \frac{V_p \times I_p}{V_s}$	
4c	In a small transformer, the primary voltage is 230 V. The secondary current is 0.02 A and the secondary voltage is 4600 V. Calculate the primary current using the equation: $V_p \times I_p = V_s \times I_s$			
4d	Explain how an alternating current, in the primary coil, can induce a current in the secondary coil of a transformer. (4)			
4e	Compare and contrast the structure of the transformers in questions 4b and 4c. (6)			

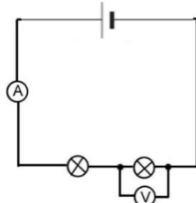
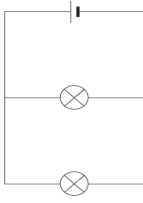
Topic 14 & 15: The Particle Model - Exam Questions

1a	Which process describes the change from solid to liquid? (1)			
	A. freezing	B. melting	C. condensation	D. evaporation
1b	Which of these kelvin temperatures is 0 °C? (1)			
	A. 273 K	B. 0 K	C. 100 K	D. 293 K
1c	Which of these words best describes an object that returns to its own shape when a force is removed? (1)			
	A. flexible	B. inelastic	C. rigid	D. elastic
1d	Describe how to identify a linear relationship between two variables on a graph. (1)			
1e	State the equipment used to measure the mass of an object. (1)			
2	A student is investigating the density of a metal block and a small stone.			
2b	The student found the volume of the metal block by multiplying the area of its base by its height. Describe how the student could measure the volume of the small stone. (3)			
2c	The student calculates the volume of the block as 14 cm³. She finds that the mass of the block is 100 g. Calculate the density of the block in g/cm³. (2)			
2d	The volume of the stone is 250 cm³ and the mass is 760 g. Calculate the density of the stone in g/cm³. (2)			
3a	Kinetic theory describes the movement of particles in the three states of matter. Gas is one of the states of matter. Name the other two states of matter. (2)			
3b	The average kinetic energy of the particles in a gas is directly proportional to (1)			
	A. the pressure of the gas	B. the temperature of the gas in degrees Celsius	C. the temperature of the gas in Kelvin	D. the volume of the gas
3c			Copy similar boxes and draw the particle model to show how particles are arranged in a solid, liquid and gas. (3)	
3d	Use ideas about the particle model to explain why solids and liquids cannot be compressed but liquids can be poured. (3)			
3e	A technician takes an ice cube from the freezer and slowly heats it until it becomes a liquid. Explain what would happen to the temperature whilst the ice cube is melting. (3)			
3f	The specific latent heat of fusion of is 3.34 x 10 ⁵ J/kg. Calculate the energy needed to melt 350 g of ice. (2) Energy transferred = specific latent heat x mass			
4	A student has a spring that is 4 cm long and stretches it to 32 cm with 4.48 N of force.			
4a	Calculate the extension of the spring, give your answer in metres (2)			
4b	Calculate the spring constant of the spring. (3)			
4c	Calculate the energy stored in the spring. (2) Energy = ½ spring constant x extension²			
5a	Describe a method that would allow a student to calculate the specific heat capacity of water using the equipment shown. (4)			
5b	State two ways that the apparatus could be adapted to improve the method. (2)			
5c	3.36 x 10 ⁴ J of energy is used to heat 400 g of water, changing the temperature by 20 °C. Show that the specific heat capacity of water is 4200 J/kg°C. (3)			
Energy = mass x specific heat capacity x temperature change				

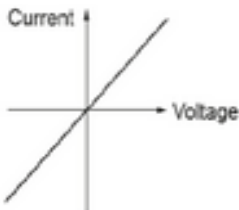
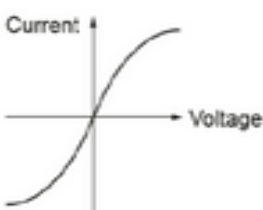
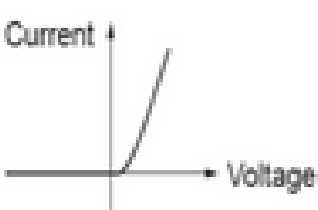
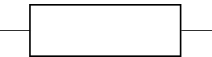
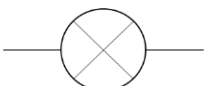
Topic 8 & 9: Energy and Forces - Exam mark scheme

1a	C. Renewable (1)		
1b	D. Magnetic (1)		
1c	A. Chemically (1)		
1d	50 – 38 = 12 J of energy wasted (1)		
1e	Efficiency = useful energy ÷ total input energy (1)		
1f	Efficiency = 38 ÷ 50 (1) Efficiency = 0.76 or 76 % (1) Correct answer on its own gets both marks		
2a	Work done = force x distance 2700 = 150 x h (1) 2700 ÷ 150 = h h = 18 m (1) Correct answer on its own gets both marks		
2b	2700 J (1)		
2c	KE = ½ m x v² 2700 = ½ 15 x v² (1) 2700 ÷ 7.5 = v² (1) v = √360 v = 19 m/s (1) Correct answer on its own gets all 3 marks		
3a	KE = ½ m x v² KE = ½ 85 x 1.5² (1) KE = 42.5 x 2.25 KE = 95.6 J (1) Correct answer on its own gets both marks		
3b	Work done = force x distance moved 1200 = F x 80 (1) 1200 ÷ 80 = F F = 15 N (1) Correct answer on its own gets both marks		
3c	The work done is the same (1) because work done depends on force and distance only/does not depend on time (1)		
3d	GPE = mass x g x height 264 = 12 x 10 x h (1) 264 ÷ 120 = h (1) h = 2.2 m (1) Correct answer on its own gets all 3 marks		
4a		Upward force labeled as normal contact force or upthrust (1) Downwards force labeled as weight or gravity (1) Both arrows same size but opposite directions (1)	4b The table pushes up on the box (1) With a force of 250 N (1)
4c	Both examples have forces that are the same size (1) and act in opposite directions (1) Balanced forces act on same object (1) Newton's 3 rd law forces act on different objects (1)		
4d		Two vector arrows drawn at right angles (1) with an appropriate scale (1) Line drawn to complete a triangle/parallelogram (1) Resultant force = 3.6 (±0.2) N (1)	
4e	Arrow drawn at 30° with appropriate scale (1) Horizontal & Vertical components drawn (1) H component = 3.9 (±0.2) N (1) V component = 2.3 (±0.2) N (1)		
5a	Dissipated (spread out into less useful forms) (1) to the surroundings (1)		
5b	Use of lubrication/oil (1) to reduce friction (1)		
5c	6 marks from: Changing height means that GPE is changing during each swing (1) when height is at highest point so is GPE (1) when height is at lowest point so is GPE (1) During each swing GPE is changed into KE (and back) (1) KE at highest when height is lowest (1) KE at lowest when height at highest (1) Height of swing decreases so max GPE/KE also decreases (1) this is because energy is dissipated (1) to the surroundings (1) due to air resistance/friction (1)		

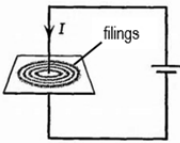
Topic 10: Electric circuits- Exam mark scheme

1a	D. charge (1)		
1b	A. electrons (1)		
1c	C. a variable resistor (1)		
2a	i. 2 marks for 2 lamps and cell with correct symbols ii ammeter in series iii voltmeter in parallel		iv. correct symbols in correct place 
2b	$R = V \div I$ $R = 1.5 \div 0.11$ (1) $R = 13.63$ (1) $R = \underline{14 \Omega}$ (1) Correct answer = (3)	2c	(Convert time into s) $6 \times 60 = 360$ s (1) $Q = I \times t$ $Q = 0.11 \times 360$ (1) $Q = \underline{39.6 C}$ (1) Correct answer = (3)
2d	(Convert 0.8 kJ into J) $0.8 \times 1000 = 800$ J (1) $E = Q \times V$ $800 = Q \times 1.5$ (1) $Q = 800 \div 1.5$ (1) $Q = \underline{533 A}$ (1) Correct answer scores all 3 marks		
3a	i. Total $R = 150 + 150 = \underline{300 \Omega}$ (1) ii. in parallel the total resistance will be <u>less than</u> 150Ω (1)		
3b	Put the component in series with power supply/battery/cell (1) Place an ammeter in series (1) to measure current (1) Place a voltmeter in parallel (with the resistor) (1) to measure the potential difference (1) Record these values at 6 different power settings (1) use the equation $R = V \div I$ (1)		
4a	$E = Q \times V$ $1.4 \times 10^{-14} = 1.6 \times 10^{-19} \times V$ (1) $V = 1.4 \times 10^{-14} \div 1.6 \times 10^{-19}$ (1) $V = \underline{87\,500 V}$ (1) Correct answer scores all 3 marks		
4b	Add more lamps (1) remove a cell/cells (1) add a resistor (1)		
4c	$V = I \times R$ $4.2 = 0.19 \times R$ (1) $4.2 \div 0.19 = R$ (1) $R = \underline{22.1 \Omega}$ (1) Correct answer scores all 3 marks		
4d	You have to use two equations to get to the answer		
	$E = Q \times V$ $100 = Q \times 4.2$ $Q = 100 \div 4.2$ (1) $Q = 23.8$ (1)	$Q = I \times t$ $23.8 = 0.19 \times t$ $t = 23.8 \div 0.19$ (1) $t = 125$ s	Convert seconds into minutes $125 \div 60 = 2.1$ $t = \underline{2 \text{ minutes}}$ (1) Correct answer gains all 5 marks
5	(Convert energy) $64 \times 1,000,000 = 64 \times 10^6$ J (1) $E = Q \times V$ $64 \times 10^6 = Q \times 330$ (1) $Q = 64 \times 10^6 \div 330$ (1) $Q = \underline{194,000 C}$ (1) Correct answer = (3)	(Convert time) $8 \times 60 \times 60 = 28800$ s (1) $Q = I \times t$ $194,000 = I \times 28800$ (1) $I = 194,000 \div 28800$ (1) $I = \underline{6.7 A}$ (1) Correct answer = (3)	
6	In both circuits current is rate of flow of charge (1) and potential difference is the energy per coulomb of charge (1)		
	Series		Parallel
Current	The current is the same everywhere in the series branch (1)		The current will split at a junction (1) The sum of the current in each branch will equal the total current (1) Current is conserved at each junction (1)
Potential difference	The potential difference will be shared between the components (1) The total potential difference will be the sum of each component PD (1)		The total potential difference is the same for each branch (1)

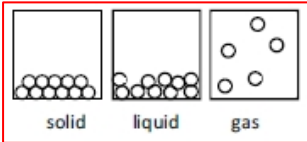
Topic 10: Electric circuits- **Exam mark scheme**

1a	C. in one direction		
1b	The temperature increases (1)		
1c	Fixed resistor 	Filament lamp 	Diode 
1d	Fixed resistor 	Filament lamp 	Diode 
2a	$P = I \times V$ $P = 7.5 \times 230$ (1) $P = 1,725 \text{ W}$ (1) Convert power to kW: $1,725 \div 1000 = 1.725 \text{ kW} = \underline{1.7 \text{ kW}}$ (1) Correct answer = 3 marks		
2b	C. 10 A		
2c	Convert time to seconds: $1 \times 60 \times 60 = 3600 \text{ s}$ (1) $P = E \div t$ $7500 = E \div 3600$ (1) $E = 7500 \times 3600$ (1) $E = \underline{27,000,000 \text{ J}}$ (1) (or $27 \times 10^6 \text{ J}$ or 27 MJ) Correct answer gains all 4 marks		
2d	Frequency is 50 Hz (1), voltage is 230 V (1) and current is alternating current (a.c.) (1)		
3a	Electrons (1) colliding with ions (in the metal lattice) (1) or electrons transfer energy to the ions during collision (2)		
3b	Convert power: $3 \times 1000 = 3000 \text{ W}$ (1) $P = I^2 \times R$ $3000 = 2.5^2 \times R$ (1) $R = 3000 \div 6.25$ (1) $R = \underline{480 \Omega}$ (1) Correct answer = 4 marks	3c	Convert time: $2 \times 60 = 120 \text{ s}$ (1) $E = I \times V \times t$ $E = 2.5 \times 230 \times 120$ (1) $E = \underline{69,000 \text{ J}}$ (1) Correct answer = (2)
3d	Energy is transferred electrically (1) to the thermal energy stores of the water and kettle (1) some energy is dissipated to the surrounding (1) by heating (1)		
4a	NB: you need to find the current so that you can then calculate resistance $P = I \times V$ $92 = I \times 230$ (1) $I = 92 \div 230$ $I = 0.4 \text{ A}$ (1) this answer = (2)	$P = I^2 \times R$ $92 = 0.4^2 \times R$ (1) $R = 92 \div 0.16$ $R = \underline{575 \Omega}$ (1) Correct answer = 4 marks	
4b	To reduce the amount of heat lost they must reduce the resistance of the wire (1) they can do this by: Using wires made of metal with lower resistance (1) or Use thicker wires (1) or Lower the temperature of the wires (1)		
5	Earth wire is for safety (1) it helps (1) prevents electric shocks (1) voltage = 0 V (1) Neutral wire provides a return path for the current (1) completing the circuit (1) voltage = 0 V (1) Live wire carries voltage from power station to appliance (1) voltage = 230 V (1) Fuse is for safety (1) protects the wiring/ prevents fires (1) by melting if current is too high (1)		
6	A explanation including some of the following points (must consider both LDR and thermistor to get higher than 3 marks) Light dependent resistors (LDR): Resistance changes with light intensity (1), Bright light = low resistance (1), No light (dark) = high resistance (1,) Low resistance gives high current (ORA) (1). Thermistor: Resistance changes with temperature (1), Negative temperature coefficient (1), High temperature = low resistance (1), Low temperature = high resistance (1), Low resistance gives high current (ORA) (1)		

Topic 12 & 13: Magnetic forces - Exam mark scheme

1a	Transformer (1)	
1b	D. Transformers have primary and secondary coils. (1)	
1c	C. cobalt (1)	
1d	C. turn the magnet around (1)	
1e	Move the magnet in the opposite direction (1) turn the magnet around/ put the other pole of the magnet into the coil (1)	
2a	Separate the magnet and the paperclips (1) paperclips are no longer attracted to each other (no longer magnetic) (1)	
2b	Use a compass (1) which will always point in the same direction / will always point north (1)	
2c	A solenoid is a coil of wire (1) with current flowing through it (1)	
2d	The magnetic field is strongest inside the solenoid (1) because the fields add together (1)	
3a	Concentration / amount of iron filings (1) is greatest where the field is strongest (1) at the poles of the magnet (1)	
3b	Use a (plotting) compass (es) (1) mark a dot in the direction the arrow points (1) place at various positions (around the magnet) (1) join the dots to show the shape of the field (1) the direction of the field is the direction the arrow points (1)	
3c	Put the wire through the card (1) put iron filings on the card / around the wire (1) allow current to flow through the wire / connect wire to power source (1) the iron filings will move (1) and show the shape of the magnetic field (1)	
3d	At least one straight, vertical line from pole to pole (1) At least 4 straight, vertical line from pole to pole (1) Arrow on any line, pointing from north to south (1) any arrow pointing south to north means this third mark can not be given	
4a	Complete the following sentences using the phrases from the right.	
i	Electrical power is generated at... A power station (1)	
ii	Electricity is transmitted over long distances by transmission lines that are part of... The national grid (1)	
iii	Electricity is transmitted at high voltages so that... Heat loss is reduced (1)	
4b	$I_s = \frac{230 \times 0.02}{5.0} \quad (1)$ $I_s = \mathbf{0.92 \text{ A}} \quad (1)$	Accept 0.9 A Correct answer gains both marks
4c	$230 \times I_p = 4600 \times 0.02 \quad (1)$ $I_p = \frac{4600 \times 0.02}{230} \quad (1)$ $I_p = 0.4 \text{ A} \quad (1)$	Correct answer gains all three marks
4d	The alternating current produces a changing magnetic field in the primary coil (1) The magnetic field is strengthened by the iron core (1) The magnetic field produces a changing voltage in the secondary coil (1) The changing voltage produces an (alternating) current in the secondary coil. (1)	
4e	Compare and contrast the structure of the transformers in questions 4b and 4c. (6) Both transformers are made from an iron core (1) with two separate coils of wire (1) The transformer in 4b is a step-down transformer (1) the transformer in 4c is a step-up transformer (1) The step-down transformer has {more turns of wire on the primary coil / less turns of wire on the secondary coil} (1) The step-up transformer has {more turns of wire on the secondary coil / less turns of wire on the primary coil} (1)	

Topic 14 & 15: The Particle Model - Exam mark scheme

1a	B. melting (1)
1b	A. 273 K (1)
1c	D. elastic (1)
1d	The graph will be a straight line (1)
1e	Balance (1)
2b	Fill a displacement can with water (1) place (fully immerse) the stone inside the water (1) volume of water displaced = volume of stone (1) or Part fill a measuring cylinder and record volume (1) fully immerse stone in the cylinder and record new volume (1) Volume of stone = new volume – starting volume (1)
2c	Density = $100 \div 14$ (1) Density = <u>7.1 g/cm³</u> (1) Correct answer gains both marks
2d	Density = $760 \div 250$ (1) Density = <u>3.04 g/cm³</u> (1) Correct answer gains both marks
3a	Solid (1) and liquid (1) Any order
3b	C. the temperature of the gas in Kelvin
3c	 In each box- solid: regular alignment and particles touching (1) liquid: irregular arrangement and most particles touching (1) gas: random and spaced out (1)
3d	3 marks from: In both solids and liquids the particles are (already) touching (1) so they cannot be pushed closer together (1) In a liquid the forces that hold the particles together are weaker (1) so particles are able to move past each other (and be poured) (1) ORA for solids
3e	The temperature would remain {the same / at 0°C} (1) because the energy is being used to weaken bonds (1) rather than make the molecules {vibrate / move} faster (1)
3f	Energy = $3.34 \times 10^5 \times 0.35$ (1) ($3.34 \times 10^5 \times 350 = 1$ mark only) Energy = <u>117,000 J</u> (allow 116,900) Correct answer gains both marks
4a	$32 - 4 = 28$ cm (1) $28 \div 100 =$ <u>0.28 m</u> (1)
4b	$4.48 = k \times 0.28$ (1) $k = 4.48 \div 0.28$ (1) $k =$ <u>16 N/m</u> (1) Correct answer gains all three marks
4c	Energy = $\frac{1}{2} \times 16 \times 0.28^2$ (1) Energy = <u>0.63 J</u> (1) Correct answer gains both marks
5a	Measure the {mass / volume} of water (1) Measure the temperature (1) Measure the start and end temperature to find change (1) Measure the energy supplied by the heater (1)
5b	Add a lid (1) Add insulation / lagging (1) Use a stirrer (1) Use a digital thermometer (1)
5c	This is a 'show that' question- so each stage is needed, not just the answer. $3.36 \times 10^4 = 0.4 \times \text{SHC} \times 20$ (1) $\text{SHC} = 3.36 \times 10^4 \div (0.4 \times 20)$ (1) $\text{SHC} =$ <u>4200 J/kg°C</u> (1)

Select and Apply equations

Students may be asked to select and apply these equations in the exam papers. These equations will be given in a formulae sheet at the end of the exam papers.

Equations required for higher tier only are shown in bold text. Higher tier only equations will not be given in the formulae sheet for the foundation tier papers.

(Final velocity)² – initial velocity)² = 2 x acceleration x distance $v^2 - u^2 = 2 \times a \times x$	
Force = change in momentum ÷ time $F = \frac{(mv - mu)}{t}$	
Energy transferred = current x potential difference x time $E = I \times V \times t$	
Force on a conductor at right angles to a magnetic field carrying a current = magnetic flux density x current x length $F = B \times I \times l$	
<u>Voltage across primary coil</u> = <u>number of turns in primary coil</u> <u>Voltage across secondary coil</u> <u>number of turns in secondary coil</u> $\frac{V_p}{V_s} = \frac{N_p}{N_s}$	
Change in thermal energy = mass x specific heat capacity x change in temperature $\Delta Q = m \times c \times \Delta\theta$	
Thermal energy for a change of state = mass x specific latent heat $Q = m \times L$	
Energy transferred in stretching = 0.5 x spring constant x (extension)² $E = \frac{1}{2} \times k \times x^2$	